

Final Report
FAO/TCP-ZAMBIA/2303(D)

**Technical Assistance for the
Culture of Mouth-brooding Tilapias (*Oreochromis
spp.*) in Zambia**

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1. EXECUTIVE SUMMARY

*This report outlines the activities accomplished by the TCDC Fish Hatchery and Feeds Specialist, and advices provided to the various stakeholders of Zambian aquaculture with a special focus on enhancing the culture of mouth-brooding tilapias (*Oreochromis andersonii* and *O. niloticus*). The main goal of the program is to achieve food security. The immediate objective is to produce more fish locally and fulfil its demand.*

During the assignment period of four week, problems of fish farming in local context were discussed meeting with several farmers individually and in groups. Several personnel of DoF offices, feed producers and other relevant experts were also consulted. Lack of high quality fry / fingerlings, appropriate farming technologies, suitable feeds and feed management techniques, and skilled human resource have been identified as major problems.

*Various attempts have been made towards solving these problems. About nine existing (or potential) hatchery operators have been provided with technical advice to improve their existing production systems and methods of all-male *O. andersonii* or *O. niloticus* fry / fingerling. It was described that by applying the same technique, hormonal sex-reversal, a hatchery can annually produce over 50 million high quality fry i.e. higher than 99% male. It has been very successful in Thailand and is expanding gradually to many other countries including Zambia. Almost all the existing hatcheries visited are keen and have potential to improve their systems and practices, and supply high quality fry to the farmers. It has been suggested that at least three such large hatcheries need to be established in order to fulfil the need for high quality fry / fingerlings in the country, either by upgrading the existing ones or establishing new. As farmers want larger fingerlings, 2-month nursing of fry has been suggested using hapas. Firstly, it can be done by hatcheries themselves and sell at higher prices. Secondly, a lead farmer can serve as middle-man who buys fry from a hatchery and nurse them before selling to his/her farmers in his/her cluster. Thirdly, farmers purchase fry from the hatcheries and nurse them individually for two months in a small hapa(s) installed in the same pond.*

At the same time, several grow-out farmers and their groups have been advised to make the water greener by using chemical fertilizers (urea and mono/di-ammonium phosphate) weekly in addition to the chicken manure. In order to avoid feed losses when fed sinking feeds, use of feeding tray has been advised. With a view to reducing feed cost, farmers have also been suggested making home-made feeds by themselves mixing locally available ingredients such as maize meal, soybean oil cake and others. All the DoF officers met have been advised to keep these in their mind while providing technical supports to the farmers. Considering the need of attracting more investors into aquaculture sector, economic models for varying scales of operation have been developed which should serve as tools for a national campaign of aquaculture promotion. Formation of fish farming groups/clusters or cooperatives, especially involving women would be the right strategy of reaching the grass-root level. It was also made clear to all the stakeholders that achieving the common goal is possible only when they work together as parts of the development process.

2. BACKGROUND

This report outlines the activities accomplished by the TCDC Fish Hatchery and Feeds Specialist/ FAO Consultant [TCP-ZAMBIA/2303(D)] who was accompanied by the National Aquaculture Technician from the Department of Fisheries (DoF), Zambia. The report also presents major findings including the problems identified and opportunities, areas of technical supports needed and possibilities or scope of improvement in the current practices aiming at increasing the production and supply of fry / fingerlings and improving their quality, and also enhancing the productivity of grow-out farms, with special emphasis on mouth-brooding tilapias (*Oreochromis andersonii* and *O. niloticus*). The report has been prepared being based on the field activities accomplished during the 4-week assignment that began from January 24 and ended by February 4, 2011. Field visits included Copperbelt, Mkushi, Southern Province, and surroundings of Lusaka.

3. DETAILED ACTIVITIES

The following field activities, arranged chronologically, were accomplished as a part of the technical assistance program:

3.1. Week 1

January 24:

- Arrived as planned, met with Aquaculture Technician (**Mr Shimbetu Mweemba**) and
- While driven to Lusaka, status, issues and problems of aquaculture were discussed
- Arrived at FAO office, Lusaka, met with **Jere Dorothy** and discussed about the logistics, assignment and other related activities

January 25:

- Morning: Visited Department of Fisheries (DoF) and met with Deputy Director and other personnel (**Joseph Mutale**, Senior Aquaculturist and ANAF National Coordinator) and explained the objectives and possible contribution to the National Strategy for the Aquaculture Sector and Planning. Discussed about possibility of human resource development (MSc and PhD), short term training and study visits for the DoF staff in Thailand
- met with **Martin Chilala** (Deputy Director and National Aquaculture Project Coordinator) at FAO office
- Met with FAO Representative **Dr Nouredin Mona** and discussed about the assignment

- In the afternoon, left for Copperbelt and arrived at National Aquaculture Research Center (NARDC), Mwekera, Copperbelt Province

January 26:

- Visited **Rivendell Enterprise** / Hatchery Farm (Owner: **Mr Nathan** and Manager: **Mr Sylvester Kanchora**), observed the system of egg incubation, and fry collection, packing and transportation.
- Made arrangement for another visit to discuss in detail for the possibility of hatchery expansion and fry quality improvement
- Participated in stocking of fish into the project farmer's ponds (two farmers namely; **Mr Alex Simutenda**'s first pond with 1283 m² stocked with 7,200 fingerlings and second pond of 836 m² stocked with 4,700 fingerlings; and **Chiwila Farm** – 870 m² pond stocked with 4,800 fingerlings).
- After seeing the pond water not adequate green, both the farmers have been advised to use urea (nitrogen fertilizer) and DAP (Phosphorous fertilizer) every week to enhance and maintain the green water. Improvement.
- Made arrangement for another visit to provide detailed guidelines on these.
- Visited **Nsoke Game Camp** or **Miengwe Fish Farm** (Super Male – tilapia fry production) including piggeries

January 27:

- Participated in '**Women's Workshop**' (Fig. 1) on "Overcoming Constraints affecting Women in Aquaculture in Zambia" organized as a part of the project (TCP/ZAM/2303) held in National Aquaculture Research & Development Center (NADC)



Fig. 1 Participants of women' workshop at NADC, Mwekera

- Presented a paper based on 'Asian Experience in Working with Women in Aquaculture' (Appendix 1) highlighting the importance of aquaculture to women and family nutrition,

emphasized integration of fish farming into the existing farming system such as vegetables and livestock

- Women's group was very keen on further interaction/discussion. Arrangement was made to visit later

January 28:

- Transportation and stocking of fingerlings into **Mrs Lungu's** pond of 836 m² stocked with 4,200 fingerlings (Fig 2).



Fig. 2 Stocking of fish: equalizing the temperature (left), releasing fish (right).

