The United Nations University
FISHERIES TRAINING PROGRAMME

unuftp.is Final Project 2013

HATCHERY DESIGN AND BROODSTOCK MANAGEMENT POLICY AS A TOOL FOR SUSTAINABLE AQUACULTURE; CASE OF CAMEROON

Joseph Tekwombuo
National Livestock, Veterinary and Fisheries Training Institute
Foumban, Cameroon.
tekwombuo@yahoo.co.uk

Supervisors
Professor Helgi Thorarensen,
Holar University College,
helgi@holar.is

ABSTRACT

Aquaculture in Cameroon has seen little progress over the last ten years and has thus contributed very little to food security in the country despite the potential that exists. This report presents the work carried out to explore lasting solutions for fish production to fully contribute to food security in Cameroon. Information was gathered to determine the number of ponds and their total surface area. The African catfish (*Clarias gariepinus*) was used as a case study, to determine the amount of seeds needed by the existing farms at different stocking densities. The number of broodstock to produce the require seeds was determined. A model hatchery was designed and based on seed requirements, transport availability, and infrastructure and a repartition pattern was proposed.

The result shows that about 46 million fingerlings are needed for adequate stocking of ponds, and about 7 thousands brood fish are required to produce the fingerlings. To produce the required seed while ensuring good management, a design of a model hatchery that can produced approximately 2.6 million seed is proposed. To satisfy the demand, 27 hatcheries have to be built in proposed locations in the 8 regions of the country. Each hatchery will require an investment capital of about 128 million francs CFA. At 75 francs per fingerling a benefit/cost ratio of 219% can be obtained if the breeding programme is implemented successfully.

This paper should be cited as:
Tekwombou, J. 2014. *Hatchery design and broodstock management policy as a tool for sustainable aquaculture: case of Cameroon.* United Nations University Fisheries Training Programme, Iceland [final project]. http://www.unuftp.is/static/fellows/document/joseph13prf.pdf

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

For the past decade, global aquaculture production has grown faster than any other part of the food sector (Subasinghe, Soto, & Jia, 2009). In Africa, as a whole and sub-Saharan Africa in particular, farmed fish production has not increased much due to lack of capital, technological know-how and poor government policy (Pillay & Kutty, 2005). Most of the world's poorest population live in this part of the world. In Cameroon, fish is the main animal protein source, especially for the most underprivileged layers of society (Nguenga & Pouomogne, 2006). The annual consumption of fish in Cameroon from 2008 to 2010 was estimated to be over 300,000 tons (Laurenti, 2013). Due to lower prices the consumption of fish is significantly higher than of meat and it is available in quantities suitable for consumers. The fisheries in Cameroon only produce approximately 176,000 tons of fish, most of it from artisanal (marine and fresh water) sector (NIS, 2012). Therefore, the government of Cameroon has imported over 120,000 tonnes of fish per year for the past decade to meet the domestic fish demand (Pouomogne & Pemsi, 2008). Aquaculture accounts for less than 9.5% of the inland fish production. However, conditions for fish culture in Cameroon are good; there is a good climate suitable for the rearing of many warm water species, appropriate soil for pond construction and natural inland waters covering over 40,000 square kilometres, and freshwater fish suitable for aquaculture, (Brummett, 2007).

The average annual per capita fish consumption in Cameroon is 17.9 kilograms. The demand for fish is increasing due to growing population (2.8% annually) and rapid urbanization. It is projected that the demand will be 400,000 tons in 2015 (MINEPIA & FAO, 2009). Reliable information on the volume of aquaculture production in Cameroon is difficult to obtain and the statistics available are conflicting and vary from one source to another. The reason for this is that there are no official records of production at farm level. Farmers are often reluctant to provide information and some of the fish produced is not traded but consumed by the producers and their families. However, all available information suggests that aquaculture has grown over the past ten years (NIS, 2012; FAO, 2012). The growth of aquaculture in Cameroon is linked to the increased demand and implementation of the Strategic Framework for the Development of Aquaculture that was initiated with the assistance of FAO and World Fish Centre (Moehl, Halwart, & Brummett, 2005). Also, the continuous population growth in Cameroon and progressive increase in demand for animal protein provide favourable conditions for the growth of aquaculture in Cameroon. This increase in demand has caused a significant increases in fish prices (GPA, 2007). In response to the increase in demand for fish, previously abandoned ponds have been put in use again, facilitated by changes in government policy of providing technical assistance to farmers and the organisation of training seminars (Pouomogne & Pemsl, 2008).

Southern and Western Cameroon, which constitute about 63.5% of the total surface area of the country, have almost year round rainfall and appropriate temperature making it favourable for aquaculture. Currently, the aquaculture sector in Cameroon is made up of small-scale farmers producing 2-5 tons of fish per hectare and large-scale farmers who produces up to 16 tons per hectare with the former predominant. Most farms use earthen ponds to grow fish although cages are being introduced. Tanks and raceways are used only in research stations. The largest farms (about 20% of the total) are concentrated around urban areas. Some of these larger farms were previously subsistence farmers but have now over 10 ponds exceeding 5,000 m² (Pouomogne & Pemsl, 2008). The larger farms have the advantage of affording the use of equipment for construction rather than digging the ponds by hand. Furthermore, they use pellets to feed the fish. Some of the larger producers have some experience in other types of agriculture such as chicken or pig farming. Despite the willingness of farmers to expand, their endeavours are most often hampered by the unavailability of seed at the desired time and in insufficient quantities. If the supply of fish from aquaculture is to increase, adequate number of young fish of good quality have to be produced. Increased aquaculture production will also facilitate the growth of various support industries such as feed production.

