Current status of aquaculture in Kisangani region, Democratic Republic of the Congo: Constraints and opportunities

N. NGALYA[1], F. MONSENGO[1], P. SAIDI[3], A. KANKONDA[2], T. NHIWATIWA[3]

(Reçu le 09/12/2018; Accepté le 15/01/2019)

Abstract

This study was carried out in Kisangani region, located in the north-east of the country. Surveys were carried out with farmers and observations were made on the nature of any aquaculture operations. Only fish farmers with a minimum of 100 m^2 ponds surface area were assessed in detail in this study. It was quite an unexpected to discover that many farmers have maintained the aquaculture tradition in this region. Within an area of 18 km radius from Kisangani town, a total of 45 fish farmers were interviewed. In Kisangani region, 44 % of fish farmers have up to 15 years experience but only about 7 % have farmed fish for 25-35 years. About 90 % of the interviewed fish farmers were not members of any fish farmers' association. The fish farmers in this region practice mainly polyculture. The most commonly cultivated fish species was *Orechromis niloticus*, followed by *Clarias gariepinus* and then *Parachanna obsura*. There is no commercially produced fish feed in the market and hence the feeding of the fish remains traditional. Most of the farmers (64 %) used rice bran; 42 % use pig waste; 78 % farmers used household wastes and about 22 % of the fish farmers do not feed the fish. The average fish production is 11.4 kg per 100 m^2 while the lowest and highest production was respectively 4.0 kg/100 m^2 and 29.5 kg/100 m^2. Fish is sold without post-harvest processing in lots or singles depending on fish size. In conclusion, Kisangani region's aquaculture is operating at a very basic level. However, fish farming culture is better established here compared to other sub-Saharan countries. The growth of the sector is being currently hampered by limited technology, inadequate training, lack of feeds and overall lack of support for fish farmers. There is great aquaculture potential as all the climatic attributes of the region are ideal for aquaculture.

Keywords: Aquaculture, Kisangani region, ponds, feeding.

État actuel de l'aquaculture dans la région de Kisangani, en République démocratique du Congo: Contraintes et opportunités

Résumé

Cette étude a été réalisée dans la région de Kisangani, située au nord-est du pays. Des enquêtes ont été menées auprès des pisciculteurs qui ont été interrogés et des observations ont permis de constater l'état des exploitations aquacoles. Dans cette étude, seuls les pisciculteurs possédant au minimum 100 m^2 d'étangs ont été enquêté. Il était assez inattendu de découvrir que de nombreux pisciculteurs ont maintenu la tradition aquacole dans cette région. Dans un rayon de 18 km de la ville de Kisangani, 45 pisciculteurs ont été interrogés. Dans la région de Kisangani, 44 % des pisciculteurs ont jusqu'à 15 ans d'expérience, mais seulement 7 % ont 25 à 35 ans d'expérience en pisciculture. Environ 90 % des pisciculteurs interrogés ne sont membres d'aucune association piscicole. Les pisciculteurs de cette région pratiquent principalement la polyculture. L'espèce la plus cultivée est *Orechromis niloticus*, suivie de *Clarias gariepinus* et de *Parachanna obsura*. Il n'existe pas d'aliments élaborés pour poissons sur le marché de Kisangani et de ce fait l'alimentation du poisson reste très basique. La plupart des pisciculteurs (64 %) utilisent du son de riz; 42 % utilisent les déjections de porc; 78% utilisent les déchets ménagers et environ 22 % n'alimentent pas les poissons. La production moyenne est de 11,4 Kg/100 m^2 tandis que la production la plus faible et la plus élevée étaient respectivement de 4,0 Kg et 29,5 Kg/100 m^2. Les poissons sont vendus sans aucune transformation après la récolte en lots ou par pièce selon leur taille. En conclusion, l'aquaculture dans la région de Kisangani fonctionne à un niveau très traditionnel. Cependant, la culture de la pisciculture y est mieux établie que dans d'autres pays d'Afrique subsaharienne. La croissance du secteur est actuellement entravée par des technologies limitées, une formation insuffisante, le manque d'aliments pour poissons et le manque général de soutien pour les pisciculteurs. Le potentiel aquacole est important car tous les atouts climatiques de la région sont propices pour l'aquaculture.

Mots-clés: Aquaculture, région de Kisangani, étangs, alimentation.

