# EVALUATION OF THE STATUS OF TILAPIA (*Oreochromis niloticus)* FARMING IN THE GAMBIA (CENTRAL RIVER REGION): A CASE STUDY

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## ABSTRACT

Evaluation of the status of *Oreochromis niloticus* farming was conducted in CRR to identify challenges hindering the development of aquaculture in general and tilapia culture. A set of questions were developed and administered through interviews in the region. Fish farmers, support institutions in aquaculture and individuals were interviewed to seek their views on the challenges in fish culture in the region. The results revealed that most farmers in the study area had little or no knowledge of improved cultural practices in fish farming. Farmers collect seeds from wild in stocking the fish ponds with little or no water management practices. The hatchery in the area is small and less functional to meet the seed requirement of the farmers and due to limited knowledge of the staff and inadequate logistics to carry out breeding programmes. The ponds are generally small (100 $m^2$) with high stocking density between 7 – 10 fingerlings/$m^2$ characterised by high mortality rate of 10 – 15%. The regional total harvest yields were less than 2.5 tons/ha/cycle. Thus, the survey suggested urgent government and intervention of development partner' in addressing the above constraints to improve aquaculture development in the region.

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# 1 INTRODUCTION

## 1.1 Background

The Gambia is the smallest country in Africa with 30-50 km in width along the banks of the River Gambia but stretching about 450 km inland. The country is surrounded by Senegal on all sides except for the West Coast on the Atlantic Ocean.

It has a population of 1.8 million people. It is located in the Sahelian Upwelling Marine Ecoregion that makes it one of the richest fishing zones within the Sub region. The coastline is roughly 80 km along the Atlantic Ocean.

The Economic Exclusive Zone (EEZ) is 200 nautical miles from the shore and covers about 500 $km^2$ of Continental shelf area, and a land area of 11,295 $km^2$.

The country consists of three geographic regions i.e. the Lower River, the Central River and the Upper River. The Lower River stretches from the Atlantic Coast to Mansakonko in the East. The river is tidally influenced inland for about 200 km (GBOS 2011). The country experiences tropical dry and wet season, the later begins in late June to early October with an annual rain fall of 990 mm. The remaining months are characterised with dry spell.

The country major exports include peanut (groundnuts), fish, cotton and palm oils (Rice *et al*. 2012).

## 1.2 Status and importance of the fisheries in the Gambia

In general, fish stocks in Central River Region are over fished. This is largely due to the use of destructive fishing methods and fishing gears used by both foreign and local fishermen. The use of fingerlings as baits for larger fish, the use of wrong mesh size, destructive fish trap locally called “Dumbo” has resulted to local fish shortage (Jallow 2014).

The Gambian Government continues to give high priority to the development of the fisheries sector because it is not only a source of revenue and foreign exchange earnings for the country but also a beacon of hope for increasing employment opportunities, particularly for women who are mainly involved in fish processing and marketing. The sector is also contributing in improving nutritional dietary in-take of the citizenry, especially in the process of alleviating poverty and ensuring adequate food security.

It is difficult to measure the sector’s contribution to Gross Domestic Product (GDP). Given the informal and unrecorded activities of women fish lauders from boats, local fish processors and middle men operating in artisanal sector are huge in The Gambia. According to official figures from the Fisheries Department, the sector contributed about 3.4 percent of GDP in 2010.

Fish exports are significant for the economy. In 2007, fish and fish products accounted for about 15 percent of merchandise export earnings (excluding re-exports) (GBOS 2011). The bulk (about 80 percent) of the exports is sent to the EU (fresh and frozen fish). Great importance is attached to its development because of its huge potential to make a significant contribution to national socio-economic development in the country. In particular, the sector is the third largest food production sector, after agriculture and livestock, and plays a significant role from a nutritional standpoint, being the main supplier of animal protein in the diets of most

Gambians. The estimated per caput fish consumption is 25kg along the coast with the average dropping to 9kg as one moves away from the coast. Also, the artisanal subsector provides direct and indirect employment to between 25,000 and 30,000 people (Figure 1**)** while about 2,000 people are presently employed in the industrial sub-sector (Jallow 2014).

**Figure 1: Women transporting and trading fish in Tanji fish landing site in The Gambia.**

## 1.3 Aquaculture in The Gambia

Fresh water aquaculture started in The Gambia in late 1970s and early1980s by the Fisheries Department and its partners such as the Catholic Relief Service (CRS), US Peace Corps and the Bansang Community. They excavated a single earthen pond to culture tilapia. The location of the pond was on high ground thus made the trial failed. Although the trial failed it provided a useful and practical experience to the fisheries staff for their subsequent efforts. It however, also encouraged private rice growers to establish isolated fish ponds in their rice plots.

Shrimp farming was introduced in The Gambia in 1986 by Scan Gambia Shrimp Ltd. in Pirang. The farm began operations in 1988 with the importation of giant tiger prawn brood stock from Asia. The company ceased operations in 1991 and in 2000 their assets, including ponds, hatchery and processing plant, were acquired by a group of local Gambian investors who later sold the farm to West African Aquaculture Ltd (WAA) (MoF 2011).

In 1995, a one-hectare poly-culture trial pond was established in the Central River Region (CRR) by the DoF for the culture of three indigenous fish species (African Catfish, *Heterotis* and Tilapia). The trial did not only prove the cultivability of these species in the country but raised national awareness of the need to diversify fish production through aquaculture.

Government through the Department of Fisheries solicited funding assistance from the Taiwan Technical Mission (TTM) and Food and Agriculture Organization of the United Nations (FAO) to expand on the gains of the trial, resulting in the establishment of more fish ponds in CRR and other parts of the country (Jallow 2014). Problems with these initial projects included inadequate technical expertise and the inability to coop space from rice farmers. Drawing on the experiences, the government observed the need to diversify the approaches for the development, promotion and adoption of aquaculture in the country.

### *1.3.1 Number of farms*

Given the nutritional and economic potentials of the aquaculture sector, the development of subsistence, small-scale and commercial aquaculture is highlighted in The Gambia Aquaculture Strategy 2008. The 2008 aquaculture strategy implementation pave the way for the private sector participation.

The Gambia is blessed with natural resources such as lands, rivers, streams, reservoirs and lakes but in spite of these great potentials, the country is still unable to bridge the gap in the short fall between total domestic fish production and population growth. This makes the need for sustainable management of aquatic farms to be high on the national agenda for the government of The Gambia.

Most fish farms in The Gambia currently are small-scale, distributed within West Coast Region (WCR), CRR south, and North Bank Region (NBR). Aquaculture is gradually and steadily growing from infancy status of few trial ponds in 1979 to about 98 small-scale fish ponds in 2016. In The Gambia, aquaculture farms are owned by the Government, communities, private individuals and schools.

Out of this 98 small scale fish ponds mentioned above, 60 of them are located in (CRR). Brikamaba Fish Farmer Association owns 53 ponds out of 60. The remaining 7 ponds are owned by individual farmers in the area.

Among the aquaculture establishments in the country, there are two (2) fish farms established for recreational purposes (ornamental fisheries and sport fishing). The only farm in The Gambia operating aquaculture on a large scale is the shrimp farm, Gambia Shrimp Aquaculture Project (GASAP), which together with its ponds in Pirang, hatchery in Sanyang and other associated facilities, was acquired by the Government (Jallow 2014).

### *1.3.2 Aquaculture practices*

Aquaculture activities in the country are carried out in different water bodies. Fresh water aquaculture is carried out in fish ponds in various communities, schools and private farms in Western Region (WR), Central River Region (CRR) and North Bank Region (NBR). Brackish water aquaculture is operated by very few farmers, in fish ponds located in coastal areas that are tidally influenced. Additionally, to shrimps, fish species like mullet *Mugil cephalus* and brackish water tilapia (Guinness's) are cultured. Marine or sea farming has not been explored in the country (Jallow 2014).

The culture methods used are mostly extensive and entirely oriented towards production for domestic consumption. 95% of these ponds are earthen ponds. The fish ponds are generally less than 20 x 15 m in size with a stocking density of 10 fingerlings in every 1-meter square (Rice et al, 2012). The main source of pond water is tidal. Fish seeds are mainly collected from the river, irrigation canals or in swamps. Stocking of wild fish of varying ages and sexes in the ponds with complete or partial harvesting in small quantities. The ponds are stocked with different fish species such as African catfish, Heterotis, mullet and Tilapia (Figure 2) Tilapia is the most common cultured species in the country.

Fish farmers mainly rely on the natural productivity of the ponds. This is supported by applying animal droppings such as chicken manure, cow dung etc. in the ponds to enhance plankton growth. Locally available organic waste such as rice bran, groundnut cake, animal bone, oyster shells and chicken waste are mixed and prepared as feed for the fish.

**Figure 2: Some of the species cultured in the Gambia**

## 1.4 Central River Region

The Central River stretches from the East of Mansakonko to Marcathy (Figure 3) is generally fresh water but also tidally influenced. The tidal amplitude is less than the lower estuarine portion of the river towards the West. The climate, the rainfall pattern and seasons are the same with the other regions in the country.


**Figure 3: Location and outline of The Gambia. Red circle describes the CRR where this survey is carried out.**

## 1.5 Aims of the government and development projects

Fisheries and aquaculture sector is consistently listed as a pillar of development and the government of The Gambia (GOTG) has over time, expanded the sector`s scope and ambition from mere utilization of the country`s marine resources to a strategic approach to poverty reduction, youth employment, gender equality, nutritional standards, foreign exchange earner and Gambian participation in the sector (MoF 2011).

## 1.6 Organisations promotion

In their effort to contribute to the protection and preservation of the environment and improve lives and livelihood of people, West African Birds Study Association (WABSA), a non-profit making conservation project also constructed 2 earthen ponds for the community of Baringoto in Niumi in 2015. The Livestock and Horticulture Development Project (LHDP), under the Ministry of Agriculture has the ultimate objective of assisting rural fish famers in the country to improve and diversify production, nutrition and income sources through integration of poultry production practices into their fish farming systems. Five fish ponds situated in Ndemban Japichum, Medina Kanuma, Njawara Agriculture Research Institute and Barra are currently being integrated with poultry which is sponsored by the project. In this technique chicken are raised over the ponds and the poultry excreta used to fertilize the fishponds. This technology, according to the farmers, enhances phytoplankton growth in ponds.