1.1 Statement of the problem

As described above the volume of aquaculture production in Cameroon is low although conditions are favourable. The limited growth of aquaculture in Cameroon can be attributed to many factors such as the lack of adequate feed, access to capital, knowledge and most importantly the scarcity of quality fingerlings and at affordable prices. Government owned aquaculture and fish fry stations as well as private backyard hatcheries have over the years failed to supply the number of seed needed by farmers. Though statistics on fingerling production are not well known as no documented information exists, farmers report that fingerlings are usually of low quality and their demands are never met. Most farmers resort to collecting wild fish to stock their ponds but only limited amount of fingerlings can be obtained this way (Brummett, 2007; Pouomogne, 2007).

The quantity of fingerlings obtained does not always meet the needs of the farmers. This has been attributed to high mortalities of fry in ponds caused by the presence of predators such as frogs, birds, larvae of toad and dragon fly, which prey on the fry or compete with them for food. Attempts at controlling these predators, such as building a fence around and interweaving of ropes above the ponds, have not been fruitful. The fingerlings caught in the wild may be agents of disease transmission and not suited for culture

The problem of access to quality seed for aquaculture in Cameroon may also be one of management. Most farmers purchase tilapia seed only once upon venturing into fish farming. These are commonly of mixed-sex and since they multiply rapidly the ponds may be overstocked with small tilapia that grow slowly or not at all. This practice has affected the growth of aquaculture in Cameroon. Finally, the catches of juveniles in the wild for aquaculture may threaten capture fisheries. For aquaculture to grow in Cameroon, the problem of fingerlings must be solved.

African catfish fingerlings are in high demanded by farmers. To meet this demand, a system must be put into place that ensures reliable supply of seed. Furthermore a simple broodstock management scheme needs to be put in place so as to ensure the quality of fingerling production. Ideally, a breeding program should also be initiated for the species to improve the growth performance of the fish. This will, among others, stimulate fish culture in the country.

1.2 Project objectives

The objective of the project is to promote sustainable fish production in Cameroon by designing a plan increase supply of fingerlings. To contribute to this objective, the following tasks will be carried out:

- Assess the number of fingerlings required for aquaculture in Cameroon.
- Design a suitable fish hatchery model for seed production in Cameroon.
- Suggest a broodstock management plan.
- Carryout an economic analysis of the hatchery operation to determine the cost of fingerling production.

2 A STRATEGY FOR FINGERLING PRODUCTION IN CAMEROON

Earlier estimates of the potential for aquaculture in Cameroon suggested that about 20,000 tons could be produced per year if the aquaculture potential of the country was fully exploited (MINEPIA & FAO, 2009). This estimate was based on the assumption that yield in extensive aquaculture was of 0.5 tons per hectare per year. However, the yield in aquaculture in Cameroon has increased due to higher stocking densities, better management practices and better access to technical support from extension officers (MINEPIA & FAO, 2009) increasing the possible yield to over three tons per hectare per year. However, this increase in possible yield has not resulted in increased production, in part due to shortage of fingerlings. It is important to estimate the number of fingerlings required for aquaculture in Cameroon. The first issue addressed in this project is to estimate the number of fingerlings required.

2.1 Main locations of aquaculture in Cameroon

An inventory of ponds was assembled in areas where conditions for aquaculture are particularly good, the soil is suitable for pond constructions, water availability and topography is favourable (Figure 1).

Figure 1. Map of Cameroon indicating the regions where fish farming is most practiced

The inventory carried out in 2012 was done through questionnaires formulated by the Department of Aquaculture of the directorate of Fisheries and Aquaculture and sent to aquaculture extension officers who work directly with fish farmers and common initiative groups. The questionnaires were distributed to the farmers who could read and write. Those who were not literate were assisted by extension officers in answering the questionnaire. The questionnaires were collected and sent to the department of aquaculture where they were analysed. Data and information on the number of ponds and average surface area were grouped per region (Table 1).

Table 1. Number of ponds and total surface area per region based on an inventory by the directorate of fisheries (Unpublished)

Regions	Number of ponds	Average pond surface area (m^2)	Total ponds surface area of ponds (m^2)
Centre	856	1355	1,160,000
Littoral	130	1538	200,000
East	1274	2017	2,570,000
South	826	1209	999,000
South-west	230	126	29,000
North-west	1510	99	150,000
West	434	574	249,000
Total	**5260**		**5,357,000**

2.2 Assessing the number fingerlings and number of broodstock required

The number of fingerlings needed to stock the available ponds in Cameroon was calculated based on the total surface area of ponds, reported stocking density and the length of production cycle.
One production cycle usually last for 8 months. After that the ponds are dried up for two weeks to a month before the next production cycle can begin. Therefore, the number of production cycles per year is 1, 3.

The proportion of ponds in use was estimated by calculating the percentage of total pond surface area used by farmers. Stocking density varies from 5-10 m^2.

The number of African catfish (*Clarias gariepinus*) brood fish needed to produce the number of fingerlings was estimated based on the personal experience from the authors work with students.