INTRODUCTION

Aquaculture accounts for an increasing proportion of global fish supply and is widely considered to have an important role in meeting increased future demand for fish (Troell *et al*., 2014). This growth into one of the fastest growing food production sectors has been spurred increased for animal protein for human consumption. Therefore, fish are an increasingly important option in animal protein production but it requires good quality feeds and suitable culture conditions to keep fish healthy and favour growth (Lara *et al*., 2003). Furthermore, in addition to animal protein, fish contain unique long-chain poly-unsaturated fatty acids (LC-PUFAs) and highly

[1] Laboratory of Aquaculture and Biodiversity Management Faculty Institute of Agronomic Sciences of Yangambi (IFA-Yangambi) P.O. Box 1232 Kisangani, DRC
[2] Laboratory of Hydrobiology,University of Kisangani P.O. Box 2012 Kisangani, RD Congo
[3] Laboratory of Hydrobiology,University of Zimbabwe P.O. Box MP 167, Mt. Pleasant, Harare, Zimbabwe. Corresponding author: drtnhiwatiwa@gmail.com

bioavailable essential micronutrients-vitamins D and B, minerals (calcium, phosphorus, iodine, zinc, iron, and selenium). These compounds, often not readily available elsewhere in diets, have beneficial effects for adult health and child cognitive development (Hlope, 2014).

Aquaculture sector has not simply increased the availability of fish but it has also prevented prices from rising as they would have if only wild fisheries were to meet the general increase in demand (World Bank, 2013). This is due to the declining or stagnant growth in fisheries production as global fish stocks have been increasingly over exploited. In general, aquaculture has contributed to poverty reduction directly and indirectly by providing food, income, and employment for both producers and other value chain actor households. Commercial fish culture systems have been shown to limit price increases of fish, leading to their increased consumption by both extremely and moderately poor consumers (Toufique and Belton, 2014).

In the Democratic Republic of the Congo (DRC), aquaculture has a long and tumultuous history. The first aquaculture trials were carried out between 1937 and 1945, initially in the Provinces of Katanga (at Lubumbashi) and Kasaï Oriental (at Ngandajika), then in Bandundu Province (Kwango and Kwilu), and lastly in the Orientale and Kivu Provinces (FAO/ADB, 1990). By 1959, 120 000 ponds had been built covering a total surface area of 4 000 ha producing over 6 000 tonnes a year, accounting for about 4 percent of aggregate national fish production (FAO/ADB, 1990). In the post-colonial period, the industry basically collapsed but there is now renewed thrust and interest for its revival. Aquaculture development is currently the mandate of the Ministry of Agriculture. In DRC, Aquaculture development in the DRC is coordinated by the National Aquaculture Service (NAS) under the Ministry of Agriculture, Fisheries and Breeding. The NAS was established in 1992 after the cessation of the various projects (Belgian project, French project and USAID project) that gave subsidies and provided extension services to fish farmers. The NAS is supposed to implements support programs across the country. The practice of aquaculture in the DRC is not based on any legislation or regulation. The various projects initiated by a number of bilateral and multilateral agencies have not produced the expected results (Kombozi, 2010).

The current low production of fish in the DRC provides an estimated an annual fish availability per capita estimated at 4.5 kg of fish/person/year, while the FAO has estimated the demand at 21 kg/person/year (FAO, 2009). In Kisangani region, the price of fish is ever increasing given the high demand for fish driven also by an increasing population growth and reduced supplies from traditional fisheries (Kathavo, 2012). As a result, the Democratic Republic of Congo imports large quantities of frozen fish in order to meet the local demand of fish.

The Democratic Republic of Congo is drained by a dense river network and more or less evenly distributed throughout the territory. The total area covered by water is 86,080 km^2 or 3.7% of the total land area largely dominated by the Congo River by both its power, its length (4,700 km) and the extent of its basin. However, the productivity of its fisheries on lakes and rivers and streams has dropped dramatically due to global climate change as elsewhere in the world, but especially due to the lack of effective regulation of fishing and the use of unsuitable fishing materials. This resulted in an increase in fishing effort on certain more or less secure areas. Fishing as currently practiced in DRC, does not allow for sustainable exploitation of fisheries resources (Luhusu and Micha, 2013).