- Pond water was seen white because of the calcium carbonate. It was informed that chicken manure was not used thinking that *O. andersonii* will need some time to make habit of feeding artificial feed
- In order to make the water green, it has been advised to use chicken manure at least 2 weeks before stocking and also chemical fertilizer urea and DAP to continue weekly.
- Return to Lusaka

January 29:

- Morning: preparation of activity schedule for the rest of the period
- Afternoon: met national economic advisor and discussed about the status, activities and national strategy for aquaculture development

January 30:

- Compiled the information gathered for the report write-up

3.2. Week 2

January 31:

- Estimated the rate of fertilization (urea and di-ammonium phosphate and explained to Mweemba which will be used as recommendations
- Visit plastic and metal shops in Lusaka and procured some containers useful for hatchery technique available
- Visited an integrated '**Aqua Farm**' in Mazabuka District, Southern Province which is growing Nile tilapia but used to run hatchery and also sell table fish of about 12 million Kwacha per day and about 200 women used to be take fish from the farm to sell along the road side and in the market.
- Has about 27 ha of land, 15 ponds with no fish and 9 ponds with fish (Fig. 3)



Fig. 3 Fry nursing hapas in pond (left) and abandoned hatchery (right) of Aqua Farm

- At the moment, fry from various sources are in nursing in hapas before they are released into the same pond
- YY-male fry are also under test from Swansea, UK. It was advised to be careful about this. As the fish and the technology were tried in Thailand but farmers did not like it because fish reproduced in ponds.
- Order 10,000 broodstock and 100,000 monosex fry
- Interested in buying materials and equipment from Thailand such as hapas, DO meter, pH meter, aerators etc.
- Due to failure in incubation system, the farm stopped its hatchery.
- Possibility of reviving the hatchery was discussed with the Managing Director, **Mr Fardeen Zumla** (aquafarmz@gmail.com) and his manager **Mr Clinton** (email: clintoncs@hotmail.com) in detail. The followings were advised:
 - o Building a compartment for 'slow sand filtration system' which filters the water to clean up or another possibility is use of UV light for water sterilization
 - o Transferring the yolk-sac fry from the incubators immediately after hatching and using boat-shaped plastic container for larval rearing. The farm was using the circular plastic basins for fry rearing which does not allow movement of fry,

instead they stay in the middle and many of them die because of lack of oxygen at the bottom

- Use of feeding trays for feeding fish sinking pellets especially during grow-out period explaining that large part of sinking pellets may sink into the mud and not available to fish
- Possibility of sourcing high quality broodstock and equipment (e.g. feed manufacturing) from Thailand

February 1:

- Met **Mr Saradhi** (Tel. 0978600776) at the Kafue junction who is from Andhra Pradesh India. He is manager of a hatchery, **Savanna Stream** uses GIFT and Chitralada strains of Nile tilapia fish imported from Thailand (Nam Sai Farm Co. Ltd.). According to him fry production is about 1.8 million but has been able to sell his fry. Due to lack of time, this farm was not visited on that day but promised to visit on Sunday (6th Feb) after coming back from Copperbelt. However, it was advised:
 - to work closely with DoF so that DoF can monitor production systems, quality of fry/fingerlings produced and can recommend farmers, if the farm comply with the guidelines to be developed or applies the right methods.
- Visited **Kafue Fisheries Ltd.** in Kafue, the biggest fish farm in Zambia and met the Manager **Mr Terry**, who showed very welcoming He mentioned that the farm was established by another large company TAP. Because of the government policy, the earnings of the company had to invest in the country – the Kafue Fisheries (Game Park) was the outcome



Fig. 4 Kafue Fisheries; pig shed on the pond dyke (left) and green house for breeding and nursing fry (right)

- Although the farm was established in 1981/82, production took off only after 2000 only.
- There are 112 ponds with 67 ha of water surface area

- All the ponds have pig shed on the dike, the manure of which is directly drained to the pond. It is originally the Chinese system
- There are about 85 staff working and living in the farm taking care of fish and pigs but altogether there are 180 staff in other section such as game animals etc.
- Fish ponds are very green because of pig manure. Stocking density of fish is normally 3-4 fish / m², highest was about 6 fish / m² with feeding of 18% crude protein finisher diet from Tiger Feeds Co.
- Earlier farm was using *O. andersonii* but has been replaced by GIFT fish imported, According to him, *O. andersonii* is more cold tolerant but GIFT grows faster e.g. 1-1.5 kg in 13 months cycle and about a kilo in 8–9 months
- Thinning / partial harvest using 3–4 inch seine net
- Market is no problem at all (Price goes up to 14,000 – 16,000 Kwacha/kg for 300g or bigger sized fish, 10,500 Kwacha for 100 – 300 g fish and 6,500 kwacha for smaller than 100 g fish. As the consumers want whole fish on the table, 100–150 g is preferred
- Has catfish in green house tanks as well but market is limited (price 8,500 kwacha/kg)
- Breeding in tanks in green houses, collect fry from tanks and do sex-reversal. The farm needs about 2.4 million fingerlings but can produce only half a million. The farm is always looking for quality fry / fingerlings.
- Nursing of fry – in green houses and capacity is 500,000 fry only but has a plan to double or even more, however, he is not interested in going for fry production business (just for the farm only)
- When there are parasite infestation, adding green water from ponds helps
- Total production of fish was 792 mt in 2010 and hopes it reaches 900 mt in 2011 (sales is about 3.5 tons/day.
- According to Terry, constraints to the expansion of aquaculture expansion are:
 - o Lack of technical manpower
 - o Relatively new business
 - o Expensive to start
 - o People want quick money but it takes time to make profits and need patience.
 Although the farm was able to breakeven within a year

February 2:

- Meeting with Mr Gordon Chiwila (**Chiwila Farms**, Email: gk.chiwila@gmail.com), who came from Copperbelt, one of the project farmers
- Interested in starting a tilapia hatchery using the technology developed in Asia
- Presented the details of the technology and explained the salient features of each step
- Discussed about the investment and possibility of getting training in Thailand and also sourcing the materials, equipment and fish from Thailand
- It was **advised:**
 - o to use feeding trays in order to minimize the feed loss

- to fertilize the ponds using Urea and DAP in addition to the chicken manure which is not adequate
- as demand is for larger fingerling, it was advised to nurse fry (when started to produce) for about 2 months after sex-reversal using hapas, feeding mixture of local available feed/or mixture of ingredients

February 3:

- Visit to **Kalimba Farm**, 20 km east of Lusaka, 25 yrs of existence
- Land is on lease from the government for 99 yrs
- The farm has 12,000 crocodiles, some cattle, pigs and even ‘reptile park’
- Mrs Cayron Thomas, the manager, wants to promote indigenous strain i.e. *Oreochromis adersonii*, because:
 - it does better in cold weather as water temperature in Lusaka drops to 15–16 °C.
 - it has to be preserved
 - Size does not matter so much as it grows up to 200 g in 6 months, typical market size suitable for a meal
 - There possibility of canning which will need small fish maximum size of 75 g.
- Total land area – 7 ha but production is from 5 ha, there will be 10 ha after expansion by the end of this year with production capacity will increased to 80 ton from current 20 ton.
- Currently she has 170 fish collected from various natural water bodies and 1,000 stock of their progeny (F1)
- She wants to work further to develop broodstock and is working with CIRAD expert (**Dr Jean François Baroiller**) who is visiting on Sunday 6th Feb – we are also invited
- As per her interest, she was advised to go ahead with the breeding trials and progeny testing so that the farm can be developed as the main centre (National Broodstock Center – 2) for this species so that it can serve as the main *O. adersonii* broodstock supplier to other hatchery operators

February 4:

- In the morning: developed economic models for the farm sizes of 200, 500, 1,000, 5,000 and 10,000 m², (see Guidebook, Appendix 3) based on which more than 1,000 m², farm size would be economically viable as it can give return of about US\$60 per month (equivalent to US\$2 or 9,000 Kwacha per day wages which an agricultural worker would get if he/she works for other farms/factories. Therefore, it is concluded that smaller than that would be suitable only for subsistence farmers who grow fish as an extra component of farming system for their family nutrition. Whereas a farm of 1 ha size would be give a return of US\$4,000 in 6 months which should be attractive enough for any investors
- In the afternoon: Met **Mr Irfaan Yousuf** (Group Chairman) of **Zambian Subsidiary Companies (Aqua Farms Ltd.**, is one of them). It was advised to revive the defunct hatchery and expand the fish farm to a larger scale as land is adequately available (27 ha).

Made arrangement to visit the Aqua Farm site for the following day and work out the plan.

February 5:

- Visited **Savanna Stream Farm** (Tilapia hatchery, Fig. 5) located in Ngege Ngege together with Manager Mr Saradhi and also had dinner meeting with the Managing Director **Mr Md. Salim Dawoodjee** (Email: msd_zm@hotmail.com) who is the MD of High Protein Foods Ltd., Savanna Beef and Savanna Stream, discussed about the future of aquaculture and advised to continue to expand business working closely with DoF to achieve the common mission
- The hatchery uses GIFT and Chitralada fish imported from Thailand; the first lot imported 10,000 and second lot 80,000. Now there are nearly 100,000 working broodstock
- Uses large brooding hapa (24m x 5m) imported from Thailand at about US\$250/pc
- Uses hapa for sex-reversal 3m x 1.8 m = 5.4 m² hapas also imported from Thailand price at US\$50/pc



Fig. 5 Hatchery (left) and broodstock hapas in ponds (right) at Shavanna Stream fish farm.

- Uses 300 females and 100 males per breeding hapa
- Size of fish ranges from 150-350 g with feeding 32% CP floating pellets
- Egg harvest every 2 weeks (but advised once a week)
- Hormone dose 44mg/kg of feed (**advised** to increase to 60mg/kg for better result.
- Other **advices** include harvest eggs every week, transfer yolk-sac fry to trays immediately after hatching, and then to sex-reversal hapas as soon as they start swimming freely
- Sex-reversed fry price is US\$20-30/1000 fry
- Production capacity = 1.8 million per month = ~15 million per year (winter 3 months no production).
- It was also **advised** to use more clean water while packing the fry for sale.

- Water in incubation system is pumped in from the Kafue River, looks turbid – ***advised*** to have settling tank first before it is pumped into to header tank and then to a sand filter.
- Visited **Aqua Farm Ltd.**, again together with Senior Aquaculturist (Mr Joseph Mutale) as per the request of **Mr Irfaan Yousuf** (Group Chairman of Aqua Farms and several other companies, email: mopani75@hotmail.com or info@mopanigroup.com), discussed various issues and strategies, who has instructed his team to revive tilapia hatchery. Decided to import 10,000 GIFT broodstock and 100,000 all-male fry from Thailand and has asked DoF to facilitate in the process.

February 6:

- Morning – 2nd visit to **Kalimba Farm** together with Mr Martin Mutala (DoF Deputy Director) and Joseph Mutale. Present was **Dr Jean François Baroiller** (Geneticist at CIRAD) and Mr Damien from Lake Harvest, Production Manager.
- Observe the sample collection (Fig. 6) for Genetic / Molecular marker for analysis in CIRAD, Montpellier, France. This would help identify of the *O. andersonii* based on the molecular marker. It will be in record and available after a couple months.



Fig. 6 Harvesting broodstock (left) and preparing fin samples for molecular analysis (right)

- It was ***advised*** that Kalimba Farm should serve as one of the centres to carry on selective breeding for the improvement of *O. andersonii* broodstock and supply to other interested hatchery operators as well as grow-out farmers. Therefore, the cooperation with CIRAD with lab analysis for molecular markers will be a beginning.
- It was ***advised*** to increase the number of broodstock collecting from various parts of the country, kept them in a separate units, compare among them, and also crossbreed to produce separate lines with hybrid vigour so that they might turn out to have higher growth compared to their either parental lines. This can be promoted as ‘improved *O. andersonii*’. Crossing with all possible lines and progeny testing for various culture practices should be repeated continuously.
- Discussed during tea time, regarding the possibility of increasing the fish production in Zambia including Quantum Leap (having several corporate investors such as **Lake**

Harvest. According to **Dr. Damien Desprez** (damnientilapia@yahoo.fr), Production Manager of the Lake Harvest produces e.g. 6,000 ton/year and has a plan to increase to 12,000 ton and then up to 20,000) and produce large volume.

- Various constraints were discussed giving the Asian contexts and examples.
- Left for Copperbelt and Mkushi and arrived in the evening.

3.3. Week 3

February 7:

- Visited **Rivendell Enterprises** (2nd Visit) and met John (father) and Jonathan (son)
- Presented the hatchery technology development process and technology transfer
- Discussed various possibilities. According to them, *O. andersonii* is vulnerable than *O. niloticus* and also grows slower. Therefore, they want to gradually move to the latter
- *O. andersonii* fingerlings were found to have tumour like tissue growth on the body.
- Considering the mortality of eggs and fry in the hatchery, a transparent plastic jar (Fig 6, left) was tried for egg incubation which showed better egg movement which was agreed / accepted by the manager. At the same time, a boat shaped plastic container (Fig. 6, right) was tried to show better movement of yolk-sac larvae which give better survival



Fig 6 Testing/demonstrating a new plastic jar for egg incubation (left) and boat shaped large bowl (right) at Rivendell Hatchery



Fig. 7 Deformed fingerling (left) and large plastic bags for fry packing (right) which is 3 times bigger than normally used in Thailand.