- The life weight of broodfish, 500 g
- Quantity of eggs produced, 50 g (10% of female life weight)
- Number of eggs per gram, 500 eggs
- Survival rate from incubation to harvest of fingerlings, 50%

A 1:1 male/female and not 1:2 female/male sex ratio which is commonly practiced in Cameroon was used in this case to reduce the number of males killed for the milt there by reducing cost. The number of broodstocks needed were calculated with the following formula:

Number of broodstock = number of fingerlings / 2 (gram of eggs produced x number of eggs/gram x survival rate)

The number of fingerlings required was calculated per year (Table 2). The total number of fingerlings is about 46 million / year. The largest number of fingerlings is required in the East region, about 21 million fingerlings, which is approximately 50% of the total. The North-West region needs the lowest number of fingerlings.

The estimated number of broodstock required was 7362, a security margin is necessary since natural mortality may occur, or some may not provide the required number of eggs for females or less milt for males. A total of 3,681 males and females each will be required (Table 2). The number of females required was estimated assuming that each female could be used twice.

Table 2. Number of fingerlings and broodstock needed per year in Cameroon

Total pond area in use (m^2)	5.357.000
Ponds stocked at 5 fish / m^2 (50% of ponds)	17,410,250
Ponds stocked at 7 fish / m^2 (30% of ponds in use)	14,673,750
Ponds stocked at 10 fish / m^2 (20% of ponds in use)	13,928,200
Total number of fingerlings required	46,012,200
Total number of eggs required / year[1]	92,024,400
Total number of males used / year[2]	3,681
Total number of females used / year[3]	3,681
Minimum number of broodstock required	7,362

[1] Assuming 50% mortality from eggs to fingerlings

[2] Assuming 25,000 eggs /female and 1 male sacrificed / mating

[3] Assuming that each female is used two times within one year

1- The total surface of the ponds was obtained by multiplying the average pond surface area per region by the total number of ponds, and then all the totals were summed.
2- The number of fingerlings was calculated by multiplying the total pond surface area by the stocking density, as well as percentage of the ponds total surface area for this density.
3- The annual number of fingerlings required was calculated by multiplying the total number of fingerlings per stocking ponds proportion by 1.3 since one cycle last one year.

In our experience, survival rate can exceed 60% under optimal conditions but when earthen ponds are used, it may be as low as 10-15%.

3 FINGERLINGS PRODUCTION IN CAMEROON

The hatcheries required to provide adequate number of fingerlings for aquaculture in Cameroon do not exist at present. Therefore, it is proposed that a new network of hatcheries will be constructed that will meet this demand. In recent years, post larvae mortality has been a recurrent problem. Therefore, it is proposed that the hatcheries will have indoor facilities for rearing from the egg to fingerling stage. The broodstock will be kept in outdoor ponds. Site selection

Selecting a suitable site for fish hatchery is the first important step to ensure success of the hatchery. Most of Cameroon's potential aquaculture zones have suitable site on which hatcheries can be conveniently constructed. The site considered for construction of the hatchery has the following characteristics:

- Topography with gentle slope for water flow by gravity.
- Desirable quantity and good quality of water all year round, free from agricultural, industrial and other sources of pollution.
- Soil with firm clayish texture so as to support the structures to be put on it without any risk of collapse as well as limit infiltrations in brood fish ponds.
- Good access by road.
- Availability electrical supply.

3.1 Model hatchery components

The basic hatchery model is designed to produce close to 2.6 million fingerlings annually. This model will then be replicated in different areas to meet the local demand. The design takes into account the availability of materials in Cameroon as well as information from specialists in building, technical information from books and field experience. The model hatchery occupies a total surface area of two hectares. It is made up of three main sections; the water reservoir and supply part (Figure 2), the indoor unit (Figure 3) and the broodstock and grow-out ponds. The water supply will come from a stream with stable flow rates and gravity flowing into the fish farm. The maximum volume of water required for the indoor units is about 72 m^3, though the total requirement is 134 m^3 but all the unit will not be functional at the same time. About 260 m^3 per day for the ponds daily. In areas without access to streams, water will be sourced from wells.