Many potential aquaculture sites remain unexploited in Kisangani, while many aquaculture sites are now abandoned and aquaculture production is now very low. Fish is acknowledged as a major nutrient-dense animal source food for a significant proportion of the nutritionally vulnerable people, overshadowing that of most of terrestrial animal foods (Béné *et al*., 2016). Before any interventions are done by the government and NGOs in promoting aquaculture, it is important to first understand and develop a baseline that creates an understanding of the current situation and factors that have either made aquaculture a success or a failure. This study is based on the hypothesis that the fish farmers of the region are not supervised so they abandon this activity that is not profitable due to the low productivity of the aquaculture ventures. The aim of this study is to provide a first insight into aquaculture in a country that is little studied and yet has some of the best natural environments for aquaculture. Factors that account for the low aquaculture productivity by fish farmers in Kisangani region are also investigated.

MATERIALS AND METHODS

Study Area

The study was conducted at Kisangani region comprising an 18km radius of the city of Kisangani. Located in the northeast of the country, Kisangani is the capital city of Tshopo Province and the third largest city of DRC. Kisangani region (0° 31›N, 25° 11'E) is situated at an average altitude of 428 m . Kisangani region has an estimated population of 1.3 million inhabiting an area of about 1900 km^2 (INS, 2009). It has six urban municipalities including five on the right bank of Congo River and another one on the left bank of the same river. The situation of Kisangani near the equator gives him an equatorial continental climate. The ponds surveyed in this are presented in Figure 1 below.

Data collection

The data collection survey on fish farming in Kisangani region was carried out from June to November 2015. Different agencies responsible of fisheries and aquaculture as well as NGOs were consulted for information on the location of fish farms in Kisangani region and any other data they had on aquaculture. Data were also obtained by the surveys carried out interviewing fish farmers using a field-based questionnaire. An individual interview approach was used instead of focus group discussions because it was difficult logistically to bring the fish farmers to one place. Physical inspections and assessments of each fish farm was also an important element of the data collection tool. The fish farm assessments involves documenting husbandry practice and also collecting data on number of ponds, state of ponds , size of the ponds and the fish species cultured at the farm

(Poll and Gosse, 1995). A GPS was used to locate each site to produce a map of the location of all the inventoried fish farms in Kisangani region. The fish farmers considered in this study are those who had a minimum of 100 m^2 of ponds surface area, and for this study, 45 fish farmers participated in the data collection exercise.

In summary the following information was obtained:

- When the farmer started fish farming,
- Membership of a fish farmers association,
- Cultured fish species,
- Feeds supplied to the fish,
- Amount of fish harvested,
- Post-harvest processing of fish,
- Marketing and sales system and
- Difficulties encountered by fish farmers engaged in aquaculture.

RESULTS

Period farmers have practiced in fish farming

The period farmers have engaged in fish farming by Kisangani region's fish farmers is presented in the Table 1. In general, 35.6 % of fish farmers in Kisangani region have been practicing for 0-5 years; 24.4 % have been active for 6-10 years; and another 24.4 % have also been active for 11-15 years old. Very few farmers have been in the industry for more than 15 years (Table 1).

Table 1: Periods engaged in aquaculture by different fish farmers in Kisangani region (2015)

Duration	Frequency	%
0-5	16	35.6
6-10	11	24.4
11-15	11	24.4
16-20	3	6.7
21-25	1	2.2
26-30	2	4.4
31-35	1	2.2
Total	**45**	**100**

Membership of a fish farmers association

The majority of the fish farmers interviewed (about 90%) were not members of any fish farmers association. There is no dedicated fish farmers association but a few of the farmers belonged to a general farmers association in which fish farming is one of the activities.

Cultured fish species

The main fish species cultured by fish farmers in Kisangani region are presented in the Table 2. The results show that *Oreochromis niloticus* is cultured by all the Kisangani's fish farmers interviewed. *Clarias gariepinus* was the second most preferred fish species among the fish farmers with nearly 96% of the farmers also culturing.