Brikamaba Fish Farmers Association’s farm is funded by FAO and located at Madina Ufanlly. The beneficiaries of this FAO TCP are Brikamaba and the surrounding villages. The first phase of the project constructed 22 ponds consisting of 20 at 100m$^2$ and 2 holding ponds at 750m$^2$ each. The second phase of the project dug 31 earthen ponds (30 sizable ones at 100m$^2$ each and 1 large holding pond at 750m$^2$). These ponds are installed with inlet and outlet pipes. All the fish ponds were stocked with tilapia and catfish (Darboe 2010).

Food and Agriculture Sector Development Project (FASDEP) of the Ministry of Agriculture has the aim to reduce rural household poverty, food insecurity and malnutrition. It´s intention goal is to increase agricultural production, productivity and commercialization. The project constructed 16 earthen ponds in 2015. These ponds are situated in different regions within the country including CRR. They are mainly for communities and schools and are stocked predominantly with tilapia (NEA 2015).

The Taiwan Technical Mission (TTM) is a mission from the Republic of China on Taiwan through bilateral agreement between the two countries. The role of the mission was to help the government of the Gambia in developing Agriculture and Natural Resource Sector of the economy through finance and technical support. As part of the technical assistance was the National Fish Hatchery they established in early 2000 to provide fish seed to farmers until 2013 when the mission left (Jallow 2014).

## 1.7 Problem Statement

Aquaculture in general and tilapia culture in particular, could not yield the desired results for farmers since its revitalization in 2008. The Taiwan Technical Mission in their attempt, to breed the indigenous tilapia species to maximum growth levels (400g-500g), failed.

The Technical Mission ended up producing fingerlings in the hatchery to supply fish farmers. When the Mission left in 2013 the hatchery became less functional due to technical and logistical problems. Since then the fish farmers continued to stock their ponds with fingerlings of different ages and sexes from the wild resulting in poor growth. Seed being the basic input into any aquaculture technologies should be accorded priority in terms of brood stock management, establishment of hatcheries, refinement of induce breeding techniques, rearing and production (Pillay and Kutty, 2005).

Poor quality feed produced locally by farmers themselves seem to have very little effect on the growth performance of the farmed fish since the average weight of the fish at harvest are less than 200g. As highlighted earlier, the farmers use organic waste with little or no consideration for the nutritional requirement of the cultured species.

The protein, lipid, minerals and vitamins are not calculated at the right proportions in the diet before supply to the fish. In addition, the rations and the time of feeding are not calculated. This practice will not only affect growth performance but could seriously affect water quality which in turn affect fish growth. This is because the unutilized feed will decompose in the pond by bacterial action, a process which reduces oxygen level in the pond.

Good pond water management practice contributes significantly to the overall growth performance of the cultured fish. However, this is often ignored by many farmers in the area. This may be due to lack of or limited knowledge on the importance of pond water management and evaluation of water quality.

The common practice is once the ponds are stocked with fish, hardly any water quality management procedures are followed. Regular monitoring of the key parameters such as the dissolve oxygen level, pH, water temperature and turbidity are prerequisite for effective growth.

Small and less functional hatchery left by the Taiwan Technical Mission has compounded the problem of fish seed supply in the region. The only available option for farmers is to collect seed from different water bodies in the area to supply the ponds.

The hatchery in question is small and less functional and lacks the required facilities and equipment such as electricity, and for water quality measures and treatment, for effective fingerling production.

Limited knowledge and skills in fish culture by farmers has equally contributed to poor yield over the years. Many farmers engaged themselves in fish culture with little or no prior knowledge in aquaculture. The notion that fish lives in the water made many farmers to venture in tilapia farming without thorough consultation with relevant authorities in the aquaculture sector.

Technologies have been observed to have significant impact in all aquaculture practices (Pillay and Kutty, 2005). The low level of human capital, lack of research establishment and development of knowledge is a great barrier for adoption of new technologies by farmers in the Gambia.

Lack of proper registration and records to help determine the productivity of the sector, quantity of fish produced, and revenue generated for proper management of the sub sector.

## 1.8 Rationale

This study is important for the fact that it is attempting to identify the key bottlenecks hindering the development of tilapia farming in the region. It is envisaged that the conclusions and recommendations drawn from the study can guide government intervention and its partners in addressing those challenges.

The CRR, where the study is focused on, has the potential to increase aquaculture yield greatly. This is because the region is covered by fresh water throughout the year with high tidal amplitude which allows the river to flow its banks. There is reliable water supply to support fish farming all year around.

Central River Region is also the bread basket of the nation due to large quantities of cereals and legumes the farmers produce including rice, which is the staple food of the nation. The region has access to raw materials such as rice bran, groundnut cake and sesame cake which can easily be obtained in fish feed processing.

It is also a region that is over fished due to illegal fishing activities as highlighted earlier on. Therefore, suggestions proposed at end of this study can increase fish farmers yield and income and thereby improve the nutritional supply of the area.

The study is in line with the Government vision 2020 blue print. The effort laid emphasis on implementing activities to enhancing food production and income security for the nation.

The government vision attached a slogan “Grow what you eat and eat what you grow” and is ready to support any endeavour related to this slogan. The outcome of the study could pave way for the development of tilapia farming in the country. As it will make recommendation of best management practices in tilapia culture.

The revised Fisheries Acts and Fisheries Regulation 2016, all laid emphasis on the development of aquaculture in the country in order to contribute significantly in food and income security of the nation.

Increased aquaculture will generate employment for women and youths and provide the much-needed foreign exchange for the country through trade. Therefore, the outcome of this research could help to enhance the achievement of the mentioned policy objectives by implementing the research recommendations.

## 1.9 Goal and general objectives

The main goal was to identify key constraints in the development of tilapia farming in Central River Region of the Gambia, for government intervention, through

- Analysing the status of tilapia farming in Central River Region
- Identifying key bottlenecks in tilapia farming in CRR
- Suggesting ways to facilitate the growth of tilapia culture in CRR.

### 1.10 Specific Objectives

- To collect and analyse data on production cost factors, income and expenditure of the farms in the region
- Find out the raw material used in feed and the cost involved
- Find out the processing methods used in making feed and discuss alternatives for improvement
- Find out the current situation of the National fish hatchery in SAPU
- Determine the number of fish farmers trained on basic fish culture and find ways to improve their knowledge.

## 2 LITERATURE REVIEW

### 2.1 Tilapia Characteristics and Production

Tilapias are species from Cichlidae family, mainly freshwater fish inhabiting shallow streams, ponds, rivers and lakes and less commonly found living in brackish water. They are suitable for various aquaculture systems, easy to propagate, tolerance to handling and can be fast growing on both natural and manufactured feeds in appropriate culture conditions. The fish can tolerate a wide range of environmental conditions and is highly marketable with good nutrient content. Tilapias are resistant to stress and diseases, have ability to reproduce in captivity and its acceptance of artificial feeds right after yolk-sac absorption makes production of seeds relatively simple. For these reasons the tilapias are ideal species for culture in many developing countries, assisting to improve feed security and producing valuables.

In terms of aquaculture production, the tilapias comprise approximately 10 percent of total global fish farming, second to the carps, which account for more than 50 percent. However, aquaculture of tilapia in Africa constitutes only approximately 19% of the world's tilapia production with the majority produced in Egypt (Ansah *et al*. 2014).

About 5.5 million tons of tilapia is being produced worldwide (Figure 4) China and Indonesia are the largest producers with a combined production of about 3 million tons. Egypt comes 3rd and lead producer in Africa with about 800,000 tons. The rest of the countries in Africa as shown above their production are far below 200,000 tons.

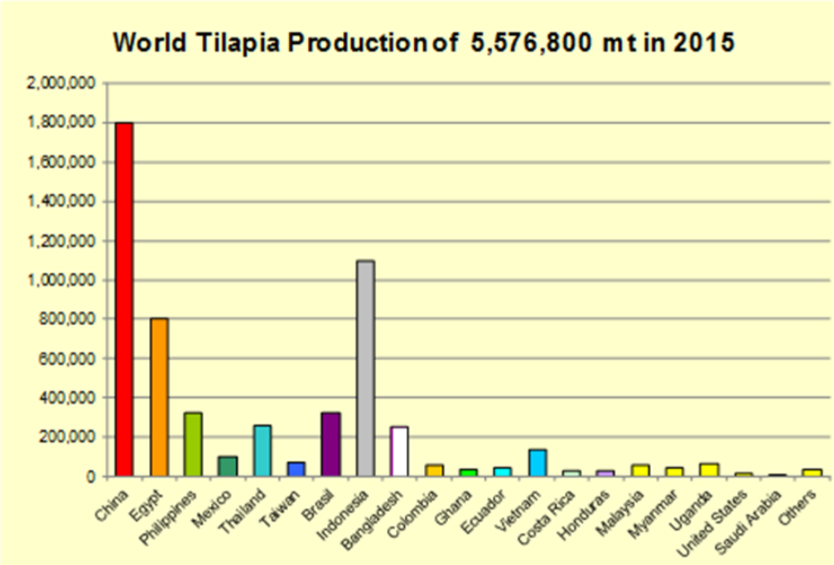


**Figure 4: Tilapia production and the share of leading producing countries (FAO 2015)**

## 2.2 Tilapia production in Sub-Saharan Africa

Tilapia is reported to be one of the most cultured fish spies in tropical to sub-tropical ecosystems of Sub-Saharan Africa. Its farming is providing livelihoods and vital food security to many people in the region. The fish is still largely available from traditional freshwater capture resources such as rivers, dams, lakes etc., much more than it is farmed.

Over 350 000 tons of tilapia (all its strains) were captured annually during the peak production period of 2007 – 2009. However, fishermen from most producing countries are reporting a decline in catches, compared to decades ago, largely due to overfishing fueled by increase in populations and greater demand. In some cases, decline in catches is attributed to climate change dynamics.