- All the steps of the hatchery process were discussed in depth. The following advices have been provided:
 - stock broodfish in hapa-in-pond system - 360 fish/60m² hapa (12m x 5m)
 - increase broodstock number to about 10,000, purchase from abroad if necessary
 - collect eggs once a week (present method is every 14 days)
 - transfer eggs to tray system after they hatch in jar
 - construct a slow sand filter separately (3 m x 3 m) size
 - transfer swim-up fry as soon as possible for sex-reversal
 - use hormone 60 mg/kg feed (current practice was 100mg/kg) as high dose might have resulted in a deformities (Fig. 7, left) in fry such as in *O. andersonii*
 - packing can be done more efficiently using 5 L bags with 2 L water and 3 L oxygen instead of 15 L bags currently used (Fig. 7, right)
 - carry out regular quality monitoring of fry (e.g. monthly or for the large batches (>10,000 fry sold to farmers))
 - make a target of 5 million fry per month (currently only about 200,000 – 300,000 fry/month)

February 8:

- Morning: training for fry quality monitoring (sex-testing) biology lab at **NARDC** (Fig. 8)
- Two males and two female fish were dissected and their gonads were squashed
- Two slides were prepared from the small portion of the fish gonads. Specimens were stained using biological stain. They were examined under microscope.
- Eggs were clearly visible from female gonads and sperms were seen like small spots from the male gonads.
- Staff including Mweemba and college students were shown how to keep records and calculate the male percentage as a quality indicator. They were also explained how to keep samples



Fig. 8 Training on quality test: dissecting fish and squashing gonad and preparing slides from the gonadal tissues (left), eggs in the ovary of female seen under microscope (right).

- Afternoon: Visited **Fish Farmers Group/Cooperative** of Kitwe known as ‘**Bream Source Farm**’ – total members 49 (27 women and 22 men)
- Majority of them either ex-miners and widows
- The Farm (Fig. 9) was started 2 yrs ago leasing rehabilitated land of energy authority
- Ponds vary in size and stocking density approx. 4 fish/m²



Fig. 9 Members of a cooperative showing their ponds at their Bream Source Farm

- Advices provided are as follows:
 - Fertilize the pond 3 kg Urea and 6 kg DAP per 500m² pond weekly
 - Feeding – use tray so that feed will not be wasted. Look for possibility of preparing on-farm feed by mixing maize bran and fish meal or soybean meal
 - Use other species as well polyculture in order to get more fish and more profits e.g. grass carp, mirror carp and catfish at the rate of 1 fingerling per square meter
- Afternoon: Met **Mr Sven K. Philblad**, (email: svenp@nmc.co.zm) General Manager of **National Milling Corporation**, Copperbelt
- Discussed about the future of fish farming, and potential role of and scope for feed manufacturers
- The followings were advised to the company:
 - Fish feed formulations should be assisted by fish nutrition expert
 - Produce floating pellets at cheapest prices possible
 - Categorise feeds; one set for cage culture (high protein diets) and the other set for pond farming which uses green water as major source of nutrients. For cage culture fish will need higher protein diets such as 30-35% whereas for fish cultured in ponds will need 30% CP for starters and just one feed containing 25% CP would be sufficient for growers, finishers and for broodstock.
 - Conduct some trials in collaboration with universities/colleges and research institutions for research or improved diet development

February 9:

- **Test of Feeding Tray for Sinking Feeds (e.g. Starter Crumbles):** a feeding was made using net and bamboo stick frame and tested sinking pellets for feeding fish raised in one

of the tanks of NARDC tray (Fig 10). At first, fish did not come to eat as the tray looks like a trap. But when the feed and tray was left over night, fish were found to be eating feed provided in the tray.



Fig. 10 Feed crumble (top left) and pellets (top right), installing the feeding tray (bottom left) and feeding in tray and checking whether fish ate the feed by lifting it (bottom right)

- **Fertilization Method Demonstration:**

- Visited (2nd visit) the project farm (**Mr Alex Simutenda**) to demonstrate how to use chemical fertilizers. The farmer mention that he bought and used Urea and DAP previous week. The farmer said that he did not know how to use. He just broadcast the urea grains as he would do for maize.



Fig. 11 Dissolving urea with water (left) and splashing the urea dissolved in water (right)

- Therefore, it was necessary to show the method. Five kg of urea for about 846 m² pond was weighed using the balance (provided by UNICEF possibly for weighing

the kids for their growth). Urea was soaked with water in bucket using pond water at the pond site

- Using a stick, fertilizer was dissolved then splashed on the surface of pond
- For DAP, it was advised to soak overnight as it is very hard to dissolve in water.

February 10:

- Morning – visited **Luanshya DoF office** and met **Mr Philip Chibumba** (District Fisheries Officer) a women farmer from a cooperative who contacted through AwF homepage.
- No. of fish farmers is around 30, among them 20 members are members of a cooperative
- Interaction with the DoF District officer revealed that the major problems in district are:
 - Lack of capital for digging pond, to dig a pond of 500m² costs about 6 million kwacha when used manual labour, whereas it may cost less when used machine e.g. CAT, Caterpillar but it has to be done in group, if possible to use it
 - Feed – up to 50% of the cost. Advised them to use Urea fertilizer to make water green and prepare feed by the group using soy bean oil cake and maize bran (1:3) with some cassava flour as ‘home-made-feed’. This can reduce the cost of feed by half, similar to preparing food for family is a lot cheaper than eating in restaurant
 - Use feeding tray so that feed loss can be minimized
 - Shortage of fry and fingerling – it was suggested and given the tel no. of Savanna Stream hatchery which is not able to sell it fry
- Visited **Ndola Provincial DoF Office** and met **Mr Caiphos Mpaka** (Principal Fisheries Officer, email: cmpaka@yahoo.com.uk) and discussed about the activities and advised to recommend farmers: use of urea and DAP, home-made-feed, use of feeding trays and informed about fry produced by Savanna Farm
- Travel to Mkushi

February 11:

- Visited **DoF Mkushi** and met two Fisheries Officers (**Mr Maltone Moyo** and **Mr Musanda Diesideloos**) get some idea about status of aquaculture. According to them there are about more than 200 farmers in the area. Farmers are growing *Tilapia rendalli*, *O. niloticus* and *O. andersonii*.
- According to them, problem is that fish do not grow.
- Advise to promote fertilization, home-made feed, and use of feeding trays.
- Visited the farm under the station which has about 10 ponds of around 1,000 m². Pond water look very clear, advised to use more chicken manure and fertilization. Also, showed feeding tray and how to use it (Fig. 12).



Fig. 12 Showing the use of feeding tray to DoF staff at Mkushi station.