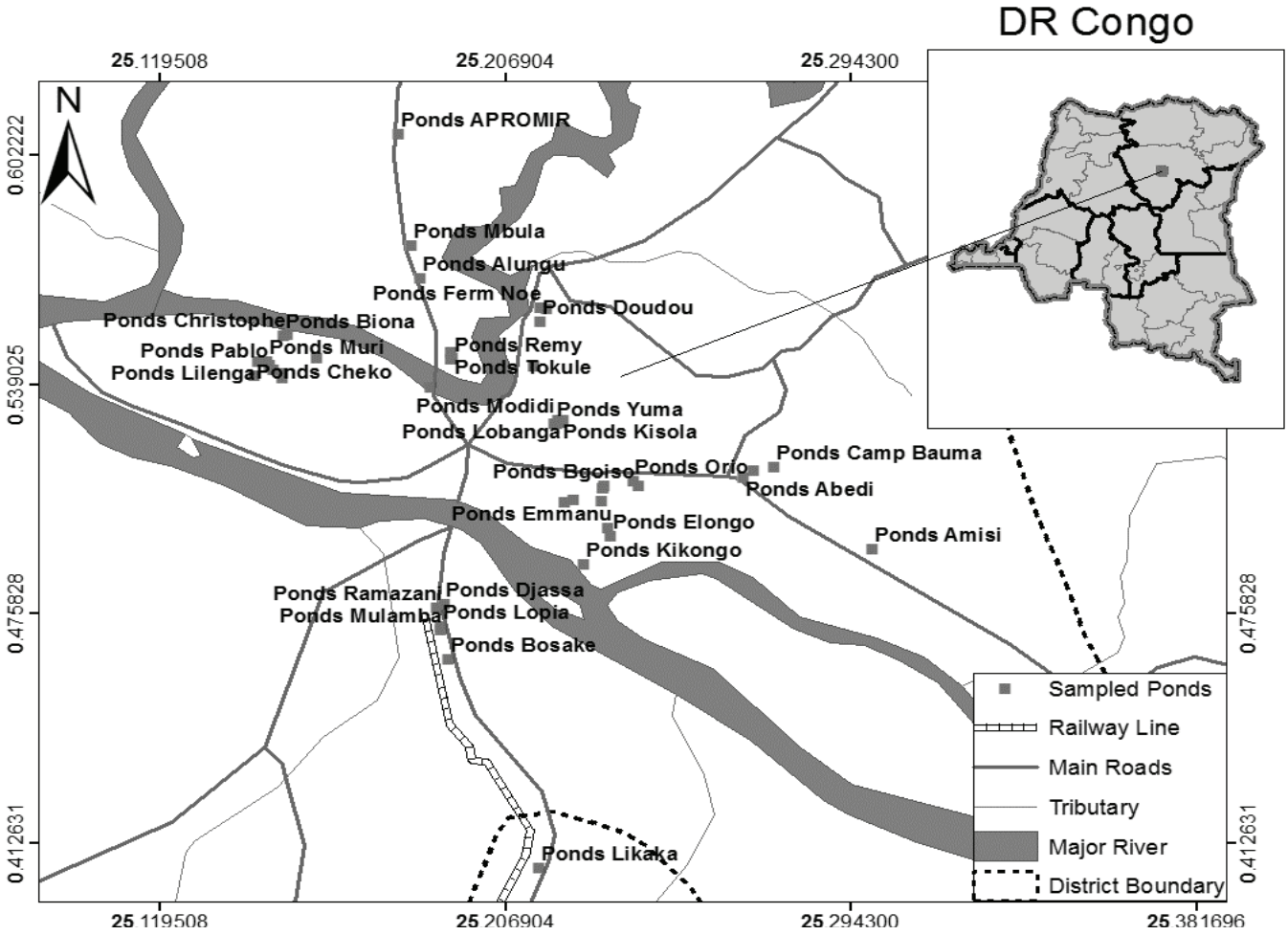

Figure 1: Study area of Kisangani region, (DRC) and the location of fish ponds

This was followed by *Parachana obsura* cultured by 57.8% of farmers. *Labeo velifer*, *Auchenoglanis occidentalis* and *Citharinus gibbosus* were the least cultured by fish farmers. Most fish farmers practice polyculture with the following species being cultured together: *O. niloticus* x *C. garipeinus* - 17.8% farmers; *O. niloticus* x two others species - 42.2% farmers; *O. niloticus* x three other species - 20% farmers; *O. niloticus* x four other species - 11.1% farmers; *O. niloticus* x five others species - 4.4% farmers; and only 4.4% farmers practice monoculture of *O. niloticus*.