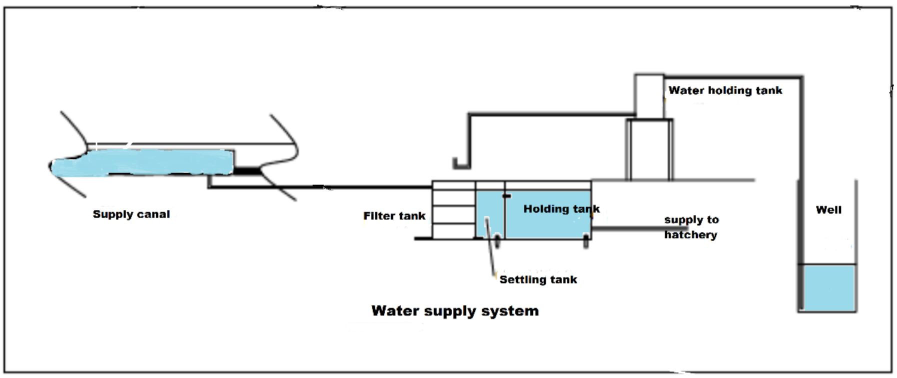

Figure 2. Water supply system

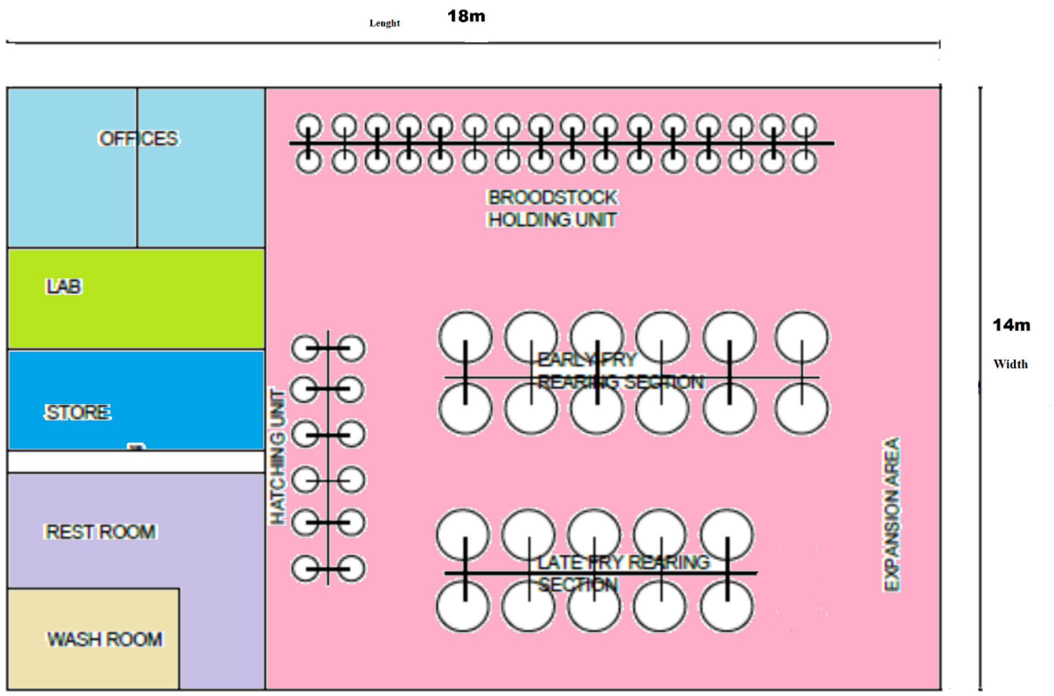

Figure 3. Hatchery building with the different units

3.1.1 Water holding structure

The water reservoir for the hatchery is made up of three compartments, a simple filtration units of two cubic metres having layers of sand, gravel and stones from top to bottom respectively for filtration. The second unit is the settling chamber while the last unit is the water holding tank with a capacity of $6m^3$ which can supply water without pump for two hours, but staff on duties at all times (Figure 2).

3.1.2 Indoor structure

A 252 m^2 (length 18 m and width 14m) building will be constructed for the indoor facilities. It is comprised of four main units, as outlined in Figure 3; the broodstock holding structure has 32 cylindrical plastic containers of 80 litres each, for holding one female each after injection for final ripening of the ovules as well as for post incubation observation period. Each of the containers will be filled with a small volume of water during holdout period.

The fertilised eggs are transferred to the incubation unit which is made up of twelve cylindrical plastic containers, 60 litres each. Each of the incubators will contain about 132g of eggs, a total of 780,000 eggs. The expected hatching rate is 90%. The hatched larvae will be moved to the early fry rearing section. The early fry unit has twelve plastic containers, each with 100 litre capacity. In this unit, the fry will be fed live feed for eight to ten days and then transferred to the late fry section. The expected survival rate through this stage is 75%.

The late fry unit is the largest, with 10 concrete circular tanks of about $1m^3$ each. This section is used for the rearing of fry to fingerlings at a density of 55 fry/L. The fish will be in these units for 25 to 30 days. They will also be used for the temporal storage of fingerlings during hardening prior to sale. The flow rate of water in each tank will be 5 L/minute. This model hatchery will be able to produce about 450,000 fingerlings every 40 to 47 days, with six production cycles per year. The assumed number of individuals, volume and water flow requirements of the hatchery are outlined in Table 3. The expected annual production is 270,000 fingerlings.

Table 3. Number, volume and flow requirements of the hatchery

	Number of units	Volume (L)	Specific flow rate (L/min unit)	Total flow rate (L/min)
Broodfish	32	80		
Eggs	12	60	3	36
Early fry	12	100	4	48
Late fry	10	1000	5	50
			Total flow rate:	**134**

3.1.3 Broodstock ponds

Five ponds of varying sizes will be constructed for holding of broodstock and grow-out of future broodstock fish. For holding the broodstock there will be two 100m^2 ponds and two 150 m^2 ponds. There will be one 200 m^2 pond for growing fingerlings to broodstock size. Water supply for the ponds will be either from a supply canal for the case of water supply by gravity or from evacuation pipes of the different units of the indoor structures when supplied by the well

3.2 Number of hatcheries and locations

The model hatcheries illustrated in Figure 2 will each produce approximately 2.7 million seeds annually. However, 50 million fingerlings are required and, therefore, 19-20 hatcheries must be constructed. The location of the hatcheries should take into consideration the number of seed required for each area, the local road network and the state of the roads to ensure that the fingerlings can be transported safely, not more than 4 hours drive from hatchery to fish farms. To satisfy current demand, 17 hatcheries are needed. These have been allocated to different areas based on the total area of ponds in each area and road infrastructure. The distribution of hatcheries in Table 4 and shown in Figure 4. The littoral region has no hatchery but can easily get fingerlings from neighbouring regions since it is easily accessible from most regions especially the West, North West and South West.