- Visited **Damusi Farms Mkushi** and met a potential fish farmer **Mr Joe Daka** (damust@zamtel.zm or Jimjoedaka@rocketmail.com). The farm has about 1,000 ha farm and has just started digging few fish ponds and want to diversify risks by having fish
- Presented the tilapia hatchery technology and explained about the scope and advantages (about 10 times higher profit) of overall fish farming.
- The farmer has very keen and has expressed interest in having training and study tours in Thailand. Either with DoF or even alone will visit in May this year or so.
- The farmer was worried about poisoning of source water. It has been advised to have a reservoir before the farm with some fish so that if poisoning happen guards can notice if fish death occur. So that they can stop water going to the farm.
- Visited the following two farms (Fig 13):
 1. **Solomon Tembo** – has 4 ponds total, 2 ponds (70m x 10m and 60m x 10m) stocked with *O. andersonii* and other ponds are under preparation. Source water is very clean. As a feeding, pond water has green algae which is good for fish growth. A pond has seepage problem, advised to use more chicken manure and next time after fish harvest to dig deeper and compact the soil with clay soil. Also, advised using feeding tray and showed how to use it, use of urea fertilizer.
 2. **Lwetona Farm:** Total 5 ponds with potential of expansion. Two ponds (~800 m²) have 4,600 *O. andersonii* fingerlings and others with *Tilapia rendalli*. Farmer is very excited as his fish are growing very fast because pond water is green. Farmer is expecting more than 12 million kwacha from each pond. He started fish culture since 1997 but it was the first time he is doing properly with guidance from DoF.



Fig. 13 Ponds with green water; Solomon Tembo (left) and Lwetona Farm (Right)

Interesting thing is that he has *Tilapia rendalli* which are:

- Very prolific substrate spawner, produced huge number of fry/fingerlings when stocked 8 fish initially
- They have a black spot on dorsal fin and swim very fast
- Eat grasses like that of grass carp
- They are very tasty fish (most tasty among tilapias?)
- It looks very promising fish species and the farmer is very keen on this. There might be a possibility of developing culture methods

February 12: Return to Lusaka

February 13: Prepare report and slides for seminar presentation

3.4. Week 4

February 14:

- Prepare report and slides for seminar presentation (Appendix 2)

February 15:

- A **Seminar** was requested to organize with a view to present draft outputs and recommendations of the assignment, at the same time, to share experience and information with DoF personnel.
- A summary of field activities, present status, problems identified and draft recommendations were presented during the seminar held at DoF premises.
- Attended by DoF personnel, representative from FAO, farmers (Chiwila Farm, Kalimba, Kafue), a feed manufacturer (National Milling Corporation) and Peace Corps and others
- Question was raised whether a guidebook could be published and any support would be there for printing.

- Other suggestions to include in the guidelines were:
 - o Description of hapa materials, mesh size and dimensions
 - o Advanced nursing or 3 months winter should be consider as over-wintering during which fry have to be held at high densities with limited feed. These fingerlings will be good to supply to farmers for stocking immediately after winter period ends.
- Afternoon visited Feed manufacturing plant of the **National Milling Corporation** in Lusaka. Met with Dr Anthony Chako (ChackoA@nmc.co.zm) and Roberto, discussed with the scope for expansion and improvement in the feed quality.

February 16:

- Leave for Chirundu, visited **Chirundu Bream Farm** and met **Mrs Cherry**
- Established in 2003 and was the first one which trained many people but left to work other farms including Rivendell and others. Now no. of people are 6 in fish section
- A Philippino technician worked for 9 months to set up the hatchery
- The farm received supports from Norwegian Company (GenoMar) and also JICA
- Hatchery system: Eggs are incubated in small cone shaped plastics containers (Fig. 14, left) and larval rearing is in large plastic bowls (Fig. 14, right) Fry production target is 300,000 fry / month but it seems they do not have demand. Only two farms; Kafue Fisheries and Aqua Farms have ordered 60,000 (2 g+) and 120,000 fry (3g+) respectively. In 2010, there was only one customer, therefore, the owner is in the opinion that if there are no customer then there is no meaning of expansion.



Fig. 14 Chirundu Hatchery: egg incubation (left) and larval rearing (right).

- Fry price is US\$50 per 1,000 sex-reversed fry and there is a sales office in Lusaka
- Number of broodstock is 3,100 purchased from Nam Sai Farm in Thailand. They are in ponds, egg harvest or fry collection is every 14th day by draining the ponds.
- Eggs are incubated in plastic jars used for watering chicken then wait until swim-up fry come out. (advised to These fry and the fry collected from the mouths of females are transferred to the hapas for hormone feeding, hormone feeding is for 21 days, first week

- 10 times a day and the remaining 2 weeks are fed 8 times daily. The hormone feed is prepared using fry mass purchased from Tiger Feeds Co. at the rate of 95 mg/kg of feed. One litre of alcohol for 10 kg feed
- About 15,000 fry are stocked in 2m x 6m or 2m x 8m hapas for sex-reversal (the density is very low, which can be increased when production is expanded)
- Grow-out pellets 20% CP is used for breeders and grow-out fish
- No. of ponds: 26 ponds (10 m x 20m) used for breeders and 10 ponds (size 80 m x 20 m); 1 has been used for sex-reversal (Fig. 15 left), two for nursing and others for grow out (Fig 15, right) as fry could not be sold; therefore, the farm is growing itself
- Ponds are fertilized with urea (0.4 g/m²/day) and MAP (0.07 g/m²/day), pond waters look green enough. Fertilization is done continuously for 15 days until pond water becomes green and then stopped. Excessive green is reduced by adding water and lime.
- Fish grow up to 300 – 400 g in 6 months from 2.5 g at stocking which is reasonable
- Sinking feed is used, as the manager thinks floating feed contains air which is not good for fish (which is not true), feeding is done 4 times daily, feeding rate starts from 10% biomass then gradually reduced.



Fig. 15 Green ponds of Chirundu Farm: sex-reversal hapa (left) and well fertilized nursing or grow-out ponds (right).