Table 2: Cultured fish species in Kisangani region (2015)

Species cultured	Frequency	% of fish farmers
Oreochromis niloticus	45	100.0
Clarias gariepinus	43	95.6
Parachana obscura	26	57.8
Auchenoglanis occidentalis	10	22.2
Labeo velifer	10	22.2
Citharinus gibbosus	9	20.0

Fish feeds

The different feeds that are given to fish in Kisangani region are presented in Table 3. The feeds are so basic and are mostly poor in protein. Among Kisangani's fish farmers, 22.2% did not feed fish at all; 64.4% used rice bran; 42.2% used pigs waste and 37.8% used household wastes to feed fish as their main feeds. However, most farmers used a combination of feeds depending on availability and a number of farmers on average used three or four types of feeds. None of the farmers in this survey used commercially manufactured fish feeds.

Table 3: Fish feeds used by fish farmers in Kisangani region

Feeds	Frequency	%
None	10	22.2
Rice bran	29	64.4
Pigs waste	19	42.2
Household wastes	17	37.8
Different kind of leaves	8	17.8
Total	83	184.4

Fish productivity of fish farms

A significant number of fish farmers in this study did not know how much they harvested from their fish ponds as they do not keep records. It was only those farms that had detailed records of their production that are presented in Table 4. From the results, an average pond surface area of 61.1 m^2 yields an average fish production of 11.1 kg/m^2. There was great variability in the productivity of the different farms (C.V. = 74.9%) in Kisangani region and there was no relationship between pond size and fish production.

Table 4: Estimated fish production per acre (100 m^2) of pond in Kisangani region

No.	Surface (m^2)	Production (kg/m^2)
1	7.5	4.0
2	200	29.5
3	36	7.2
4	70	6.6
5	14	22.0
6	150	4.8
7	100	5.95
8	17.5	6.3
9	7.5	16.0
10	8.5	11.7
Total	611.0	114.0
Mean	61.1	11.4
SD	68.35	8.5
CV	111.87	74.9

Post-harvest processing and marketing

All the fish farmers interviewed in Kisangani region do not practice any post-harvest processing of fish after harvest. Fish were either sold freshly caught and ungutted (i.e. round fish) or after some storage in the freezer as frozen fish. The sale of farmed fish was done mostly on site. Among the fish farmers, only 13.3% sold their fish weighed per kilogramme, while others (about 86.7%) sold in lots or as singles. Fish sold as singles were the bigger ones, while the smaller fish were sold per lot. However, the weight of the single fish or lots were not known by the fish farmers or their customers. The prices of fish are very high at US$5 per kilogramme.

Major Constraints

The major constraints for aquaculture development in Kisangani region are presented in Table 5. From this table, it clears that the lack of institutional support to fish farmers is the main constraint to the development of aquaculture in this region. The farmers also highlighted that losses of stock due to theft was also a serious constraint for fish farmers. Finally, the unavailability of commercial fish feeds in Kisangani region is also a major constraint and fish farmers have to make do with on farm products as fish feed supplements.

Table 5: The major constraints for aquaculture development in Kisangani region from the fish farmers perspective

Major constraints	Frequency	%
Losses due to theft	24	53.3
Lack of institutional support	29	64.4
Unavailability of commercial feeds	9	20.0

DISCUSSION

The most interesting outcome of this study was the discovery that fish farming is still being practiced in the region without any significant institutional or government support for the sector. In Kisangani region, 84.4% of fish farmers had up to 15 years' experience but only about 7% have farmed fish for 26-35 years. For such a small area, the number of fish farmers was impressive compared to other African countries like Zimbabwe where small holder aquaculture is in its infancy. Hence, aquaculture is an established agricultural practice in the DRC and is not a new concept. This therefore present a unique opportunity for the further promotion and development of the industry. However, the need for institutional support was very evident as most fish farmers did not have sound knowledge of what this industry requires and are therefore in need of training. Some of the fish farmers have already accumulated several years' experience culturing fish and further training would only serve to strengthen their operations since they have some practical appreciation. Furthermore, due to the lack of adequate institutional support, the fish farmers have not been able to organise themselves into an association that would further strengthen their industry. An association would make it easier for farmers to lobby for resources and services, and they can support each other to develop aquaculture from their individual experiences. As a result, most farmers started aquaculture without knowledge of elementary principles, except that they had acquired a favorable site. Training is required for fish farmers in Kisangani region to promote and to properly ensure the sustainability of aquaculture (ACF, 2013).