In fact, aquaculture production of tilapia has grown tremendously, at an annual average rate of 20 percent over the last decade and is presently the top fastest growing aquaculture sub-sector. In 2012, about 150 000 tons of tilapia were produced through aquaculture in the region. Farming of tilapia is practiced by smallholder producers either in home backyards for subsistence purposes, to small scale commercial ventures, using various production systems. Large, vertically integrated and industrial scale ventures are found mainly in Ghana, Zambia and Zimbabwe. Nile tilapia (O. niloticus) is the preferred species for aquaculture production (Ansah *et al*. 2014)

## 2.3 Aquaculture Challenges and Success in Sub Saharan Africa (SSA)

Depending on the specific aquaculture system to be promoted, low pond productivity, shortages of availability of good feed and seeds, good quality information or appropriate technologies and limited access to capital and markets have constrained the development of the sector. Furthermore, the other largely donor-driven projects have often not been based on values and needs/priorities in the receiving communities, nor have they had the sustained uptake of aquaculture as a key principle in mind. As a result, many fish farming initiatives have been abandoned once projects and their associated supporting finances have ended (Brummett and Williams, 2000)

Success factors that lead to more sustainable aquaculture development include:

- Development and adoption of locally appropriate and viable production systems and technologies.
- Longer-term education, training and technical assistance.
- The presence of a commercial hatchery sector for production of fingerlings.
- Fisheries or/and agriculture industry with products and by-products available in fish feed and the presence of local feed industries.
- Availability of credit and other means of investment in infrastructure and specialized aquaculture equipment.
- The development of niche markets and connection to urban and international markets
- The presence of strong farmer organizations and/or of conglomerates/networks of stakeholders, including farmers‟ organizations, private enterprises, government and research institutes (Delgado *et al*. 2003)

## 2.4 Institutional challenges and promotional policies

Policies can encourage positive linkages. In Zambia for example, strategies that have been applied to agriculture are being extended to tilapia culture. They follow the Indonesian aquaculture approach that encourages small-scale farms to link up with a larger farm. This is to stimulate technology sharing among farmers such as dissemination of techniques and enhance economies of scale for small farmers. Similar benefits can come from clustering of aquaculture farms (Martinez *et al.* 2004).

In addition to this environment often hostile to private investment, a major hurdle facing entrepreneurs wishing to start or expand commercial aquaculture in SSA is the availability and cost of credit. Aquaculture is often a new and unknown industry to potential domestic investors and creditors and with uncertain prospects during the early years. The result is lack of credit and cash flow crunches. Compounding the problem are weak property rights. Not only do uncertain property rights reduce the incentive to invest, they also undermine farmers' ability to use the farm as collateral against loans (Hishamunda and Manning 2002).

## 2.5 Pond Construction

A well designed and constructed fish pond enable farmer to good manage, reduce labour cost and bring greater profit to the farming. To achieve these the fish farmer must make the following fundamental assessment:

- The soil used for constructing the pond should have good water holding capacity.
- The size, shape and the depth of the pond must be measured well to suit the purpose.
- The dykes should be well compacted, and the pond need proper drainage system to enhance water exchange in the pond (Ngugi *et al.* 2007).

## 2.6 Stocking Density in Fish Ponds

Stocking density in an extensive or semi – intensive tilapia pond culture is of high importance for maintain maximum production yield. Optimum density is linked to the primary nutritional production in the pond and added management input to stimulate fish growth, affecting the production period. The effect of high stocking density results in overcrowding, competition for feed and poor water quality and growth (Ngugi *et al*. 2007). For maximum return to be realised under semi intensive culture systems, stocking a rate of 1-2 fish per meter square, where mixed sexes or mono-sex 20- 40g fingerling in size, are recommended. Stocking too few fish may result in fast growth and large fish but an uneconomical use of the pond. However, stocking too many fish will result in slow growth and a large number of very small fish.

In polyculture systems with tilapia and catfish, every 1000 tilapia fingerlings should be stocked with 50 to 100 catfish, but tilapia fingerlings should be 4 times bigger than the catfish to avoid early predation by the later. The catfish would later feed on the young ones produced in the pond by the stock after their first spawning in 3months.

## 2.7 Hatchery Management

Successful production of high quality fingerlings relies on quality brood fish for spawning. It also requires preparation of spawning areas (pond, tanks or hapas) and proper brood fish nutrition. Technical and management input can be highly beneficial in seed production. Collection of eggs or fries from the female's mouth gives much higher seed production yield compared to unmanaged reproduction in the pond. The operator need knowhow and some equipment to run the facility (Ngugi *et al*., 2007).

## 2.8 Fertilization of ponds

Fertilizing ponds in extensive or semi intensive aquaculture is necessary to stimulate planktonic growth, which is the primary feed source for the tilapia. In Thailand, applying chicken manure weekly at 200-250 kg DM (dry matter)/ha and supplementing it with urea and triple super phosphate (TSP) at 28 kg N/ha/week and 7 kg P/ha/week produces a net harvest of 3.4-4.5 tonnes/ha in 150 days, at a stocking rate of 3 fish/m$^2$ or an extrapolated net annual yield of 8-11 tonnes/ha Ahmed *et al*., (2013).

Similar yields are obtained solely with inorganic nutrients if alkalinity is adequate. In Honduras yields of 3.7 tonnes/ha are obtained at a stocking rate of 2 fish/m$^2$ with weekly application of chicken litter at 750 kg DM/ha and urea at 14.1 kg N/ha. There is sufficient natural phosphorus in the water. Fertilization strategies produce fish to a size of 200-250 g in 5 months Ahmed *et al.,* (2013).

## 2.9 Feed and Feeding in Fish Ponds

Tilapia can grow up to 500 g in 8 months if breeding is controlled and food supply is adequate (Ansah *et al.,* 2014). For the most effective use of feeds, feeding management plays a crucial and influential role. Feeding rate is determined by the growth conditions (temperature, oxygen) and the fish size. Smaller fishes grow faster and require relatively more feed pr. weight biomass in comparison to bigger fishes. Small fish also need higher protein level in their diet and higher feeding frequency. For optimal growth of the fish the available and added nutrients in the fish diet need to fulfil its requirement.

### 2.10 Maintaining Water Quality in fish farms

Water quality in a culture pond is important. In particular the oxygen need of the fish must be met but accumulation of excretory components, like $CO_2$ and ammonia must be avoided. To high phytoplankton density will result in high oxygen fluctuations through the day. Similarly, the $CO_2$ will fluctuate, affecting the pH of the water. Renewal of water or mechanical aeration may improve the oxygen concentration making better growth conditions for the fish. Aeration will also strip out some of the $CO_2$ content and may lead to more stable growth conditions for the fish. Aeration is most effective at night and in early morning when oxygen levels in the ponds are at their lowest and the $CO_2$ level at the highest Ahmed *et al*., (2013).

### 2.11 Harvesting Techniques

Complete harvests are necessary in ponds and are accomplished by seining in combination with draining. A complete harvest is not possible by seining alone as tilapia are adept at escaping seine nets. Leaving fishes in the ponds may lead to uncontrolled production and over-crowding of fishes in the production unit. The pond should be sun-dried between production cycles to prohibit accumulation of micro-organisms and eventually treated with pesticides to kill tilapia fry to avoid carryover to the next production cycle. Liming of ponds is common practice to balance the pH and water quality (Ngugi *et al.,* 2007).

### 2.12 Keeping Fish Farm records

In fish farming enterprises, efficient operation and high production can only be achieved if ponds are properly managed. Management activities begin with the preparation of the pond for the fish crop and continue with stocking and feeding the fish, ensuring that water quality remains high throughout the culture period. Regularly measuring the growth of the fish and the development of estimated biomass is important for evaluation of the daily feeding. Registration of the feeding is necessary to estimate the utilization of the feed, indicating its quality and efficiency. Recordkeeping also include registering and taking measures to prevent invasion by predators, the occurrence of diseases, and harvesting the fish. An important ancillary management practice that should never be overlooked is keeping good records of expenses and income and of all activities and events associated with the pond or farm. This information can be used to improve operations in the future. Records are sets of information that have been systematically and carefully collected and appropriately stored for a specific purpose. To be able to run any economic enterprise successfully, carefully thought out and properly collected records are a must. Comprehensive record keeping will assist both in tracking farm activities and expenses. Also, in assessing the level of investment, the motivation of the investor, and the management skills of the farmer. As the management level rises, culture systems become more complex and so does the record-keeping (Ngugi *et al.* 2007). Simultaneously the operation gets proper overview on its yield and profitability.

## 3 METHODOLOGY

Information on the status of aquaculture in the Gambia and the Central River Region in particular, was collected by sending questionnaires to people and institutions involved in aquaculture in the study area CRR (Fish Farmers and Support Institutions). A questionnaire was also developed and administered by identifying some highly knowledgeable and experienced individuals in the field of aquaculture, to seek their views on prospects and challenges facing fish farmers in CRR. The identification of respondents was based on their participation or knowledge and experience in the development of aquaculture in the area.

The respondents include:

1. The Unit head for aquaculture sub-sector at the Department of Fisheries. The Unit is responsible for implementing aquaculture activities in the field.

2. Supervisor of National Fish Hatchery in SAPU, under Fisheries Department, responsible for fingerlings production for fish farmers in the country.

3. Former Assistant Director of fisheries and head of aquaculture sub-sector in fisheries department.

4. A consultant on aquaculture sub-sector review (strategy and action plan 2016-2020) and a lecturer from the University of the Gambia.

5. Personnel from National Environment Agency (NEA) responsible for monitoring and evaluation of Agriculture and Natural Resource sector (ANR) activities in the study area.

6. Food and Agriculture Sustainable Development Project (FASDEP) under Ministry of Agriculture (MoA). The project provide support for aquaculture activities in the region and other part of the country.

7. Brikamaba Fish Farmer Association which has 200 members (150 females and 50 males) managing 53 fish ponds in one location.

8. Last but not the least are the individual fish farmers in the study area.

Four sets of questionnaires were developed and administered in the field by two fisheries department staff identified for this exercise (Appendix 1).

The 3 questionnaires developed for individual fish farmers, Focus Group Discussion (FGDs) with Brikamaba Fish Farmer Association and the National Fish Hatchery were similar in content and structure. They were administered by a data collector through face to face interview with the fish farmers in the study area.

It should be noted that 90% of small scale fish farms in the country are located in this region and 75% of these farms are owned by the fish famers association. Therefore, a Focus Group Discussion, targeting 25 participants from the association members was held. The issues surrounding the management of their farms were discussed.

Hatchery Supervisor and the staff were also interviewed on the management of the Plant.

A set of questionnaires were used to collect information from 5 individual fish farmers. This was administered through random sampling of respondents to avoid biasness.

While that of the support institutions (Fisheries Department and FASDEP) and experts from UTG, NEA and former Assistant Director of fisheries, the questionnaires were based on the prospects and challenges of aquaculture in CRR. In that regard, some questionnaires were distributed by the other data collector to the aforementioned respondents to share their views on the issues surrounding aquaculture development in area.

The information collected from the field was analysed using illustrations such as pictures and tables to interpret the results obtained.

The evaluation of the collected information was approached by reviewing the literature on tilapia farming in the tropics in comparison of the aquaculture in the region. Best management practices were identified in the literatures and lectures offered in United Nation University that could be adopted by fish farmers in the region. Primary challenges were identified and listed up. Conclusion and some recommendations on best management practice are made on key issues which are conclusively important for progress of aquaculture in the area.