Table 4. Distribution of locations for hatcheries in different regions and potential production based on the number of fingerlings produced

Regions	Number of hatcheries
Centre	5
East	6
West	1
North-west	1
South	3
South-west	1
Total	17

Figure 4. Proposed location of multiplier and broodstock hatcheries in Cameroon

3.3 Improving seed production and quality

The estimates presented in this report indicates a current need for 17 hatcheries to meet demand of Clarias fingerling. However, the survey did not include ponds under construction. Here I assume three more hatcheries will be needed to satisfy increased demand in the next few years. The number of fingerlings produced from 20 model hatcheries could support an annual production of 12,000 to 25,000 tons of African catfish depending on market size (400-600 g) and survival from fry to harvest (50-80%). The current aquaculture production in Cameroon is not known, however, it is likely to be close to 1000 tons annually. Therefore, the hatcheries could be a significant boost to aquaculture in the country and an important step to reach the goal of 100,000 ton annual production.

The hatcheries have the potential to provide quality fingerlings with good growth rate and feed conversion ratio with good genetic management of the broodstock (Melba & Bondad-Reantaso, 2007). Further improvement of the stock could be attained trough a breeding program. There is evidence suggesting that African catfish fingerlings in Cameroon and most of Africa have reduced growth rate due to inbreeding (FAO, 2007). This has also reduces fecundity, fertilisation, hatching, and larval survival rates (Ponzoni & Nguyen, 2008). To obtain an acceptable rate of genetic gain and to keep the rate of inbreeding within acceptable levels, a breeding program which does not exist in Cameroon and many African countries is necessary as much can be gain through this in fish production.

To start the program in Cameroon, a certain number of fish from the wild, especially from different water bodies has to be collected. The fish selected for use as founder stock, should be examined and certified as being free from diseases, free of all physical abnormalities, should be of the same species and of similar weight. The selected fish will then be transported to the breeding station and kept in different tanks or ponds for a quarantine period of about 30 days for further examination. Selecting 100 fish for the founder stock should ensure adequate number to avoid inbreeding with good management practices and record keeping. This will require one central hatchery, with an indoor structure like that of the multiplier hatcheries (Figure 2), but with different setup in terms of equipment and their number. Also more ponds and some of bigger sizes will be needed for this purpose.

4 ECONOMIC ANALYSIS OF THE HATCHERY

To assess the economic feasibility of setting up the hatchery information on the expected investment and running costs was collected. This information included the cost of items used for the model hatchery from different stores in Cameroon and information on services of public work and land tenure was also obtained. The information came also from documents and the author experience from fingerlings production in Cameroon. The estimate indicates the investment cost for each hatchery is 54,681,000 francs CFA which at current rate of exchange is equal to 121, 513 USA dollars, land and construction constituting approximately 77% of the amount (Table 5). A total of 128,567,120 francs CFA will be needed for the year of construction of the hatchery with the running cost representing 57% of this amount (Table 5). Running annual cost for a hatchery is 73,886, 120 francs CFA and when depreciation and taxes are included, the annual operation cost is about 91 million francs CFA, or just over 200,000 USD. The annual operating cost of the hatchery was calculated using information from tables 5 and 6. The result shows that a total of 91 million francs CFA is the amount needed to produce the approximately 2.6 million fingerlings. A breakdown of cost estimates and annual operating costs are outlined in Tables 6 and 7.

Table 5. Breakdown of Invest asset cost for the hatchery

Land and constructions	Designation	Quantity	Unit cost	Total in Fcfa
	Land/m2	20,000	1,000	20,000,000
	Ponds	5	250,000	1,250,000
	Hatchery building	1	10,000,000	10,000,000
	Water reservoir construction	1	2,000,000	2,000,000
	Well	1	2,500,000	2,500,000
	Concrete rearing units	10	200,000	2,000,000
	Overhead tank.	1	500,000	500,000
	Contigency	10%		3,825,000
	Total 1 (T1)			**42,075,000**
Depreciation	**Yearly depreciation of constructions and land for 10 years**			4,207,500
Equipment	Pump	2	350,000	700,000
	Water parameter measuring instrument (multimetre)	1	2,500,000	2,500,000
	Microscope	1	800,000	800,000
	Refrigerator		250,000	250,000
	Scale balance	3	50,000	150,000
	60L plastic containers	13	18,000	234,000
	100Lplastic containers	12	150,000	1,800,000
	100Ø pipe	1	100,000	100,000
	63Ø pipe	1	180,000	180,000
	40Ø pipe	1	120,000	120,000
	Computer	1	100,000	100,000
	Electric generator	1	1,500,000	1,500,000
	Wheel barrows	2	25,000	50,000
	Spades	6	2,000	12,000
	Electric cables	1	1,000,000	1,000,000
	Grass cutters	2	200,000	400,000
	Elbow joints and others	1	200,000	200,000
	Contingency	10%		1,009,600
	Total 2 (T2)			**11,106,000**
Depreciation of equipment over 5 years				2,221,200
Other cost	Environmental impact assessment	1	1,500,000	1,500,000
	Total cost of investment (T1+T2)			**54,681,000**