The fish farmers in this region mainly practice polyculture, with *Oreochromis niloticus* and *Clarias gariepinus* being the most cultured fish species in Kisangani region. These findings agree with the results of the report on the state of fish farming state in Eastern province (DRC) done by FAO (2007). Besides these two species, others wild species having a great commercial interest and are also cultivated by fish farmers in Kisangani region (Micha, 1974). These species are *Parachana obscura, Labeo velifer, Auchenoglanis occidentalis* and *Citharinus gibbosus.* The fingerlings and juveniles of these wild fish species are collected in natural areas (rivers and streams) because most of them do not reproduce in ponds. However, in ponds they grow faster than *Oreochromis niloticus* because there is absence of reproduction and so most of energy is used for growth. *Oreochromis niloticus* uses considerable energy in egg production and does feed when incubating eggs (Bahnasawy, 2009). Many fish famers cultured those species that are omnivorous, herbivorous and microphagous except *Parachana obscura* which is a fish-eating predator. The predatory fish are stocked in the same ponds with others species and they serve to regulate the number of tilapia fingerlings.

The basic idea of polyculture is growing species with complementary or minimal competing feeding habits and different ecological requirements that can utilize different trophic niches in the pond (Milstein, 2005). Indeed, a fish community with different diets can increase the net return and so the value of production per unit of surface. However, doing polyculture with several species having the same diet can decrease growth performance resulting in a low yields, as the subordinate species is outcompeted and its food intake scaled down significantly. Due to lack of adequate training, some fish farmers in Kisangani were mixing fish species that have the same trophic guild which results in increased competition and subsequent low yield. Pond yield can increase if the target species are in general species lower in the food chain with precocious breeding like tilapia and predators are included to control the population (ACF, 2013). *Parachana obscura* a fish-eating predator, and *Clarias gariepinus* an omnivorous species are both ideal species for the control of tilapia populations in ponds.

Feeds given to fish in Kisangani region consists of various plant products because commercially manufactured feeds are not available. Fish farmers do not know how to make their own fish feeds from the locally available ingredients (Liti *et al*; 2006). It was noted that a diet containing 30% crude protein was suitable and economical for Nile tilapia growth (Bahnasawy, 2009), and so plant and animal products available in Kisangani region can be mixed up to give a consistent feed for fish needs. Other farm products like rice bran, pigs waste, leaves and household wastes should not be used for feeding fish but rather as fertilizers to manure the ponds because many of the cultured species are herbivorous and omnivorous. The use of such fertilizers can actually reduce the quantity and cost of supplemental feeds. Nile tilapia, the main cultivated species in Kisangani region is a diversified feeder, also feeding on green and blue green algae, diatoms, zooplankton and benthic organisms which contain high amount of protein which provides additional protein to fish cultivated in earthen ponds (Omar, 1994b). Increase in natural food in ponds has a great effect on tilapia production but a complementary feed could have a positive effect on fish growth and the yield. Results of the study by Brown *et al*. (2002) indicated that reducing feeding rates either by delaying the introduction of feeds or by feeding less than the amount required for satiation had no effect on growth or yield of fish reared in fertilized ponds. Feeding using only natural feed would not have a positive yield and this is why Kisangani aquaculture production is very low.

Fish productivity was low overall in Kisangani region (11.4 kg/acre/year or 1.14 tonnes/ha/year), but in comparison to another, ACF (2013) reported annual return of around 1-15 tonnes/ha/year for ponds with 1 to 5 fish per m^2 in polyculture system. Similarly, Abou et al. (2007) reported harvests of 28.8 kg to 101.4 kg/acre/year when feeding Nile tilapia with diets comprising 28.5% crude protein in fish ponds with varying levels of *Azolla* and stocking densities. Therefore the main reasons of low return of ponds in Kisangani region could be the lack of good quality fish feeds; too high or too low stocking densities; poor pond fertilization; and poor water quality management.

Fish farmers in Kisangani region sell their fish without any post-harvest processing so there is no value addition.