# 4 RESULTS

A total of 9 questionnaires out of 12 sent in the field, were received as response on the interviews conducted. The results are described in Tables 1-7 where fish farmers (respondents) gave and account of the fish farming activities on their farms. These activities cover production and productivity, feed and feeding, water management practices, harvesting, marketing and storage, farm records and farmer training.

The results also cover the views of support institutions and individuals that were interviewed on the prospects and challenges facing aquaculture development in the survey area CRR.

## 4.1 Production and Productivity

Nearly all the farmers interviewed are doing extensive or semi intensive aquaculture on tilapia, but in some of the ponds run by Brikamaba farmers Association is a polyculture of tilapia and Clarias catfish. Little or no consideration is made for improved management practices to maximize production output (Table 1). The structures used were mainly earthen ponds with exception to hatchery farm, where nursery tanks (Figure 6) or ponds are concrete even though the nurseries were not producing fingerlings due to lack of knowhow and logistics problems.

The grow out ponds were generally 100 – 200$m^2$ in size but few of the ponds measured 750$m^2$, 800$m^2$ and 2400$m^2$ respectively. The numerous small and static ponds were operated with little or no good management practices such as good water management or supply of right diet rations in a given feeding period. Farmers stocked the ponds using mixed sexes of fingerlings collected from the wild. These might be some of the reasons for low production output in most farms.

The effect of soil erosion is reported in many farms, where the dyke walls were eroded causing sedimentation in ponds bottoms (Figure 5). This might affect water quality as water becomes turbid and resulting in respiratory difficulties by the fish and other living organisms. There was no specific culture technique used in these farms (Table 1).


**Figure 5: The effect of pond erosion (run off) in some of the fish ponds in CRR.**

**Table 1. Aquaculture facilities and systems undertaken by fish farmers in the survey area**

| Respondent | Culture system | Facility | Pond size | Erosion on farm | Culture species | Culture tech. |
|---|---|---|---|---|---|---|
| Ind.farmer 1 | Semi intensive | 2 earthen ponds | 200m$^2$ each | Dyke walls | Tilapia | Mix sexes |
| Ind. Farmer 2 | Extensive | 1 earthen pond | 200m$^2$ each | Dyke walls | Tilapia | Natural stocking |
| Ind. Farmer 3 | Semi intensive | 2 earthen ponds | 200m$^2$ each | None | Tilapia | Mix sexes |
| Association fish farm | Semi intensive & Extensive | 53 earthen ponds | 3 ponds 750m$^2$ each, 50ponds 100m$^2$ each | Some ponds | Tilapia & catfish | Mix sexes |
| Hatchery farm grow out ponds | Semi intensive | 15 ponds (10 concr. nurseries,4 brood fish and 1 grow out) | 10 ponds 25m$^2$ 4@800m$^2$ and 1@2400m$^2$ | None | Tilapia | Mix sexes |

Almost all the farmers stock their ponds with seeds from the wild except one farmer who got seeds from the fish hatchery in SAPU (Table 2). The fingerling weight at stocking ranges from 5g – 20g and the initial stocking density is 6-10 fingerlings /m$^2$. Mortality figure of 12 – 15% has been reported in 2 farms which is quite alarming in small scale fish culture. The average harvesting size of fish is very small (60-150 g) considering the 12 – 16-month culturing period.

**Table 2. Stocking density and productivity of fish farms in the CRR-region**

| Respondent | Fingerling source | Fingerling stocking weight (g) | Stocking density N/m$^2$ | Mortality (%) | Average harvest weight (g) | Culture cycle (mth) |
|---|---|---|---|---|---|---|
| Ind. farmer 1 | River | 10 | 6 | 10 | 100 | 12 |
| Ind. farmer 2 | River | 5 | 8 | 10 | 60 | 12 |
| Ind. farmer 3 | National hatchery | 9 | 7 | 9 | 150 | 16 |
| Association fish farm | River | 5 | 10 in large ponds and 7 in small ponds | 15 | 100 | 12 |
| Hatchery farm grow out ponds | Grow out ponds | 20 | Nursery 7 and Grow out 10 | 12 | 150 | 12 |

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**Figure 6: The side view of non-functional nursery tanks at National Fish Hatchery in SAPU CRR.**

## 4.2 Feed and feeding

Fish farmers supplied large quantities of feed to the pond per feeding period (Table 3). The feeding volume seems to be very rough estimate according to fish size and biomass. The cost of producing a kilogram of feed could not be determined by many farmers as they claimed to purchase raw materials in bulk. No information was given on the type or cost of raw material used as fish feed.

A particular farmer gave 0.5 USD as cost for him in producing 1kg of feed. The price of imported feed could not be determined since most farmers were supplied by the project. The different prices were provided on the cost of transporting feed to the fish farms. A farmer claimed to have transport cost of 2.2 USD/ 50kg bag of imported feed and for the fish farmer association it cost them 1.1 USD/50kg bag of feed to the farm. Others were either supported by the project or carried on bicycles.

The fish hatchery was the only farm that used feed milling machine to prepare pelleted feed. The rest of the fish farmers used local mortar and pestle in mixing and grinding their raw materials into fish feed. Feeding frequency varies from one farm to another, some farmers supply ponds 3times a day (morning, afternoon and evening) others 2 times a day morning and evening.

**Table 3. Feed and feeding process carried out by fish farmers in the region**

| respondent | Qty of feed supply/pond/day | Feeding frequency | Cost of prod. A kg of feed (USD) | Price of imported feed/kg | Transport cost of feed to fish farm (USD) | Processing methods used |
|---|---|---|---|---|---|---|
| Ind. farmer 1 | 5kg | 2 times/day morning and evening | FASDEP supplied | FASDEP project support | Provided by FASDEP | N/A FASDEP support |
| Ind. farmer 2 | 10kg | 2 times/day morning and evening | Annul bulk purchase | Annul | Use bicycle | Mix and grin in mortar using pestle |
| Ind. farmer 3 | 4kg | 3 times morning, afternoon and evening | 0.5 | FASDEP project support | 50kg bag imported feed paid by FASDEP | Mix and grin in mortar using pestle |
| Assoc. Farm | 3kg for small ponds and 15kg for large ponds | 3 times/day morning, afternoon and evening | bulk purchase | Not use | 1.1 | Mix and grind in mortar using pestle |
| Hatchery grow out ponds | 1kg morning and 1kg evening | 2 times/day morning and evening | Annul purchase in bulk | Not use | Feed is produced at the hatchery | Feed milling machine to prepare and pelletize |

### 4.3 Water Management Practices

Very little water management practices were carried out in fish farms at the study area (Table 4). No water quality measures are made but two are attempting to aerate the water mechanically. Although, occasional water exchange was reported at the fish hatchery. Besides, the only farmer that practice water management relied on the tidal influence of the river that supply water in and out of his farm. The rest of the fish ponds are static ponds which requires regular water exchange to enhance growth.

**Table 4. Water management practices carried out by fish farmers in the region.**

| respondent | Water exchange yes/no | Water exchange frequency yes/no | Testing water temperature yes/no | Testing water pH yes/no | Test for dissolve oxygen yes/no | Use aerators yes/no | Type of aerators |
|---|---|---|---|---|---|---|---|
| Ind. farmer 1 | no | no | No | no | no | no | no |
| Ind. farmer 2 | no | no | No | no | no | no | no |
| Ind. farmer 3 | yes | Tidal influence | No | no | no | yes | No |
| Assoc. farm | no | no | No | no | no | no | No |
| Hatchery grow out ponds | yes | depend on circumstance | No | no | no | yes | Mechanical |

## 4.4 Harvesting

The results in Table 5 clearly demonstrate the low level of aquaculture production in the survey region. Harvesting was conducted in all the farms. Although most ponds were partially harvested except the fish hatchery where complete harvest was carried out (Figure 7). Nonetheless, the total quantity harvested in a given production cycle (90 – 750kg) was relatively low when compare to the number of ponds harvested. This low production output might be attributed to the limited knowhow in improved techniques by fish farmers and lack of the required production inputs to maximise production output.

**Table 5. The harvesting of ponds by fish farmers in the region.**

| Respondent | Harvested yes/no | Complete/partial | Quantity harvested kg/pond | Total quantity in kg/cycle operation |
|---|---|---|---|---|
| Ind. farmer 1 | yes | partial | 45 * 2 pond | 90 |
| Ind. farmer 2 | yes | partial | 75 * 2 pond | 150 |
| Ind. farmer 3 | yes | partial | 115 * 1 pond | 115 |
| Assoc. farm | yes | partial | 20 * 50 pond | 1060 |
| Hatchery grow out | yes | complete | 50 * 15 pond | 750 |

**Figure 7: Partial harvesting of fish pond at National Fish Hatchery in SAPU CRR.**

### 4.5 Marketing and storage

The fish farmers visited were all involved in marketing their produce within the communities (Table 6). Few reported to have marketed the produce at the farm gate and the surrounding villages. The distance to the various markets ranges from less than 0.5 to 2.5km.

Different types of transport facilities were used to transport the produce to the market. Others claimed to have paid transport cost at 3.1 – 5 USD/100kg bags in transporting the produce to the village market and the surrounding communities.

Only one farmer reported to have access to cold storage facility in nearby school, where he stores the produce when the produce is not sold. The rest of the fish farmers had no storage facilities. In the event of any leftover, they were processed locally through salting and sun drying and later sold at lower price. Some farmers sell the leftover on credit. The hatchery farm uses the leftover fish to prepare feed for the stock.

**Table 6. Marketing and storage of farm produce in the region.**

| Respondent | Market the produce yes/no | Market place | Distance to market (km) | Market transport cost (USD)/100kg | Storage facility yes/no | Processing method used |
|---|---|---|---|---|---|---|
| Ind. farmer 1 | yes | Village market | within | own transport | no | dried and salted |
| Ind. farmer 2 | yes | in town | 1 | self on bicycle | no | Unsold, gift to neighbours |
| Ind. farmer 3 | yes | in town | 0.5 | School vehicle free of charge | yes | school cold store |
| Assoc. Farm | yes | in village and surrounding communities | 2.5 | 3.1 | no | Unsold, given to members on credit |
| Hatchery grow out | yes | farm gate and village market | 2.5 | 5 (fuel for vehicle) | no | Is dried and used in feed preparation |

## 4.6 Farm Records and Farmer Training

Many fish farmers in the survey area mainly keeping record on sales made per production cycle (Table 7). Hardly anyone keeps record on production related activities such as water quality parameters, growth and feed usage and feed efficiency, cost on farm inputs like seed, feed, hired labour or machinery or estimates on production cost in general.

Some farmers have received basic training on fish culture in number of times, but others have no training or education at all in fish farming.