Table 6. Break down of running cost estimates

Variable costs	Designation	Quantity	Unit cost	Total in FCFA
	Broodstock	480	5000	2,765,000
	Pellet feed (kg)	3200	500	13,278,260
	Lime	5	15,000	75,000
	fuel	1	1,898,000	1,898,000
	Materials for parcelling	2000	1000	2,000,000
	Electricity bills	1	360,000	360,000
	Internet and telephone bills	1	750,000	750,000
	Hormone 10ml recipient of oval prim	352	35,000	12,320,000
	Feed for fry (kg)	16000	600	9,600,000
	Live feed (artemia)	70	40,000	2,800,000
	Contingency	10%		4,936,920
	Total 3 (T3)			**54,306,120**
Fixed cost	Office materials	1	2,000,000	2,000,000
	Maintenance cost	1	1.000,000	1,000,000
	Salary for hatchery manager	12	200,000	2,400,000
	Salary for 04 technicians	48	150,000	7,200,000
	Salary for night watch man	12	50,000	600,000
	02 Labourers	24	50,000	1,200,000
	Transport	1	1,000,000	1,000,000
	Administration	1	2,400,000	2.400,000
	Contingency	10%		1,780,000
	Total 4 (T4)			**19,580,000**
	Total running cost (T3+T4)			**73,886,120**
Total cost for 1st year (investment + running cost)				**128,567,120**

Table 7. Annual operating cost

Designation	Amount in francs CFA
Variable cost	50,430,882
Fixed cost	19,580,000
Depreciation of land and constructions over 10 years.	4,207,500
Depreciation of equipment over 5 years	2,221,200
Depreciation of Environmental impact assessment over 5 years	300,000
Taxes, 19% of investments	10,389,390
Total	**91,004,210**

4.1 Profitability of the project

A project can only be attracted to financing when the investor are sure not only to recover their money but equally make acceptable benefit. The gross revenue was estimated at different sales price per unit of fingerling, in Table 8, in order to determine the possible sale price of fingerling in Cameroon. To determine the attractiveness of the project, the following was calculated:

Profit = gross revenue-annual operating cost.

Rate on return on investment (RROI) = Profit / Total investment cost

Breakeven production = Total operating cost / Unit price of product
Breakeven price = Total operating cost / Quantity of production

The results as shown in Table 9 indicate that, profit, rate of return on investment and benefit cost ratio all increase with increasing price, while breakeven production drops with increased price. At 34 francs CFA, the production of about 2.6 million fingerlings neutralises annual operating cost. This is considerably less than the current price 150 Fcfa for a unit African catfish fingerlings.

Table 8. Gross revenue at different unit price

Income (gross revenue)				
Item	Number produced	Unit price (FCFA)		
Fingerlings	2,658,150	50	75	100
Sales		132,907,500	199,361,250	265,815,000

Table 9. Profitability indicators

Components	At 50 FCFA	At 75 FCFA	At 100 FCFA
Profit.	46,078,528	112,532,278	178,986,028
RROI	77%	198%	320%
B/C	146%	219%	292%
Break even production	1,820,084	1,213,389	910042
Break-even price	34		

5 DISCUSSION

The results of this study suggest that the operation of at least 17 hatcheries in Cameroon for producing African catfish broodstock is feasible and that it could be a significant boost to local aquaculture. The 17 hatcheries could provide the 46 million fingerlings required to support the production of up to 25 000 tons of catfish. This would increase the production of catfish fingerlings fifteen-fold compared with the current output (3 million) of government and private hatcheries (Pouomogne & Pemsi, 2008). The lack of good quality fingerlings has hampered the growth of fish farming in the Cameroon and in other African countries such as Nigeria where fingerlings production was estimated at 55, 8 million while requirements stood at 4,3 billion annually (Adewumi & Olaleye, 2011). Also Marimuthu *et al.* (2009) commented that, the most important drawback of large-scale commercial culture of several fish species is the deficiency of quality seed of uniform size, free of diseases, parasites, and pests at the time of stocking in culture ponds. The 17 hatcheries will not only increase the supply of fingerlings but can also, with good broodstock management, ensure better quality of fish than is currently available. The impact of the hatcheries on aquaculture in Cameroon is of course dependent on other factors such as good management practices in fish farms and certainly the expected increase in production will not be realised without proper management.

From the result of the study, it is clear that fingerlings production in Cameroon can be a very profitable business venture. At just 50 francs CFA, a profit of up 41 million francs CFA is obtained in one year, with a benefit/cost ratio of 77%. The breakeven price of 34 francs CFA and benefit/cost ratio of 292% at 100 francs a fingerling, directly shows that fingerling production in Cameroon is an attractive sector to invest in. Similar result were noted in Cambodia by So Nam *et al.* (2005) who reported that fish seed production in general is a profitable venture with average profit margins of 290% to 300% in farmers and government operated hatcheries and up to 800% in small scale hatcheries. This high profit margin may be linked to the short production cycle. However in case of any incidence like low fecundity, low hatchability and survival rate of fry, the situation may turn the other way round. For an annual production of about 2.6 million juveniles, a profit margin of about 118% is likely when a fingerling is sold at 75 Fcfa, this is half the sale price recommended by the ministry of commerce for hatchery produced catfish fingerling in Cameroon (MINEPIA & FAO, 2009). However, increased supply of fingerlings will have a tendency to push the price of fingerlings down. Therefore, this high profit margins may not be realised if and when the production increases.