- **Problems and possible solutions discussed:**
 - o Very few customers as there are no fish farmers in surrounding area, except one across the Kafue River (advised to do marketing and promote farming through women's group)
 - o No system in place to check the quality of fry and some farmers have complained about the fry quality. It was done only once some time ago, result was 98% male but not sure at the moment whether it is still that level
 - o Staff after getting experience leave from the Chirundu Farm, possibly higher salary offered by others (it can be solved by offering performance based rewards)
 - o While culturing fish in cages, Environmental Council stopped destroying the cages. But one of the study showed that the water beneath the cages was found to

be clean as fish in the lakes/rivers come and consume feed/nutrients leached from the cages and cleaned the area (now Govt is allowing cage culture for at least 5 years without EIA and upto 100 mt production level, hoping that after 5 years any farm will grow and be able to pay for 15 million kwacha to do the EIA later)

- Village Chief and others including a staff sue to the court for land title deed and for salary compensation respectively (this is more political problem and needs to be resolved organizing meeting face-to-face meeting with people who might be the potential threat to the farm in order to convince them the farm is doing good thing for the country).
- ***Advices provided:*** Spending for more than 4 hours, we discussed all aspects of production process for possible improvement in each step including broodstock management in hapas (stocking density), need of more broodstock which can be done by keeping a batch of at least 10,000 fry collection of eggs once a week, incubating eggs in jar, transferring them immediately to trays when they are hatched and then to sex-reversal immediately after they become swim-ups. Sex-reversal hormone dose has to be re-checked, feeding frequency can be reduced to 5 times per day instead of 10 and 8. Quality test, certification and marketing is to be done in cooperation with DoF. In order to promote aquaculture in surrounding areas, it is advised to form women's group/cooperatives working together with DoF and other potential people who can mobilize them.
- Visited **DoF office of Chirundu** and discussed about fish farms around. It seems there are very few fish farmers. Advised them to work with Chirundu Hatchery Farm to create women's groups. The DoF office has only two officers with no vehicle for travel except a boat to monitor fishing activities for which high fuel cost has been a problem

February 17&18:

- Visited **DoF Office in Kalomo District** and intended to visit few fish farms. It was surprise visit (not informed in advance), only an Office Assistant was present in the office who did not know where fish farms are and how many fish farms are there in that area. He said there are many farmers but could not tell how many, even could not guess, he did not know the location of any farm either.
- Although the Assistant was a new recruit (joined in Dec 2010), it was advised that he should have visited some farms, kept the records of farms/farmers (size of farms, production, inputs etc.) and at least should have been aware of monthly reporting to the central DoF office.
- It seems that there was a lack of proper job orientation and lack of guidance. This might be the common problem in other districts as well.



Fig. 16 DoF office in Kalomo District

- It was advised that:
 - Although the Office Assistant is not a technical personal, he should have some basic knowledge, at least number of farms, location, and some records.
 - Advice to the DoF authority: Two standard templates (one for Catch and the other for Culture) for reporting (monthly and quarterly) should be developed and distributed to every district so that district officers / office assistants would work on collecting those data. It would also help on maintaining up-to-date database
- On the way back to Lusaka, a lot of fish (red-breasted bream and other types of tilapias caught from rivers), were seen for sale along the roadside in **Mazabuka District** (Fig. 17) and at least 4 more places. Although fishing was banned (Dec 1st – March 1st). This indicates that fishing ban might not have been effective. DoF and other authorities/stakeholders involved are advised to have monitoring of compliance of the ban and take action to those who break the government rules.



Fig. 17 Fish sold along the roadside of Mazabuka District Headquarters

- Return to Lusaka in the afternoon.

February 19 – 20:

- Report Write-up

February 21:

- Visited World Fish Center (WFC), Lusaka
- Met Ms Tabeth Chiuta (email: T.Chiuta@cgiar.org), the Regional Director – Africa
- Discussed various aspects of fisheries and aquaculture including cage culture in Kariba
- Due to environmental concern cage culture has been an issue but it was ***advised*** that WFC as a promoter of fish farming and sustainable livelihoods, problem should be looked into the depth and be based on the scientific facts rather than running behind the exaggeration from the environmental journalists. It was suggested to work out how much nutrients actually remain in the system from fish cages. For example, in cages fish are fed at about 5% of the body weight, fish digest at least 75% of most of it dry matter and then produce hardly little amount. If we divide the amount released into the water by the volume of the whole water body, the percentage of the nutrient released can be 10^{-20} .
- It was also mentioned that having cages in lakes can be even beneficial for the fishes in the lakes, as they may get food and clean up the area
- It was mentioned that there is no concern in Mekong River and others in South East Asia with cage culture, people live on cage houses in Cambodia and Vietnam. Pollution comes mainly from run-off water, industrial wastes and municipality wastes.
- Only concern is conflict between the communities and the private sector which want to have cages
- However, it was advised that promoting pond aquaculture is a lot easier instead of spending energy arguing for cage culture because farmers have full control of it
- It was also suggested using the idea of promoting fertilization and home-made feed among the farmers in rural areas where they may not be able to buy feeds
- She mentioned that fish seed is one of the important part of the WFC projects and will be in touch with DoF and Asian partners for potential collaboration as it has been felt that south-south cooperation has a lot of advantages in transferring technologies, especially Thailand can offer a lot including academic degrees, short-term training, study tours, internship and so on.

February 22:

- Report submission
- Preparation for leaving

4. SUMMARY OF FINDINGS

4.1. *Major challenges*

Aquaculture programs and fish farming in Zambia started since 1950s. However, production of fish did not increase as expected to meet the country's need probably because main focus was on small-holder farmers and was limited to their family nutrition only. Majority fish was supplied capture fisheries. But drastic decline in natural stock resulted in drastic decline in consumption from 16.5 kg in 1971 to 6.2 kg in 2000. Although, recent years fish farming has been emphasize by the government and various other agencies including FAO, aquaculture production has not achieved as expected. According to the government figures there were 6,500 farmers and about 14,000 fish ponds in 2002. Current estimate for annual fish production is about 8,500 mt fish production with the seed demand of about 15 million. However, only 50% of the seed is produced in the country. However, field visit during the mission, shows that Savanna Farm located at Ngege Ngege alone produces about 15 million fry of Nile tilapia and has capacity of increasing the production. The problem is how to build the trust that they produce high quality fry and how to spread the message to farmers.

More importantly, high quality seed supply is required to support and trigger the anticipated growth of aquaculture. According to the estimates in 2006, total annual fish demand in Zambia is 120,000 tones. It is believed that the demand has reached to 140,000 tones per year in recent years. Production figures from capture and culture seem to be unclear. It is believed that total capture and culture supplies between 80,000 and 100,000 tones per year. This shows a shortage of at least 40,000 tones of fish per year which is likely to increase annually (by at least 10%) due to increase in income of consumers and awareness of health benefits. To be able to produce 40,000 tones of fish per year, country needs at least 20,000 fish growers with the annual capacity of 2 tones which is possible from 0.5 ha farm size. Accordingly to the DoF data, there are about 6,500 fish farmers; most of them have 200 - 300 m² ponds which produce very low volume compared with the estimated demand. Therefore, it has been realized that past aquaculture development programs contributed to family nutrition to some extent but did not contribute much in terms of supplying fish to the market. As a result fish have to be imported from abroad e.g. China. Aquaculture promotion focusing on subsistence farmers has raised a question and the need of paradigm shift to focus on commercial farming has been realized.