**Table 7. Record keeping and trainings of fish farmers in the region**

| Respondent | Keep record of farming | Prod. record yes/no | Sales record yes/no | train on fish farming | Training type | Number of times |
|---|---|---|---|---|---|---|
| Ind. farmer 1 | no | No | no | no | N/A | N/A |
| Ind. farmer 2 | yes | No | yes | no | N/A | N/A |
| Ind. farmer 3 | yes | No | yes | yes | basic fish culture | 1 |
| Assoc. farm | no | No | yes | yes | basic fish culture | 2 |
| Hatchery grow out | yes | No | yes | yes | basic fish culture | 3 |

## 4.7 The views of support Institutions and individuals on prospects and challenges in fish farming in CRR.

Support institutions and individuals that were asked to give their views on prospects and challenges for the aquaculture in the area. Similar opinions were reflected in many of the answers and are compiled in the points below.

*The prospects*

- **Access to land (space) and water**: The entire region is blessed with numerous water bodies that can support the culture of fish and tilapia in particular. The communities close to the water can use the river as a water source in their farm instead of using wells, taps and boreholes which might be very expensive for small scale fish farmers.

- **Environment**: The flat landscape coupled with the accessibility to water make region conducive for fish farming. The proximity to water source made it possible for farmer in the region to fetch the fingerling and use them to stock their ponds. The environmental condition of the region supports the cultivation of rice. The rice bran can be used for fish feed preparation. The topography of the land and the clay nature of the soil enable the construction of earthen ponds with high water retention capacity.

- **The cost of producing feed locally/feed cost**: Is cheap because agricultural by-products such as rice bran, coos bran, groundnut and other oil cakes (sesame cake, palm kennel cake) are easily available in the area, particularly after harvest season. Low developmental level of aquaculture and low demand for the ingredients at the moment encourages cross-border trade in these by-products**.**

- **Political stability**: The peace and prosperity in the region and the country at large, enable farmers to go on with their routine activities without any worries.

- **Labour cost**: The cost of labour is often minimal because most fish farms in the region are owned by association. The members themselves mobilize each other to do the labour in the farm, and they hired experts when it comes to highly technical work. The money budgeted for labour can be diverted for other activities in the farm.

- **Interest in fish farming**: The giant drive towards food self-sufficiency and food security encouraged youths and women to practice aquaculture in the Region.

- **Easy official procedure to establish fish farm**: Small scale farmers require very little official procedure to start aquaculture. However, those who want to practice fish farming on a larger scale may sometimes need to follow some official procedure. Like Environment Impact Assessment at NEA, the use of water resource permit (Department of water resource) and pond construction permit (Fisheries Department) etc.

- **Other opportunities** include availability of tidally irrigable flood plains throughout the entire length of the country, availability and abundance of agricultural by-products that could be compounded in fish feed.

- **The location of the region**: CRR is close to both LRR NBR and URR. It also shares border with some communities in Senegal. This makes it possible for farmers to buy raw materials from the other regions or even from neighbouring communities in Senegal.

- **Cage culture:** Cage culture has potentials in the Gambia. There are sheltered areas within the estuary where strong winds are rare. However, there is limitation for the potentials of cage culture in the freshwater zone (CRR and URR). The river flow rate in these regions is so fast cage culture may not be quite ideal. Furthermore, there are voracious predators in the river (Crocodiles, hydrocynus, Hepsetus etc).

- **Availability of markets for the product:** There is high demand for fish in rural Gambia. A large volume of fish production through intensive production system is required in order to saturate the market and to alleviate fish shortage. Government embarks on refrigerated transportation of fishery products from the coast to the inland. Market for fishery products extend far beyond The Gambia. Products from rural Gambia are traded as far as Burkina Faso and Mali. The nationals of these countries living in the urban area constitute significant part of the market for fishery products.

- **Increased production output –decreased production cost:** The proximity to Senegal and other regions in the country is a key factor in minimizing input and maximizing output. Farmers can easily travel to neighbouring communities in Senegal to purchase raw materials for feeding, equipment, fingerlings etc. This can sharply decrease the cost of transportation than if they were to come all the way to the greater Banjul area.

*The challenges*

- **Production of seeds.** Only one defined hatchery is in the region. At the moment it is not operated functionally. Reconstruction and restructuring the operation, with skilled people, can produce considerable number of quality fries and fingerling to fish farmers in the region. This might improve the quality of stock for culture, hence elevates the level of production.

- **Lack of feed mill in the region.** It is important to manufacture nutritious feed of higher quality that fulfil the dietary requirement of fish. The lack of quality feed is a big bottleneck for the tilapia farming in the region. Feeds that do not contain the nutrients in their correct proportion may lead to stunted growth and sometimes death of the fish. Current feed usage seems to be a waste of money and sources. There is presently an access to raw-materials in the region which can be utilised in fish feed. Formulation and processing of feed require some knowledge, but any reform might make huge difference.

- **Other equipment material availability**: The lack of sophisticated operational materials makes it very difficult for farmers to increase their level of production. Equipment like excavators, tractors, aerator etc. are very expensive for farmers whose financial capacity is weak.

- **Lack of storage facilities in the region.** Fish is highly perishable and the lack of storage facilities like cold stores and ice production can lead to spoilage of fish. Product quality control mechanism has not been instituted. No farm fishery product goes through processing for value or quality addition so far.

- **Cost of electricity (power) for large scale production**: There is high unreliability and cost of electricity in the region. Farmers who intended to practice large scale production find it very difficult to use farm equipment and machinery that require electrical power to operate. Fuel is expensive for those who operate on generator. Solar energy (Solar Panels) is less expensive since the energy is harness from sunlight. However, the cost of the equipment and its installation require a considerable amount of money.

- **Limited Technical knowhow**: Most fish farmers in the region are illiterates. They only received few short trainings that are not enough especially for those who want to practice aquaculture on a large scale. Generally, there are not more than ten people who study aquaculture up to master's degree level in the country. Fisheries department has only one trained personnel out of the number mentioned above to manage aquaculture activities, which is not adequate. Furthermore, there are few if any people or companies specialized in pond construction, feed manufacturing or seed production.
  For a more successful culture of tilapia particularly *O. niloticus* requires knowledge in mono-sex culture, through hybridization or hormone treatment to circumvent prolific spawning and stunting. That requires skilled people in brood stock handling and seed production in well functional hatchery. Aquaculture is still at its infancy such that both management and technology are still rudimentary and incomplete.

- **Access to bank loans or other economic assistance** to start business: In Gambia there is no Agricultural Development bank that could grant soft loans to potential investors in Agriculture and aquaculture. Development loans are difficult to access from local commercial banks and even if they are granted interest rates are extremely high (>25%).

- **Conflicts in gaining access to the water resources**: There are no conflicts at the moment. However, Department of Water Resources warns against excessive extraction of water from The River Gambia for irrigation, particularly in the freshwater region of CRR. The department fears acceleration of saline intrusion into the freshwater zone of the river. At one time there was a moratorium on the sinking of bore hole to tap underground water for multiple purposes. This moratorium affected only the coastal regions for the fear of marine saltwater intruding the aquifer. In CRR underground water could be resorted to limit extraction from surface water (river).

- **Economy – high construction and production cost:** Aquaculture is capital intensive at the start, particularly in the areas of construction. This often threatens its development as could not ascertain return on investment with unanalysed risk factors in the back ground. The population, particularly the business community, is inadequately sensitized about aquaculture. Few new that fish are cultivable and can make rapid return on investment. Government pays only lip service to aquaculture development in budget speeches but after the speech feels reluctant to provide logistic support to aquaculture development. Aquaculture development accounts are often empty or funds inaccessible. Logistics such as vehicles, fuel and other equipment become not even secondary but tertiary.

- **Dropping price of the product:** The price of fish drops based on seasons. The fish coming from neighbouring Senegal and other regions in the country can affect the price since the law of supply and demand will come into force. The higher the supply of fish the lower the price and vice versa. The price of meat can also affect the price of tilapia. If the price of meat drops people would automatically go for meat instead of fish since meat consumption is considered as a source of prestige.

- **Competition – domestic, imported:** There is competition with fish that comes from neighbouring Senegal or other parts of the country. There is high competition with capture fisheries.

- **Pollution**: Is not an issue in the region at the moment. However, the accumulation of residuals from agro-chemicals like pesticides, herbicides could pollute fish farms in the long term.

## 5 DISCUSSION

Aquaculture in The Gambia and Central River Region in particular, is highly characterised with extensive and semi intensive culture systems. All the farms visited are engaging in this fish farming practices with little or no attention paid on best management practices to maximise production output. As can be seen from the results the operations are in general facing several major problems and the aquaculture is not delivering much to the community. The main challenge is to improve the knowledge in tilapia culture in general.

## 5.1 Pond construction

Some of the ponds constructed by the FASDEP project were poorly designed. The dyke walls are steep but not gently slope towards the pond bottom which in the long run may collapse either as a result of seepage or run off by rain. This situation if not checked on time, could lead to gradual sedimentation of the pond bottom and turbidity due to siltation by run off. This affect pond water quality by reducing sun light penetration through the water for photosynthesis to take place to release oxygen in the pond. Thus, reduction in dissolve oxygen level for the fish stock resulting to respiratory related symptoms in fish causing limited fish growth and high mortality at the end.

The other problem observed in most fish ponds constructed by the FASDEP project in the study area was there orientation i.e. where located in North- South direction. When in actual fact should be located in East-West direction to enhance the movement of the wind or air in the pond to supply dissolve oxygen for the fish.

## 5.2 Pond management

In general, the fish ponds are relatively small with an average size less than 100 $m^2$ and high stocking density of 7 to 10 fingerlings per meter square at an average fish weight of 10g. This condition in fish ponds according to Ngugi *et al*. (2007) can results to overcrowding, competition for feed and poor growth. Ngugi *et al*. (2007) reported that for maximum return to be realised in standard earthen fish ponds under semi intensive culture systems, where mono sex all male is to be used, 20-40g fingerling size are recommended for stocking at a rate of 1-2 fish per meter square.

In the case of mix sexes, the researchers maintained the same size and rate would be stocked as described above. This time with catfish in polyculture in which every 1000 tilapia fingerlings should be stocked with 50 to 100 catfish but tilapia fingerlings should be 4 times bigger than the catfish to avoid early predation by the later. The cat fish would later feed on the young ones produced in the pond by the stock after their first spawning in 3 months. In this way it was possible to maintain maximum growth rate and improve farmer's income.