6 CONCLUSION

This study aimed at finding how a network of hatcheries and broodstock management could promote the growth of aquaculture in Cameroon where the lack of fingerling has for decades been the bitter pill in the development of this activity in a country in dire need for fish. The number of juveniles required and the projected possible production clearly points to the fact that the lack of seeds is a great handicap to the progress of fish farming in the country. The production of the needed fingerlings obviously necessitates the continuous supply of sufficient fingerlings and of good quality. A broodstock management scheme, possible through the network of hatcheries, is the corner stone of further development of aquaculture. To encourage seed production, a suitable hatchery model is proposed that can be used to construct hatcheries in different parts of the country. Economic analysis indicates that at 75 Fcfa per fingerling, a high profit can be obtained. This high expected profitability is likely to attract private investment. The network of hatcheries will provide a steady supply of fingerlings to fish farmers and a more stable fish production, leading to the availability of more fish to the population.

7 RECOMMENDATIONS

The results of the current study suggest that:

- Construction of hatcheries in at least 17 locations in Cameroon could significantly increase the supply of catfish fingerlings and promote the further growth of aquaculture
- The network of hatcheries should include one central hatchery that focuses on broodstock production and possibly a breeding program to improve the broodstock.
- Government, through extension officers should reinforce the collection on the statistics of fish farms, fingerling and fish production.
- The government should strictly apply the law on the acquisition, transport and collection of fingerlings so as to discourage the act of harvesting seeds from the wild which is a threat to the environment and risk of introducing diseases in farms.
- A system on the certification of seed supply to farmers and frequent visit by competent officials to hatchery should be installed to ensure the quality of seeds produced.

- Training on broodstock management, seed production and certification should be regularly organised to enforce the capacity of officials.
- Further training of fish farmers is important to ensure that the increased supply of fingerlings will result in maximum increase in aquaculture production.

ACKNOWLEDGEMENTS

My sincere thanks to my supervisor, Professor Helgi Thorarensen, for his guidance, opinions and untiring contribution in shaping this project.

I would also like to thank Olafur Sigurgeirsson, the Director and staff of Holar University College and the staff at VERID, Saudarkrokur for the knowledge, care and the hospitality accorded to us.

I would sincerely like to thank Dr. Tumi Tomasson, Director of the UNU-FTP, Mr. Thor Asgeirsson, Deputy Director, Ms. Sigridur Kr. Ingvarsdottir, Office manager and Ms. Mary Frances Davidson, Project manager for giving me the opportunity to attend this wonderful capacity building course and for their care and untiring support during our stay in Iceland.

My gratitude to the director and staff of the Icelandic Marine Research for kindness.

Sincere thanks to the government of Iceland for making our stay a memorable one.

My thanks to the government of Cameroon for giving me permission to attend this wonderful training.

I would like to thank all fellows especially Sunil Bandara those at the Holar University College for their friendship and cooperation.

Last but not least my gratitude goes to my wife for taking care of the children for the last six months.

REFERENCES

Adewumi, A. A., & Olaleye, F. V. (2011). Catfish culture in Nigeria: Progress, prospects and problems. *African Journal of Agricultural Research, 6(6)*, 1281-1285.

Agnèse, J.-F., Otèmè , Z. J., & Gilles, S. (n.d.). Effects of domestication on genetic variability, fertility, survival and growth rate in a tropical siluriform: Heterobranchus longifi lis. *Aquaculture*, 197-204.

Akankali, J. A., Seiyaboh, E. I., & Abowei, J. N. (2011). Fish Hatchery Management in Nigeria. *Advance Journal of Food Science and Technology, 3*(2), 144-154.

Anna, B. R. (2010). *Financial Feasibility Assessments; Building and Using Assessment Models for Financial Feasibility Analysis of Investment Projects.* Reykjavik.

Bondad-Reantaso, M. G. (2007). *Assessment of freshwater fish seed resources for sustainable aquaculture.* FAO Fisheries Technical Paper. No. 501, Rome.

Brain, F., & Army, C. (1980). *Induced fish breeding in South East Asia.* Repot of the workshop, Singapore.

Brummett, R. E. (2007). *Fish seed supply case study: Cameroon. FAO regional workshop Accra, Ghana. 13 p.*

Charo, H., & Oirere , W. (2000). *River-based artificial propagation of the African Catfish, Clarais garipinus: An option for the small fish farmer.* NAGA-The ICLARM.

Dupont-Nivet, M., Vandeputte , M., Haffray, P., & Chevassus , B. (2006). Effect of different mating designs on inbreeding, genetic variance and response to selection when applying individual selection in fish breeding programs. *252*, 161-170.

Dupont-Nivet, M., & Vandeputte, M. (2005). Does avoiding full sibs matings preserves genetic variability in a selection scheme? Case of single pair matings. *Aquaculture, 247*, 12.

Fabozzi, F., & Peterson, P. P. (2003). *Financial management & analysis.* New Jersey: John Wiley & Sons.

FAO. (2008). *Aquaculture development. 3. Genetic resource management. FAO Technical Guidelines for Responsible Fisheries* (Vol. 5). Rome.

FAO. (n.d.). *Inbreeding and Brood Stock Management. Fisheries Technical Paper.* Rome.

Gallardo, J. A., Lhorente, P. J., García, X., & Neira, R. (2004). Effects of nonrandom mating schemes to delay the inbreeding accumulation in cultured populations of coho salmon (Oncorhynchus kisutch). *Canadian Journal of Fisheries and Aquatic Sciences, 61*, 547-553.