In order to increase significant volume of fish production, one of the ways is to improve productivity of existing farmers up to 2 tones per year, and expand their pond area to at least 0.5 ha. At the same time, it is highly necessary to attract more people / farmers towards this business. Current number of fish farmers has to increase by 3 fold. Another way of achieving this is to attract large corporate investment which can produce large volumes e.g. Lake Harvest which produces around 6,000 mt / year and has a plan to increase by 2 or 3 folds. This 'Quantum Leap'

may happen gradually because of the availability of large water bodies and land resources in the country. In order to support the anticipated expansion, another challenge is to produce and supply high quality seed as it is one of the most important basic needs of aquaculture. If aquaculture expands to meet the expected demand, a very crude estimation shows that 200 million additional fry / fingerlings will be needed annually which is possible only if the mono-sex fry production technology, which has been successful and rapidly expanding in Thailand and other parts of Asia, is applied. One or two large commercial hatcheries could meet the demand, given the technology is followed strictly.

Two species of tilapia are the species of choice which have the potential to meet the shortage through aquaculture. The first priority has given to the 3-spotted bream (*Oreochromis andersonii*) as it is indigenous to the country. At the same time, Nile tilapia (*Oreochromis niloticus*) attracted attention of especially the commercial farmers because of its popularity in Asia and many other countries. It has been already imported in Zambia by some farmers. As availability of quality fry / fingerlings is the main bottleneck for aquaculture development. Therefore, a short to medium-term plan for fry production will be developed based on the current shortfall of fish.

4.2. Opportunities / scope

Although afore mentioned problems seem to be critical, observations and various studies show that the country has a great potential to produce more fish and meet the demand given the available resources can be managed wisely. The following points can be considered as strengths:

- a. Fish has been the most preferred traditional source of animal protein
- b. Demand for fish is high but catch from the natural water bodies is declining
- c. High rate of unemployment should be taken as an opportunity by the farms as they can be hired as labour at cheap rate
- d. Adequate water resource - at least 10% of the land area of Zambia is covered by water
- e. Land is still plenty and relatively cheap if one goes about 30 km away from the roadside
- a) Indigenous species of tilapia such as *Oreochromis andersonii* is still available in natural water bodies for the development of its farming. Most people like them very much. This should be taken as a good opportunity
- f. All the farmers met and discussed with, are very keen / enthusiastic on improving their productivity and expanding the business, especially the fry production
- g. Women's groups and cooperatives are already in operation in rural areas such as Copperbelt (Kitwe and Luanshya) which should serve as model for other areas
- h. Government of Zambia / Department of Fisheries and their staff have realized the problem of fish shortage in the country, felt the need of technical cooperation, and very much keen on supporting farmers
- i. International organizations e.g. FAO, Peace Corps and others have very good supports

4.3. Main areas of support needed

While discussing with several fish farmers / managers and other personnel associated with the sector / industry, the following major areas have been identified for technical support needs:

- b) Broodstock sourcing, founder stock development and management of indigenous species of tilapia, also called three-spotted bream (*Oreochromis andersonii*).
- c) Broodstock sourcing and management of Nile tilapia (*Oreochromis niloticus*) which has become one of the most important species in Asia and many other countries. It has also been imported in Zambia.
- d) Assist hatchery operators with improved technology to produce more fry/fingerlings.
- e) Maintaining and assessing the fry / fingerling quality.
- f) Nursing systems in order to ensure high quality fry for stocking into the farmer's ponds and efficient transportation of fry / fingerlings.
- g) Development of cost-effective feeds for fry, fingerlings, broodstock, and grow-out and feeding practices or methods.
- h) Quality monitoring of fry and fingerlings, and certification for quality assurance.
- i) Development of economically viable grow-out packages for the farmers.
- j) More interactions and information exchange among hatchery operators, grow-out farmers and DoF.
- k) Data collection and database maintenance
- l) Institutional capacity building and human resource development

5. MAJOR OUTCOMES

5.1. Summary of advices provided

At least nine hatchery farmers (existing or potential), several personnel of DoF offices, two persons of a feed manufacturer and several grow-out farmers, individually or in groups, have been provided with technical advice for all-male *O. andersonii* or *O. niloticus* fry / fingerling production and grow-out farming. Table 1 shows their names and presents a summary of potential impacts.

Table 1. List of farms visited and advised.

SN	Farms / hatcheries / individuals	Potential impacts
1	Rivendell Enterprise (Copperbelt)	likely to adopt new ideas modifying its current practices to improve survival and quality of fry. Also, is planning for expansion
2	Chiwila Farms (Copperbelt)	likely to start a new hatchery from its grow-out farm as per the advice or with some modifications
3	Aqua Farms (Mazabuka)	Most likely to revive its abandoned hatchery and expand grow-out culture as per the advice (has a capacity of producing up to 1 million fry per month)
4	Kafue Fisheries (Mazabuka)	likely to stick on its own way of producing fry for its own demand (2-3 million fry per year) but not willing to supply others, if good quality fry are available willing to purchase from others
5	Kalimba Farm (Lusaka)	Likely to continue the production of <i>O. andersonii</i> , therefore, as been advised to specialize its breeding and serve as the main supplier
6	Savana Streams, (Mazabuka)	likely to follow suggestions to improve quality and also increase quantity (up to 5 million per month), if DoF supports for marketing
7	Damusi Farm (Mkushi)	Likely to go for training in Thailand and start tilapia hatchery upon return within 6 month

8	Chirundu Bream Farm	As per the advice farm is likely to improve the system and can easily expand its capacity up to 1-2 million fry per month
9	NARDC, Mwekera	Has a potential to produce and supply tilapia as well as carps and catfish fry/fingerlings
10.	DoF Office and Staff a. Headquarters, Chilanga b. DoF, Provincial Office – Ndola c. DoF Office, Mkushi d. DoF Office, Luanshya e. DoF Office, Chirundu f. DoF Office, Kalomo	Interaction with DoF personnel has been very fruitful. They have been informed about the problems of low fish production and ideas of fertilization, use of feeding trays, and formation of fish farming groups/cooperatives and gathering data. They look keen on using the ideas for extension.
11	Farming Cooperative – Kitwe	The group was explained with the possible ways of increasing productivity. They show strong commitment and can be a model for the country
12	Individual grow-out farmers	Alex Simuntenda (Kitwe) Mrs Lungu (Copperbelt) Lwetona Farm owner (Mkushi) Solomon Tembo (Mkushi)
13	Feed manufacturer	National Milling Corporation - Dr Anthony Chako (Head Office, Lusaka) - Mr Sven K. Philblad (General Manager, Copperbelt)

5.2. *Guidelines developed (Appendix 3)*

- a) Guidelines for *Oreochromis andersonii* and *Oreochromis niloticus* broodstock development and maintenance of quality (Chapter II of the Guidebook)
- b) Guidelines for broodstock development and maintenance, fry quality improvement, transportation and feeds and feeding for grow-out (Chapters II - VI of the Guidebook)
- c) Fry production, nursing and supply models (Chapter II & III of the Guidebook)
- d) Economic models for grow-out with benefits costs analysis (Chapter VI of the Guidebook)
- e) A set of guidelines (a guidebook) for the production of high quality tilapia fry and table fish (The Complete Guidebook).