As reported by farmers during the survey, fingerlings were collected from the river, swamps and flood plains with mix sizes and ages. These were stocked in ponds with little or no regards to right stocking densities. The practice of collecting fish seed from different water bodies of slightly temperature differences couple with mix sizes and ages for stocking can cause high mortality due to difference in temperature requirement and stress at catching and transport. The practice could also result to disease outbreak in ponds due to overcrowded condition. Already a mortality above 5-10% in average have been recorded in most fish farms visited, which according to them were observed immediately after stocking the ponds.

The techniques such as hand sexing to separate females from males for mono culture are not practiced but is an easy procedure. This traditional method of stocking ponds with mix sexes and ages has far reaching negative implication on the ultimate output of a fish farm as tilapia reaches sexual maturity in 2 to 3 months to produce the young ones. This may lead to overcrowding of the pond, thus competition for food, space and dissolve oxygen becomes apparent resulting to stunted growth.

Transportation of seeds and temperature fluctuation will cause stress which has negative effect on tilapia. Ngugi *et al.* (2007) advised that the plastic containers or tanks used to transport fingerlings to the pond, should remain floating on the pond water for long time, to merge the temperature, before releasing the fish. This practice highlighted above, is contrary to what fish farmers do in stocking their fish ponds. There seeds are collected using the local nets and are released in ponds with little or no regards to the recommended practices. The mortality reported during the survey could partly be attributed to improper handling and stress.

## 5.3 Pond productivity

According to Pillay (1993) the extensive aquaculture is characterised by the low inputs supply by the farmers in culturing fish. Farmers rely heavily on the natural productivity, that is the algae and zooplankton that grows in the pond, to provide food for the fish. The stocking rates are typically low and supplemental feed may or might not be supplied to the fish. The indicated yield is usually less than 0.5 Mt/ha/year.

In semi-intensive aquaculture the ponds are fertilized by manure and/or inorganic fertilisers. Fish may be fed with some external feed of varying quality. The cycle of production can evolve around 6-9 months and the yield varies from 1 to 5 Mt/ha/year in good water temperature and water quality.

The above practices on extensive and semi-intensive aquaculture are to some extent different from what is found in the study area, CRR. In extensive aquaculture for instance, the stocking density is as high as 7 to 10 fingerlings per meter square with occasional supply of locally made feed to the ponds. The ponds are small family holdings and are generally less than $100m^2$ with no water management practice. The ponds are partially harvested with traditional fishing gears and the yields are basically for home consumption. The idea of this system of aquaculture is to provide fish for household use with little or no surplus for the market. As can be shown from the results, the production output is very small.

In the semi-intensive culture systems in CRR the cycle in many farms are 12 months and beyond and the production cycle turnover is less than 1 ton per hectare.

The situation described above clearly demonstrated the low level of understanding of fish farmers in the region on basic culture techniques in aquaculture. As reported by Ahmed *et al*., (2013) that in Thailand, applying chicken manure weekly at 200-250 kg DM (dry matter)/ha and supplementing it with urea and triple super phosphate (TSP) at 28 kg N/ha/week and 7 kg P/ha/week produces a net harvest 3.4-4.5 tonnes/ha in 150 days at a stocking rate of 3 fish/$m^2$ or an extrapolated net annual yield of 8-11 tonnes/ha.

Considering the initial stocking density in most fish ponds in the region roughly 7 – 10 fingerlings/$m^2$. In $200m^2$ pond one would have expected the average yield to be at least above 90kg in 12- 16 months' culture cycle. This low production output could be partly attributed to complete lack of security in fish farms resulting to theft during odd hours.

## 5.4 Feed and feeding

Many fish farmers in the region are largely dependent on locally made feed for feeding the fish. The farmers mix rice bran, fish meal, ground nut cake, wheat flour, vegetable oil, salt and water in uncalculated proportions to compost feed. The feed is prepared by mixing the ingredients inside a mortar and grind using the pestle. The grinded materials are mixed with water in a basin and later sun dried none pellet for a day or two before supply to the ponds. The quantity per feeding period varies from one fish farm to another. In general, the quantity supplied at a given time was quite high considering the size and the depth of the fish ponds and the biomass. Since most fish ponds are in average are less than 100m$^2$ in size with a depth of roughly 1m. If the information from the questionaries' are right, one can easily see the fundamental problem. If, for instance, the given fish density or 6-10 per m$^2$ is right and one calculate average weight of fish 50 g, the biomass of 100m$^2$ pond would be 30-50 kg. Supplying 5 to 10 kg of feed on average per feeding period is then considered to be very high and most probably a waste of sources. This practice could also lead to reduction in dissolve oxygen in the ponds because the unutilized feed will decompose a process that require the use of oxygen by the decaying organisms in the pond.

Ansah *et al*. (2014) stated that tilapia can grow up to 500g in 8months if breeding is controlled and food supply is adequate in terms of nutrient content and volume. This growth can be achieved through application of improved management techniques, water quality control, feeding quality feed and use of faster growing tilapia breed.

### 5.5 Cost of feed

The survey report could not determine the cost of the raw materials used to compose feed, as farmers claimed to buy in bulk. The farmers however, gave a rough estimate cost of producing 1kg of feed at D20.00 which is equivalent to 50 cents in United States Currency. If this is the case, it is obvious that feeding cost of D100 /day is not paying back in increased fish biomass. The production time is far too long and the yield in each production cycle/ pond is much too small. The price and the volume of the product will never pay back the estimated total feed cost.

The fish farmers also acknowledged the support made by FASDEP Project in fish farming in the region. Some of the materials provided by the project were wheel barrow, harvesting nets, scoopers and imported feeds. The provision of the materials highlighted above they said has significantly reduce the expenditure they would have incurred on fish farming.

Some of the constraints highlighted during the survey were difficulty in accessing the raw materials such as rice bran and ground nut cake in making fish feed. They said large quantity of raw materials for fish feed are sold outside the country in cross border trade, thus make it difficult to compose feed at certain time of the year. The other constraint mentioned was the poor road network to the fish farms. This hinder the transportation of feed and other materials to the farm.

### 5.6 Water quality and management

The fish farmers in the region hardly conduct any form of water management in their fish farms. According to them once ponds are stocked with fish it is occasionally supplied with locally made feed. The farmer also made mention of supplying household waste (food remnant) to the ponds. There are hardly any water quality kits such as oxygen meter, pH meter, thermometer etc. in the area, to measure and follow important water quality parameters. As already indicated, most fish ponds are static ponds. Unless regular water exchange take place along with check on temperature, pH and turbidity levels the quality of water to support maximum production and growth could easily be compromised. To maintain water quality in semi-intensive earthen ponds, the farm would need aerators. Especially if the ponds are static. Manual or mechanical devices to enhance oxygen supply in water can be used at night and in early morning when oxygen levels are at their lowest.

Fish mortality has also been reported in almost all the farms visited. This could be partly attributed to the manner in which harvesting is conducted in the ponds. The ponds are relatively small in size and little or no water quality measures are carried out. So, harvesting with local nets will erode the bottom surface of the pond causing mineral turbidity which causes respiratory difficult in fish resulting to death. A good overview on water quality and its fluctuation, with correct response and management, can decrease fish mortality.

## 5.7 Harvesting and sales

**A**s mentioned earlier, fish farming in the region is still at its infancy. The culture systems are either extensive or semi intensive with little or no input to maximize production output. Therefore, the produce from the farms as gathered during the survey on average was 433kg per production cycle. Thus, the produce is sold on farm gates, village markets, and through middle men to the surrounding communities.

Fish farmers in the study area hardly conduct complete harvesting of their farms. They usually embark on partial harvesting using locally made nets. Although farmers have different length of production cycle, but the average cycle was reported to be the 9$^{th}$ month of the calendar year. Small holder family fish ponds were reported to have occasionally harvest their ponds to meet the nutritional needs of the household. In some instances, harvest to sell in order to solve domestic problems at home. The fact that the seeds used for stocking are not uniform in sizes, the marketability of its produce becomes difficult. Most consumers prefer fish with uniform size, large and of good quality rather than the small fish. Thus, resulting to reduction in farmer`s sales.

Partial harvesting of ponds was the practice of most farmers in the study area. This might be due to farmer’s limited knowledge on the benefits of complete harvesting and draining of ponds. The fish ponds in the region were never completely drain by farmers an act which is considered important in fish culture. To allow pond bottom expose to sunlight and liming to kill all the small fries and pathogens in the soil before the next production cycle.

Although some farmers expressed difficulty in selling their produce at certain time of the year when capture fish or wild harvest is abundant in the market. In such situation they said the produce is either given out on credit or dried and sold later. There are no storage facilities for aquaculture fish farmers in the region. The farmers disclosed that if the produce is not sold is either given out on credit bases or is dry and later sold within the village.

## 5.8 Record keeping

Record keeping was found to be a serious weakness in all the farmers visited in the region. Records were barely kept on the quantity sold in a given production cycle. Those records were mainly provided in 2016 production cycle.

The rest of the fish farms visited were engaged in sporadic harvesting with little or no records kept on the quantity harvested and income obtained. However, record keeping in any aquaculture operation is essential as mentioned in Ngugi (2007) report that to run any economic enterprise successfully. Carefully thought out and properly collected records are a must. Comprehensive record keeping will assist both in tracking farm activities and expenses and in assessing the level of investment, the motivation of the investor, and the management skills of the farmer. As the management level rises, culture systems become more complex and so does the record-keeping. This is the reason the farmer must think very carefully about which records need to be kept the report highlighted

### 5.9 Know-how

Capacity building remains a major challenge in aquaculture sub sector in the country. All the issues related to seed production, feed production, farm management, or simply said, aquaculture in general, relies on knowhow and education of people involved. Knowhow is probably the main bottleneck in the development of aquaculture in The Gambia.

There is only one fisheries staff that had MSc degree in aquaculture in the whole department so far. This has created a serious capacity gap which has reflected on the low number of fish farmers that receive awareness training on basic aquaculture techniques as revealed in the survey. In the whole region only 150 participants- 100 females and 50 males all from the same Association, attended sensitisation training on fish culture and its importance for livelihoods. These 150 participants mentioned above, were sensitised during FAO/TCP 2year project implementation 2010–2012, which constructed 53 fish ponds for the said association. The rest of the fish farmers in the region, according to findings, acquired little or no training on fish farming. For them they see fish culture as simple collection of seeds from the wild, stocked in ponds and harvest for home consumption and for sale. The information's received in this survey clearly demonstrate how little these activities delivers.