Fish sold on site and without any post-harvest processing are sold cheaper and the reason for this is that they have to be sold quickly before the fish starts to decompose. Processing of fish is important, as it gives post-harvest value addition to fish products and can increase returns of fish farming. Processed and preserved fish can also be sold after long time when and where demand is better and fish farmers acquire better bargaining power. Nile tilapia harvested by farmers are actually easier to process than catfish. This is because lean, small fish such as tilapia are much easier to process than large, fatty fish like catfish (ACF, 2013). Lack of leadership and cohesion among fish farmers is a weakness and is also the cause of why there is a poor fish marketing system. If fish farmers were in associations, they could come up with better marketing strategies.

According to the fish farmers, lack of institutional support is the main constraint for fish farming development in Kisangani region. In fact, for aquaculture production to increase it is important to invest in people through capacity building in fish farming techniques. This will help fish farmers to acquire knowledge on the principles of pond construction; stocking; feeding; fish processing; and maintenance of ponds after harvesting the fish. In addition if fish farmers are supported, they can also be organized into an association for the development of their activity and be able to lobby government structures responsible for the necessary support. Financial support in the form of loans or credit to eligible fish farmers can also increase aquaculture production in this region as farmers can increase the number of ponds and improve overall management. To improve security, fish farmers should also get organized and maybe invest in collective security as this lessens the burden. Although this may increase the cost of production, the current situation requires that they take measures otherwise fish farming would not be a viable venture.

CONCLUSION

In conclusion, Kisangani region's aquaculture is an established agricultural practice and is not a new concept, but it remains very basic. However, the interest is there despite all the challenges the country has faced. The growth of the sector is being currently hampered by limited technology, inadequate training, lack of feeds and overall lack of support for fish farmers. We recommend as means of increasing fish production the introduction of technical training for the farmers and funding to equip them with the necessary technology.

ACKNOWLEDGEMENTS

The authors thank the OWSD (Organization for Women in Science for the Developing World), IFA Yangambi (Agronomic Institute Faculty of Yangambi), University of Kisangani (Democratic Republic of Congo) and the University of Zimbabwe for their contributions to this study. We would like to thank also the fish farmers in Kisangani region who provided information all the data for this study.

REFERENCES

Abdel F., (2002). Effects of stocking density and feeding levels on growth and feed efficiency of farming Nile tilapia (*Oreochromis niloticus* L) fry. *Aquaculture Research,* 33: 621 -626.

Abou Y., Fiogbe E. D. et Micha J.-C. (2007). Effects of stocking density on growth, yield and profitability of farming Nile tilapia, *Oreochromis niloticus* L., fed *Azolla* diet, in earthen ponds. *Aquaculture Research*.38 :595 -604.

ACF. (2013). La pisciculture de subsistance en étangs en Afrique: Manuel technique. 294 p.

Alanärä A. et Brännäs E. (1996). Dominance in demand-feeding behaviour in Arctic charr and rainbow trout: the effect of stocking density. *Journal of Fish Biology,* 48:242-254.

Al Hafedh Y. S. (1999). Effects of dietary protein on growth and body composition of Nile tilapia, *Oreochromis niloticus* L. *Aquaculture Research*, 30:385-393

Bahnasawy M. H.(2009). Effect of Dietary Protein Levels on Growth Performance and Body Composition of Monosex Nile Tilapia, *Oreochromis niloticus* L. Reared in Fertilized Tanks. Pakistan *Journal of Nutrition.* 8: 674-678.

Barki A. etbKarplus I.(2016). The behavioral mechanism of competition for food between tilapia (*Oreochromis* hybrid) and crayfish (*Cherax quadricarinatus*). *Aquaculture*. 450: 162-167.

Béné C., Arthur R. Norbury H. , Allison E. H., Beveridge M., Bush S., Campling L., Leschen W., Little D., Squires D., Thilsted S. H., Troell M., Williams M. (2016). Contribution of fisheries and aquaculture to food security and poverty reduction: Assessing the current evidence. *World Development,* 79: 177-196

Beya I.C. (2014). Etat de lieu de la pisciculture dans la commune de Makiso. Travail de fin de cycle. inédit IFA Yangambi 30p.

Brown C., Bolivar R., Jimenez E., Szyper J.(2002). Reduction of feed rations below satiation levels in tilapia pond production. In:K. McElwee, K. Lewis, M.

Nidifferand P. Buitrago (Eds.). Nineteenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP, Oregon State University, Corvallis, Oregon, pp: 21-23.