6. RECOMMENDATIONS / STRATEGIES

6.1. *Immediate strategies:*

- a) Emphasize establishing three large tilapia / bream hatcheries either new or developing from the existing ones which can produce and supply up to 3-5 million high quality (99% male) fry per month so that interested farmers can access easily whenever they want. In order to avoid long distance transportation, they should be located in each of the Copperbelt area, Southern Province, and in Lusaka or around.
- b) As farmers demand large fingerlings, nursing of fry can be done for 1-2 months or to 10 g fingerling in hapas so that they are not mixed with feral stock. This can be done either by the hatcheries or farmers by themselves. Hatcheries can use a pond and few hapas for this purpose. It is not difficult for them. Similarly, if the hatcheries sell small fry (<1g), then farmer's group can arrange transportation and stock them in hapa(s) in one of the farmer's pond which can be distributed when they are about 10 g fingerlings. One of the ways can be establishing a nursing system. A leader farmer from each cluster invests on transportation and carries out the nursing activity in each village / cluster, then sells to the farmers with an additional price that covers his/her costs with some profit margin.
- c) It is suggested establishing a unit, for example, Technical Assistance and Quality Certification Unit (TAQCU) within the Department of Fisheries (DoF) which generates its own funds by providing fee-based technical service, and quality monitoring and certification. The unit should have 2-3 skilled persons who can provide technical assistance to farmers in advising farmers manage their fish farms as commercial enterprises. At the same time, it develops and sells various business models or ideas (e.g. hatchery as well as grow-out farms) to interested parties to invest in fish farming and charge reasonable fees.
- d) DoF station / facilities at the provincial and district levels should run as commercial hatcheries and grow-out farms, wherever possible, as models for demonstration and training. By doing this DoF staff get learning-by-doing experiences so that they can train farmers/extension workers and do more research. At the same time, these stations could generate some income which could cover at least some part of their expenses. For example, provincial stations of DoF in Thailand have tilapia hatcheries which produce fry / fingerlings and sell to farmers at reasonable price in addition to providing technology at free of cost.

- e) Once the hatcheries start producing a large number of fry maintaining high quality as per the guidelines, it should be publicised using public media such as TV, radio and magazines so that common public who want to invest could get the information easily.
- f) More farm visits to encourage farmers to get involved and provide technical advices with improved farming practices and appropriate technologies. For example, use of inorganic fertilizers e.g. urea and di-ammonium phosphate (DAP), use of feeding trays to reduce feed losses into the bottom mud.
- g) Provide DoF staff and farmers with short-term training and field visits / study tours to successful farms in-country as well as abroad, if possible.
- h) During an annual function (e.g. agriculture fair), reward one of the DoF staff and also farmers who work hard and produce best results so that others are also encouraged to do so e.g. best staff of the year and best farmer of the year.
- i) Launch a national campaign at national level with slogan of ‘one-family-one-fishpond’ or similar to be chosen to make people aware of economically viable packages / business opportunities e.g. producing fish in a pond of 1,000 m² water surface area gives at least reasonable profits and farms with 1 ha of water surface area or more would be attractive to private investors.
- j) Produce more handbooks, manuals, brochures, flyers and posters providing factual information about fish farming of various kinds and make them available on-line as well as hard copies to be distributed throughout the country.
- k) Database and reporting: It is necessary to maintain good database in order to support planning and implementation of any projects/programs. However, it seems no systematic data collection, compilation and analysis practices. It is suggested to implement the policy that all the farmers have to register their farms with their corresponding District Offices and also report their fry/fingerling supply, and fish production and consumption data at least annually categorized based on the species. DoF should develop a data sheet or a template form to facilitate this process and make easily available to the farmers. At the same time, DoF should develop a common template containing the detailed information of fish and fingerling productions in each district so that all the District Offices can collect, compile and report to the Headquarters.
- l) As aquaculture is relatively new, aquaculture industry needs more regional interactions/seminars/conferences/workshops. More visitors to and from Asia, Europe, and America to Zambia could help refresh and widen the knowledge of DoF staff (policy makers, researchers and extension workers).

6.2. **Medium- and long-term strategies:**

- a) **Fish species:** Emphasizing only one species for culture may not be helpful for the sector's development. Options should be kept open for all the species which are currently available in the country. The indigenous species, locally called bream (*O. andersonii*) has a good potential to be developed as a species for culture in Zambia as it is believed that it does better during winter as compared to *O. niloticus*. However, very limited information is available regarding the species. Research and culture technologies developed for Nile tilapia (*O. niloticus*) may need to be slightly adapted for this species. Therefore, a series of research should be carried out in order to ascertain the culture techniques developed for Nile tilapia applies to this species, for examples;
- Breeding trials to select best performing lines / strains
 - Respond to fertilization (manure and inorganic fertilizers)
 - Type of feeds and feeding strategies (feeding rate, frequency and timing)
 - Polyculture with other species such as catfish, mirror carp, grass carp and others
- b) **Human resource development** is urgently needed. There are ...PhDS, There should be a good Master Plan to develop expertise for the country according to the need. For examples, hatchery and breeding expert, feed and nutrition expert, socio-economic expert and so on. Those experts could lead the Research and Extension in their specific areas in the country.
- c) **Institutional capacity building:** In most countries, education, research and extension functions are clearly divided among institutions. Whereas in Zambia, it appears that fisheries/aquaculture education is limited to Bachelor's degree only. Very few get chance to receive higher degrees. It is recommended towards establishing M. Sc. Degree in Aquaculture / Fisheries. However, curriculum has to be developed through rigorous process so that graduates receive practical and relevant education. Similarly, DoF stations which pond/tank/hatchery facilities should be developed as Research Institutions with the mandate of carrying out research, and developing technologies and testing them through outreach programs.

7. APPENDICES

7.1. *Appendix 1: Women's workshop presentation*

Women in Aquaculture in Nepal – paper presented during the workshop at Mwekera, NARDC, Copperbelt (A separate document / file enclosed)

7.2. Appendix 2: Seminar presented at DoF
(A separate document / file enclosed)

7.3. Appendix 3: Guidebook

That includes:

- Guidelines for *O.andersonii* and *O.niloticus* broodstock
- Strategies for good *O andersonii* broodstock
- Feed rations for *O.andersonii* and *O.niloticus*
- Hatchery best practice prepared
(A separate document / file enclosed)