The success of any aquaculture production enterprise must have a well establish fish hatchery to produce the required quantity and quality seeds needed in fish farming. Unfortunately, this is not the case with fish farmers in the study area. The farmers in this region stock their ponds with wild fingerlings. This practice continued because the fish hatchery in question is operating on very limited scale to meet the seed requirement of the farmers. Therefore, it is an urgent need to get the hatchery functional with help of skilled people. A well functional hatchery must have quality brood fish for spawning, preparation of spawning areas (pond, tanks or hapas) and the operator should have the knowhow and equipment to run the facility as well.

In fact, this survey revealed that at national fish hatchery, the 10 nursery ponds which was built to raise seeds were found completely dry with crack walls and broken pipes connecting the tanks. The only functional ponds were the 5 growth out ponds measuring 800m$^2$ each and 10 brood stock ponds of 200m$^2$ each. There was no breeding activity taken place and the ponds were left under natural production with occasional supply of locally made feed. The water quality kits such as dissolve oxygen meter, thermometer, pH meter and other required equipment's like oxygen cone are not functioning in the hatchery since Taiwan Technical Mission left. From 2013 to date, the ponds were never completely harvested. The team at the hatchery occasionally conduct partial harvesting with little or no post-harvest water quality assessment. This practice can seriously affect pond water quality, since the ponds are static and therefore requires regular water exchange and periodic testing of the water parameters.

### 5.10 The prospects and challenges

The views expressed by the support institutions and individuals on prospects and challenges in fish farming at CRR, were to some extend in agreement with the challenges outlined by farmers in the region. However, the farmers held a different view regarding the availability of raw material for making feed. Farmers reported that they encounter serious shortage of raw materials at certain time of the year to compost feed as oppose to what the support institutions and individuals reported.

Support institutions and individuals for them shortages in agriculture bio products occurred due to low aquaculture activity in the region. As a result, the bulk of the raw materials are purchase by Senegalese during cross border trade. It is believed that with the availability of a fish feed processing plant in the region, the bulk of the agricultural bio product purchased by Senegalese can be processed as fish feed in the region.

The other differed opinion was the availability of market for the produce. To farmers marketing of the produce sometimes post a challenge especially when bumper harvest was realised from capture fisheries coupled with the fish supplied from neighbouring Senegal.
In all cases required a special feasibility study to establish the reality in the region.

## 6 CONCLUSION

Despite the available water bodies that support fish culture all year around in The Gambia and Central River Region (CRR), aquaculture continued to remain under developed. Many challenges have been identified by both fish farmers, support institutions, and individuals that hinder the development of fish farming in the region. Improving the general knowledge in aquaculture is the primary task. Therefore, there is urgent need for the government and its development partners for effective involvement in addressing the challenges highlighted during this survey in the country and in Central River Region, in particular.

## 7 RECOMMENDATION

- The government and its development partners to provide capacity building training for all people involved in aquaculture practice, including fisheries staff at degree level (bachelors, master's and PhD) in order to address the knowledge gap in the sector.
- The fisheries staff should provide the farmers with counselling and courses. A lot of fish farmers training manuals (e.g. from FAO) already exists, which can be used to improve culture techniques and essential procedure.
- Increase budgetary allocation for aquaculture development that would account for more farmer education on improved practices in fish farming.
- The government and its development partners to expand the National Fish Hatchery in CRR with skilled personnel and sufficient equipment to enhance seed production for farmers.
- Fisheries Department to introduce selective breeding programme using the native stock to identify, select and multiply the best available genetic material.
- Establish viable fish feed processing Plant in CRR and other regions in the country to in order to address feed shortage.

- Build some cold storage facilities for both aquaculture and capture fisheries produce in the region.
- Provide efficient and reliable source of energy (electricity and solar power) in the region to facilitate aquaculture development.
- Government to encourage and promote local and foreign investment in aquaculture, through reduction in import duties levy on aquaculture equipment and other inputs necessary in its operations.
- Fisheries Department to help organise fish farmers into consumer cooperative society. This will help farmers to jointly purchase aquaculture inputs at discount prices.
- Fisheries Department and its stakeholder institutions should strengthen and enforce regulation on procedures for establishing a fish farm in the country. This will eliminate the potential damage aquaculture could have on the environment.
- Finally, there should be a focus on improved collection, documentation and dissemination of market information, and investment in public infrastructure, including road networks and fish marketing facilities at local markets. Where possible, there should be reduction in regional and international trade barriers and the harmonization of import/export regulations through strengthening competent authorities' capacity and facilities to fully implement food Sanitary and Phytosanitary (SPS) regulations.

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# APPENDIX

**INDIVIDUAL QUESTIONAIRES FOR CRR**

**TOPIC: Evaluation of the status of tilapia *Oreochromis Niloticus* farming in the Gambia (Central River Region a case study)**

The questionnaire is intended for individual fish farmers to give a detail account of the issues surrounding the management of their farm. This will be in response to the questions raised below.

**Section A Personal information**

1. Name…………………………………………………………

Surname……………………………………………Gender M or F

2. Age
   a. A. 20 to 30
   b. B.30 to 40
   c. C.40 to 50
   d. D. 50 to 60
   e. E.60 an above

**Section B Production**

3. Are you a fish farmer?
4. Yes,
5. No

1. If yes, how long are you in fish farming?

6. which fish species do you culture?
7. Which culture system do you use?
   a. Extensive
   b. Semi intensive
   c. Intensive
   d. Rice and fish
   e. Others
8. Which of the following structures do you use in fish culture?
   a. Earthen ponds
   b. Concrete tanks
   c. Plastic tanks
   d. Cages
   e. Others
9. How many ponds do you have?
10. What is the size of each pond?
11. What is the average weight of the fingerling used for stocking?
12. What is the stocking density of your fish pond?
13. What is the depth of your fish ponds?
14. Which sources of water do you use for fish culture?
    a. Well
    b. Bore hole
    c. River
    d. Stream
    e. Others
15. Where do you get your fingerlings for stocking?
    a. River
    b. Irrigational canals
    c. Swarms
    d. Flood plains
    e. Others

16. Do encounter any mortality in your fish farm?
    a. Yes
    b. No
17. If yes at what stage of production?

a. During stocking of ponds
b. Immediately after stocking the ponds
c. During harvesting
d. Immediately after harvesting
e. During hot weather
f. Others

18. What is the percentage mortality in each pond?
19. How much money is 1kg of fingerlings?
20. Do you receive extension services?
    a. Yes
    b. No
    c. If yes, how often

**Section C Feed and Feed Production**

21. Do you feed your fish?
    a. Yes, or
    b. No?
22. If yes,
    a. locally made
    b. or imported?
23. If locally made, what are the raw materials used?
24. What is the quantity of each raw material used in feed making?
25. What method do you use in making feed?
26. What is the cost of each raw material used in making 1kg of feed?
27. How much it cost to produce 1kg of feed?
28. How much do you pay in transporting your prepared feed to the fish farm?
29. How often do you supply feed to the fish ponds?
30. What is the quantity of feed supply in each feeding period?
31. Do you supply floating or sinking feed to the fish ponds?
32. Do you encounter any problem in providing feed for your stock?
    a. Yes
    b. No
33. If yes, what are the problems?
34. Is there any problem in getting raw material for fish feed?
35. Do you use imported feed in your fish farm?
    a. Yes
    b. No
36. If yes, how much is 1kg of feed cost?
37. What is the transport cost of the imported feed?

**Section D Pond Water Management Practices**

38. Do you practice any water management in your fish farm?
    a. Yes
    b. No
39. If yes, what type of water management?
    a. Occasional water exchange
    b. Testing the water temperature and dissolve oxygen
    c. Testing the pH of the Water
    d. Conducting all of the above
    e. Conducting none of the above
40. Do you use aerators in your fish ponds?
    a. Yes
    b. No
41. If yes, what type of aerator do you use in your ponds?
    a. Mechanical aerators
    b. Electrical aerators
    c. Oxygen pump
    d. All of the above
    e. None of the above
    f. Others

**Section E Culture Techniques used**

42. Which culture technique do you used in your fish farming operations?
    a. Used sex reversal to all male tilapia production
    b. used imported breed
    c. Natural stocking from the wild environment
    d. Fingerlings from national fish hatchery in SAPU

**Section F Harvesting, Marketing and Storage**

43. Have you ever harvest your ponds?
    a. Yes
    b. No
44. If yes, is it complete or partial harvest?
45. How many times in a year?
46. How many kilograms of fish do you harvest in each pond?
47. What is the average size or weight of your fish at harvest?
48. What is the price of a kilogram?
49. Do you sell or market your produce?
    a. Yes
    b. No
50. If yes, where?
    a. In the village
    b. Surrounding villages
    c. Neighbouring countries
    d. Through the middle men
    e. Others
51. How much it cost to transport your fish to the market?
52. What do you do with the fish if not sold?
53. Do you have any storage facility for the fresh harvest?
54. How much money do you make in each harvest season?
55. Do you keep record of your fish farming activities?
    a. Yes
    b. No
56. If yes, what was your total income generated in fish farming last year, year before last and year before that?
57. What was the total cost of production for last year, year before last and year after that?
58. Have you ever received training on fish culture?
    a. Yes
    b. No
59. If yes, how many times?
60. If no, why?
61. Individual and group fish farming which one has greater advantage
    a. If individual give reasons?
    b. If group give reasons?

**QUESTIONNAIRE FOR NATIONAL FISH HATCHERY IN SAPU**

**The survey topic: Evaluation of the status of tilapia *Oreochromis Niloticus* farming in the Gambia. (Central River Region) a case study.**

The questionnaire is intended for the Hatchery supervisor and the support staff to give a detail account of the issues surrounding the management of the hatchery. This will be in response to the questions raised below.

**Section A Hatchery**

1. Is hatchery producing fingerlings?
   a. Yes
   b. No
2. If no, please explain
3. If yes, what is the quantity supplied in kilogram 2016, 2015, 2014?
4. How many nursery ponds do you have in the hatchery?
5. What is the total quantity of fingerlings produced in 2016, 2015, and 2014?
6. What is the average sales size of a fingerling?
7. What is the average size of a fingerling for stocking?
8. What is the measurement of each nursery pond?
9. Do you have growth out ponds in the hatchery?
   a. Yes
   b. No
10. If yes, how many ponds?
11. Do you use hapas in the pond for broodfish and fingerling production?
12. If yes, how many broodfish in a hapa?
13. What is the sex ratio of male to female e.g. (1 male to 3 females or what)?
14. Do you flush the eggs from the female mouth and carry them to the hatchery?
15. If yes, what equipment do you use in the process above?
16. What do you feed the brood fish with?
17. What is the average size of the brood fish
18. What is the measurement of each pond?
19. Which source of water is used in the hatchery?
20. What is the source of power used in the hatchery?