Gbore, F. A., Oginni, O., Adewole, A. M., & Aladefan, J. O. (2006). Effect of transportation and Handling Stress on Haematology and plasma Biochemistry in Fingerlings of Clarias gariepinus and Tilapia zili. *World Journal of Agricultural science, 2(2)*, 208-212.

Gjerde, B., & Rye , M. (1998). *Design of breeding programmesin aquaculture species: Possibilities and constraints. In: Bartley D .M. (ed.), Basu rco B. (ed.). Genetics and breeding of Mediterranean aquaculture species.*

Gjerde, B., Gjøen, M. H., & Villanueva, B. (1996). Optimum designs for fish breeding programmes with constrained inbreeding. Mass selection for a normally distributed trait. *Livestock Production Science, 47*, 59-72.

Gjerde, B., Gunnes , K., & Gjedrem, T. (1983). Effect of inbreeding on survival and growth in rainbow trout. *Aquaculture*, 327-382.

GPA. (2007). *Statistiques informatisées sur les importations transitant par le port de Douala. Extraits.* Douala.

IRAD. (2003). *Projet de maintenance de semences de pre-base et de production de semences de base au Cameroun. Document de Projet PPTE, financé.* .

Laurenti, G. (2013). *Fish and fishery products: world apparent consumption statistics based on food balance sheets.* Rome: FAO.

Little, D. C., Satapornvanit, A., & Edwards, P. (2002). Freshwater fish seed quality in Asia. 185-193.

Mahmoud, A. R. (2008). Genetic Improvement of Clarias gariepinus. *Proceedings of a Workshop on the Development of a Genetic Improvement Program for African Catfish Clarias gariepinus* (pp. 96-102). Accra, Ghana: The WorldFish Center.

Marimuthu, K., Haniffa , M. A., & Aminur Rahman , M. (2009). Spawning performance of native threatened spotted snakehead fish, Channa punctatus (Actinopterygii: Channidae: Perciformes), induced with Ovatide. *Acta Ichthyol. Piscat., 39 (1),* 1-5.

Melba, G., & Bondad-Reantaso. (2007). *Assessment of fresh water fish seed resources for sustainable aquaculture.* Rome: FAO.

MINEPIA & FAO. (2009). *Revues sectorielle aquaculture Cameroun.* Yaounde.

Moehl, J., Halwart, M., & Brummett, R. (2005). *Report of the FAO-WorldFish Center workshop on small-scale aquaculture in sub-Saharan Africa: Revisiting the aquaculture target group paradigm. Limbé, Cameroon, 23-26 March 2004. CIFA Occasional Paper. No. 25. Food and Agriculture Organization, Rome. 54 p.* Rome: FAO.

Moretti, A., Fernandez-Criado, M. P., & Vetillart, R. (2005). *Hatchery production of seabass and gilthead seabream.* Rome: FAO.

Nam, S., Tong., E., kent, S. N., & Hortle. (2005). *Use of fresh water value fish for aquaculture development in the Cambodia's Mekong basin. Consultancy report for Mekong river commision.* Consultancy report for Mekong river commision.

Nguenga, D., & Pouomogne, V. (2006). *Etat actuel de la recherche aquacole et halieutique au Cameroun. Atelier de rapprochement Minepia-Minresi pour le développement du secteurhalieutique au Cameroun.* Worldfish Centre.

NIS. (2012). *Nmmiaure Statistique de Cameroun: Recueil des séries d'informations statistiques sur les activités économiques, sociales, politiques et culturelles du pays jusqu'en 2010.*

Olesen, I., Gjedrem, T., Bentsen, H. B., Gjerde, B., & Rye. (2003). Breeding programs for sustainable aquaculture. *Journal of Applied Aquaculture, 13,* 179-204.

Park, C. S. (2002). *Comtemporary engineering economics. 3rd edition.* New Jersey: Prentice-Hal,l Inc.

Pillay, T. V., & Kutty, M. N. (2005). *Aquaculture principles and practices.* Blackwell.

Piper, R. G., McElwain, I. B., Orme, L. E., McCraren, J. P., Fowler, L. G., & Leonard, J. R. (1982). *Fish Hatchery Management.* Washington D. C.

Ponzoni, R., & Nguyen, N. H. (2008). Proceedings of a Workshop on the Development of a Genetic Improvement Program for African catfish Clarias gariepinus. *WorldFish Center Conference Proceedings Number 1889,* (p. 130). Penang, Malaysia.

Pouomogne. (2007). *Review on the use of wild caught Clarias catfi sh as seed in aquaculture: Case of Santchou agro-fishers in Western Cameroon. 28 p. FAO technical report.* FAO.

Pouomogne, V., & Pemsl, D. E. (2008). *Recommendation Domains for Pond Aquaculture Country Case Study: Development and Status of Freshwater Aquaculture in Cameroon WorldFish CenterStudies and Reviews No. 1871. 60 p.* Penang, Malaysia: Worldfish Centre.

Simonsen, V., Hansen, M. M., Sarder, M. I., & Alam, M. S. (2005). Wide spread hybridization among species of Indian major carps in hatcheries but not in the wild. *Journal of fish Biology*, 794-808.

Subasinghe, R., Soto, D., & Jia, J. (2009). *Global aquaculture and its role in sustainable development.* Blackwell Publishing Asia Pty Ltd.

Sunil, N. S. (2007). *Fresh water fish seed and supply.* Rome: FAO.