De Silva S., Gunasekera R.M., Atapattu D.(1989). The dietary protein requirements of young tilapia and an evaluation of the least cost of dietary protein levels. *Aquaculture*. 80 :271-284

FAO (2009). Profils des pêches par pays: Vue générale du secteur de pêche national République Démocratique du Congo (FID/CP/RDC) août 2009.13p.

FAO. (2007). Rapport de l'état de lieu de la pisciculture en Province Orientale. Projet Assistance à la Définition de la Stratégie nationale et Plan de développement de l'Aquaculture en RDC TCP/DRC/3102, 33p.

FAO/BAD. (1990). Vue générale du secteur aquacole national, République démocratique du Congo. Rapport annuel 6p.

Gunasekera R.M., Shim K.F. et Lam T.J.(1995). Effect of dietary protein level on puberty, oocyte growth and egg Chemical composition in the tilapia, *Oreochromis niloticus* (L.). *Aquaculture*. 134:169-183.

Hlpe N. (2014). Sustainable fisheries and aquaculture for food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome, 119 p.

Institut National des Statistiques (INS) (2009). Rapport annuel de l'Institut National des Statistiques. Kinshasa: Ministère du Plan, Province Oriental

Kathavo K.S. (2012). Sélection et amélioration génétique du tilapia en zones tropicales demontagnes: réponse comparée entre populations locales et populations importées. Thèse présentée et défendue en vue de l'obtention du grade de Docteur en Sciences agronomiques, Université Catholique du Graben. Faculté des Sciences Agronomiques-Facultés Universitaires Notre Dame de la Paix de Namur Faculté des Sciences. Pp 6-8.

Kawarazuka N., Béné C. (2010). Linking small-scale fisheries and aquaculture to household nutritional security: *An overview. Food Security*, 2: 343-357.

Khaldi A.F. (2010.) Effect of different stress factors on some physiological parameters of Nile tilapia (*Oreochromis niloticus*). *Saudi Journal of Biological* Sciences 17: 241-246.

Lara-Flores M., Olvera-Novoa M. A., Guzma´n-Me´ndez B.E., Lopez-Madrid W. (2003). Use of the bacteria Streptococcus faecium and Lactobacillus acidophilus, and the yeast Saccharomyces cerevisiae as growth promoters in Nile tilapia (*Oreochromis niloticus*) *Aquaculture,* 216: 193-201.

Likobe .O. G. (2014). Etat de lieu de la pisciculture dans la commune de Mangobo. Travail de fin de cycle inédit IFA Yangambi 28p

Liti D.M., Mugo R.M., Munguti J.M., Waidbacher H. (2006). Growth and economic performance of Nile tilapia (*Oreochromis niloticus* L.) fed on three brans (maize, wheat and rice) in fertilized ponds. *Aquaculture Nutrition,* 12: 239-245.

Luhusu K.F., Micha, J.C. (2013). Analysis of exploitation means of Lake Mai-Ndombe fisheries resources in Congo Democratic Republic. *Geo-Eco-Trop,* 37: 273-284

Maki A.J.(2014). Etat de lieu de la pisciculture dans la commune de la Tshopo. Travail de fin de cycle inédit IFA Yangambi 31p

Micha J.C. (1974). La pisciculture africaine, espèces actuelles et espèces nouvelles. Zoologie et Assistance technique, (J.Cl. RUWET ed) pp. 163-195.

Milstein A., (2005). Polyculture in aquaculture. Anim. Breed. Abstr. 73, 15N-41N.

Omar E.A., (1994). Supplementary feeding of tilapia (*Oreochromis niloticus*) cultured in earthern ponds.1-Effect of dietary protein levels and sources. *Alex. J. Agric. Res.,* 39: 109-128

Poll, M., Gosse J.P. (1995). Genera des poissons d'eau douce de l'Afrique. Mémoire de la Classe des Sciences, Collection in-8°, 3è série, Tome IX. Académie royale de Belgique, 324p.

Toufique K.A., Belton B. (2014). Is aquaculture pro-poor? Empirical evidence of impacts on fish consumption in Bangladesh. *World Development,* 64: 609-620

Troell M., Naylor R.L., Metian M., Beveridge M., Tyedmers P. H., Folke C., de Zeeuw A. (2014). Does aquaculture add resilience to the global food system?. *PNAS*, 111:13257-13263

World Bank (2013). Fish to 2030. Prospects for Fisheries and Aquaculture, World Bank Report Number 83177-GLB.