**Section B Production**

21. which fish species are produce in the hatchery?
22. Which of the following structures are use in the hatchery?
   a. Earthen ponds
   b. Concrete tanks
   c. Plastic tanks
   d. Cages
   e. Others
23. What is the average weight of the fingerling used for stocking?
24. What is the stocking density of nursery and growth out ponds?
25. What is the depth of nursery and growth out ponds?
26. Do you encounter any mortality in hatchery ponds?
   f. Yes
   g. No
27. If yes at what stage of production?
   h. During stocking of ponds
   i. Immediately after stocking the ponds
   j. During harvesting
   k. Immediately after harvesting
   l. During hot weather
   m. Others
28. What is the percentage mortality in each pond?
29. How much money is 1kg of fingerlings?

**Section C Feed and Feed Production**

30. Do you feed the stock?
   n. Yes, or
   o. No?

31. If yes,
    - p. locally made
    - q. or imported?
32. If locally made, what are the raw materials used?
33. What is the quantity of each raw material used in feed making?
34. What method do you use in making feed?
62. What is the cost of each raw material used in making 1kg of feed?
63. How much it cost to produce 1kg of feed?
64. How often do you supply feed to the fish ponds?
65. What is the quantity of feed supply in each feeding period?
66. Do you supply floating or sinking feed to the fish ponds?
67. Is there any problem in getting raw material for fish feed?
68. Do you use imported feed in hatchery?
    - a. Yes
    - b. No
69. If yes, how much is 1kg of feed cost?
70. What is the transport cost of the imported feed?

**Section D Pond Water Management Practices**

71. Do you practice any water management in hatchery?
    - a. Yes
    - b. No
72. If yes, what type of water management?
    - a. Occasional water exchange
    - b. Testing the water temperature and dissolve oxygen
    - c. Testing the pH of the Water
    - d. Conducting all of the above
    - e. Conducting none of the above
73. Do you use aerators in your fish ponds?
    - a. Yes
    - b. No
74. If yes, what type of aerator do you use in your ponds?
    - a. Mechanical aerators
    - b. Electrical aerators
    - c. Oxygen pump
    - d. All of the above
    - e. None of the above
    - f. Others

**Section E Culture Techniques used**

75. Which culture technique is use in hatchery operations?
    - a. Used sex reversal to all male tilapia production
    - b. used imported breed
    - c. Natural stocking from the wild environment
    - d. Others

**Section F Harvesting, Marketing and Storage**

76. Have you ever harvest the ponds?
    - a. Yes
    - b. No
77. If yes, is it complete or partial harvest?
78. How many times in a year?
79. How many kilograms of fish do you harvest in each pond?
80. What is the average size or weight of your fish at harvest?
81. What is the price of a kilogram?
82. Do you sell or market your produce?
    - a. Yes
    - b. No

83. If yes, where?
    a. In the village
    b. Surrounding villages
    c. Neighbouring countries
    d. Through the middle men
    e. Others
84. How much it cost to transport your fish to the market?
85. What do you do with the fish if not sold?
86. Do you have any storage facility for the fresh harvest?
87. How much money do you make in each harvest season?
88. Do you keep record of your fish farming activities?
    a. Yes
    b. No
89. If yes, what was your total income generated by the hatchery 2016, 2015, 2014 and 2013?
90. What was the total cost of production for 2016, 2015, 2014 and 2013?
91. Have you ever received training on fish culture?
    a. Yes
    b. No
92. If yes, how many times?
93. If no, why?

**QUESTIONNAIRE FOR FOCUS GROUP DISCUSSION IN CRR**

**TOPIC: Evaluation of the status of tilapia *Oreochromis Niloticus* farming in the Gambia (Central River Region a case study)**

The questionnaire is intended for Fish farmer associations to give a detail account of the issues surrounding the management of their farm. This will be in response to the questions raised below**.**

**Section A Personal information**

94. Name of the fish farm……………………………………………………………………Gender how many Male…………. and Female……………
95. When did the fish farming association established?

**Section B Production**

96. Are you in fish farming now?
97. Yes,
98. No

2. If yes, how long are you in fish farming?

99. which fish species do you culture?
100. Which culture system do you use?
    a. Extensive
    b. Semi intensive
    c. Intensive
    d. Rice and fish
    e. Others
101. Which of the following structures do you use in fish culture?
    a. Earthen ponds
    b. Concrete tanks
    c. Plastic tanks
    d. Cages
    e. Others
102. How many ponds do you have?
103. What is the size of each pond?
104. What is the average weight of the fingerling used for stocking?
105. What is the stocking density of your fish pond?
106. What is the depth of your fish ponds?
107. Which sources of water do you use for fish culture?
    a. Well
    b. Bore hole
    c. River
    d. Stream
    e. Others
108. Where do you get your fingerlings for stocking?
    f. River
    g. Irrigational canals
    h. Swarms
    i. Flood plains
    j. Others
109. Do encounter any mortality in your fish farm?
    a. Yes
    b. No
110. If yes at what stage of production?
    a. During stocking of ponds
    b. Immediately after stocking the ponds
    c. During harvesting
    d. Immediately after harvesting
    e. During hot weather
    f. Others
111. What is the percentage mortality in each pond?
112. How much money is 1kg of fingerlings?

113. Do you receive extension services?
    - d. Yes
    - e. No
    - f. If yes, how often

**Section C Feed and Feed Production**

114. Do you feed your fish?
    - a. Yes, or
    - b. No?
115. If yes,
    - a. locally made
    - b. or imported?
116. If locally made, what are the raw materials used?
117. What is the quantity of each raw material used in feed making?
118. What method do you use in making feed?0.
119. What is the cost of each raw material used in making 1kg of feed?
120. How much it cost to produce 1kg of feed?
121. How much do you pay in transporting your prepared feed to the fish farm?
122. How often do you supply feed to the fish ponds?
123. What is the quantity of feed supply in each feeding period?
124. Do you supply floating or sinking feed to the fish ponds?
125. Do you encounter any problem in providing feed for your stock?
    - a. Yes
    - b. No
126. If yes, what are the problems?
127. Is there any problem in getting raw material for fish feed?
128. Do you use imported feed in your fish farm?
    - a. Yes
    - b. No
129. If yes, how much is 1kg of feed cost?
130. What is the transport cost of the imported feed?

**Section D Pond Water Management Practices**

131. Do you practice any water management in your fish farm?
    - a. Yes
    - b. No
132. If yes, what type of water management?
    - a. Occasional water exchange
    - b. Testing the water temperature and dissolve oxygen
    - c. Testing the pH of the Water
    - d. Conducting all of the above
    - e. Conducting none of the above
133. Do you use aerators in your fish ponds?
    - a. Yes
    - b. No
134. If yes, what type of aerator do you use in your ponds?
    - a. Mechanical aerators
    - b. Electrical aerators
    - c. Oxygen pump
    - d. All of the above
    - e. None of the above
    - f. Others

**Section E Culture Techniques used**

135. Which culture technique do you used in your fish farming operations?
    - a. Used sex reversal to all male tilapia production
    - b. used imported breed
    - c. Natural stocking from the wild environment
    - d. Fingerlings from national fish hatchery in SAPU

**Section F Harvesting, Marketing and Storage**

136. Have you ever harvest your ponds?
    a. Yes
    b. No
137. If yes, is it complete or partial harvest?
138. How many times in a year?
139. How many kilograms of fish do you harvest in each pond?
140. What is the average size or weight of your fish at harvest?
    a. Do you sell or market your produce?
    b. Yes
    c. No
141. If yes, where?
    a. In the village
    b. Surrounding villages
    c. Neighbouring countries
    d. Through the middle men
    e. Others
142. What is the price of a kilogram?
143. How much it cost to transport your fish to the market?
144. What do you do with the fish if not sold?
145. Do you have any storage facility for the fresh harvest?
146. How much money do you make in each harvest season?

147. Do you keep record of your fish farming activities?
    a. Yes
    b. No
148. If yes, what was your total income generated in fish farming last year, year before last and year before that?
149. What was the total cost of production for last year, year before last and year after that?
150. Have you ever received training on fish culture?
    a. Yes
    b. No
151. If yes, how many times?
152. If no, why?
153. Individual and group fish farming which one has greater advantage
    c. If individual give reasons?
    d. If group give reasons?

**QUESTIONNAIRE FOR SUPPORT INSTITUSIONS IN AQUACULTURE DEVELOPMENT AND INDIVIDUALS**

**The survey topic: Critical evaluation of the status of tilapia *Oreochromis Niluticus* farming in the Gambia. (Central River Region) a case study.**

Name……………………………….Surname………………………………….Gender M/F

**Prospects**

1. Are there any prospects in developing fish farming in CRR and tilapia culture in particular?
2. Would you consider the following as prospects in fish farming at CRR?
   - Environment`
   - Political stability
   - Labour cost
   - Interest in fish farming
   - Access to land (space) and water
   - Easy official procedure to establish fish farm
   - Others please explain
3. If yes, please given reasons for each outlined above. If no, why?
4. Would you consider the following as prospects in fish farming at CRR and tilapia culture in particular?
   - Cage culture
   - Availability of markets for the product.
   - Education of fish farmers.
   - Increased production output –decreased production cost.
   - Improved management and technology.
   - Improved quality of the product
   - Others, please explain
5. If yes, please give reasons for each mentioned above (how!). If no, why?
6. What are the possible threats in development of fish farming in the region and tilapia culture in particular?

**Challenges**

7. What are the challenges in fish farming at CRR and tilapia culture in particular?
8. Would you consider the following as challenges in development of fish farming in CRR and tilapia culture in particular?
   - Feed material availability
   - Other equipment material availability
   - The stock of fish used for culture
   - The cost of producing feed locally/feed cost
   - Fingerling production and cost in terms of quantity and quality
   - Provision of floating /extruded feed, - its cost,
   - Cost of electricity (power) for large scale production
   - Weak local economy
   - access to bank loans or other economical assistance to start business.
   - Know how?
   - Are there conflicts in gaining access to the water resources?
   - 
   - Others please explain
9. If yes, please give reasons for each mentioned above. If no, why?

10. Would you consider the following as challenges to fish farming in the region and tilapia culture in particular?
    - Economy – high construction and production cost.
    - Dropping price of the product.
    - Competition – domestic, imported.
    - Pollution –environmental issues /conflicts
    - Introducing a new fish species in the region
    - Diseases
    - Cage culture
    - Licences and regulations from the authorities
    - Others please explain
11. If yes, please give reason for each mentioned above. If no, why?