ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2016; 4(3): 428-435

www.fisheriesjournal.com
Received: 18-03-2016
Accepted: 19-04-2016

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Tilapia cage culture in Rwanda: Current status and prospects for future development

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Abstract
The objectives of present study were to investigate the current situation of tilapia cage culture as well as the constraints affecting the current production system and its economic indicators in Rwanda. The findings of this study revealed that there were 52 tilapia cage operators located in four lakes (Kivu, Ruhondo, Burera and Muhazi) and grouped into 23 tilapia cage-based parks with a total of 656 floating cages. Most of the floating cages installed were not restocked due to various reasons such as lack of funds to buy feed, lack of fingerlings and high mortality rate of fingerlings. The management practices were found to vary from one operator to another. Most of the operators did not undertake the innovative and adequate management practices such as optimum stocking, stock manipulations, sexing and grading, disease control and prevention, records keeping on inputs and outputs of the cage culture operations due to lack of knowledge and know-how skills. The operators have been sensitized and motivated by the Government to start or adopted tilapia cage farming through subsidised inputs provision. As consequences, there was a high dependency of most of the operators to donors. Both technical and socio-economic factors were found to slow down the adoption of this new technology in Rwanda.

Keywords: Tilapia (*Oreochromis niloticus*), cage culture, current, future, prospects, Rwanda

1. Introduction

Aquaculture in Rwanda has been predominantly land-based subsistence system since its inception in the 1950's [10]. In most of East African Countries, aquaculture is still at premature state. In Uganda and Kenya the sector is more advanced, whereas in Rwanda and Burundi is less developed. Small scale aquaculture is a dominated system with extensive production of Tilapia and/or African catfish in earthen ponds [2, 4, 5].

National demand for fish is steadily increasing parallel with the expansion of national population. The current fish production in 2012 was estimated at 17,158 MT, all from capture fisheries. The aquaculture sector has not yet developed and its contribution to natural fish production is still insignificant [9]. For supplying an increase fish demand, Rwanda is straggling to reach the level of sub-Saharan fish per capita consumption of 6.7 kg per year while Rwandan annual fish consumption is still at 1.5 kg annual per caput [8].

However, since 2000 the development of cage culture technology has been recommended by Government of Rwanda due to its substantial contributions on livelihoods, food demand and poverty alleviation [8]. Thus, Tilapia cage culture technology has been frequently tried and piloted in Rwandan water bodies. The first trials and piloted projects at both households and commercial scales have been conducted from 2000 to 2003 in lake Kivu by the fishermen cooperative through FAO and USAID funds (Kampayana and Ntakirutimana, 2003 unpublished dissertations). Unfortunately, after the period of first trials, this new introduced aquaculture technique has not been expanded and all infrastructures had completely depleted without any trace.

The technology was still remained at the experimental and demonstration levels for over the decade and it has been rejuvenated in 2010 by Inland Lakes Integrated Development and Management Support Project (PAIGELAC). Recently, this new technology has been largely piloted and adopted in the most potential lakes.

Rwanda is blessed with abundant network of inland lakes, rivers and wetlands which provide the fundamental for supporting aquaculture development and economic growth of the country [8]. There are 24 inland lakes which occupy 128,000 ha of total surface area and most of these water resources are suitable for aquaculture production [1]. The potential for aquaculture that has been ascertained for commercial tilapia cage farming exceeds 50 cage-based parks of more than 150,000 floating cages in only three large Rwandan lakes (Kivu, Burera and Ruhondo) [8]. The Government of Rwanda is now calling for both local and foreign investors to jump in this sector. The objectives of present study were to investigate the current situation of tilapia cage culture as well as the constraints affecting the current production system and its economic indicators in Rwanda.

2. Materials and methods

2.1. Study area

In Rwanda, tilapia cage culture was only practiced in four lakes; Burera, Ruhondo, Muhazi and Kivu (Figure 1). This study was conducted from January to June 2014 and due to small population no sampling method used for this study. A total of 23 cage-based parks were visited and all 52 tilapia cage operators were surveyed using structured questionnaires which were personally administered to respondents.

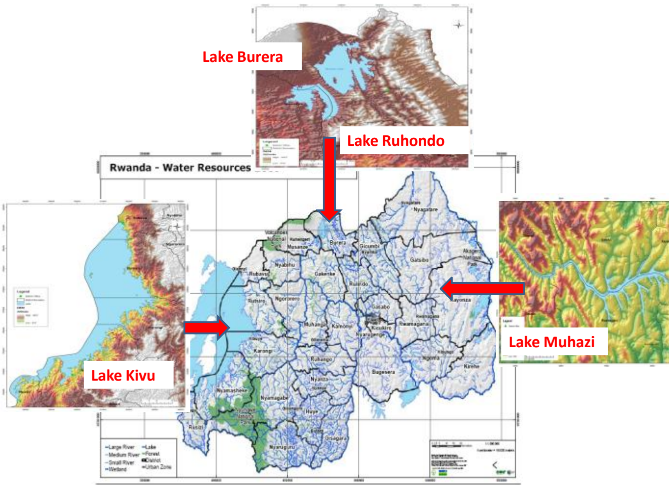

Fig 1: Study area (Rwanda Map showing the water resources and potential lakes of tilapia cage culture)

2.2. Study design

Primary data collected included the information on the socio economic of tilapia cage operators, management practices and constraints of the current tilapia cage culture system. Additional relevant information was obtained from personal field observations and in-depth interviews with key informants and stakeholders.

The evaluation of economic efficiency followed the traditional procedures of financial analysis for agriculture projects according to Gittinger [3]. The profitability was measured per unit of 10 cages of 8 m^3 each and expressed in monetary value. Two kinds of income were calculated based on the optimum production recorded; total income was calculated by multiplying the quantity of total harvest by the selling unit price and net profit which was calculated by subtracting the total costs from the total income. Break-even points and rates of return as a measure of production efficiency were also calculated according to Shang [14].

2.3. Statistical analysis

Data were analysed using SPSS 18 software while Microsoft Excel was used to prepare graphs and tables. Pearson Correlation Coefficient at P = 0.05 and P = 0.01 levels was used to generate the significant correlations between parameters.

3. Results

3.1. Current situation of tilapia cage culture in Rwanda

The survey included 52 respondents practicing commercial cage culture in Rwanda. All respondents are distributed in four lakes; at the proportion of 50 %, 25%, 13% and 12% in lake Burera, Ruhondo, Muhazi and Kivu, respectively (Figure 2). So, all 52 tilapia cage operators were identified and most of them (50%) were located in lake Burera.

Among 52 tilapia cage operators; 86% of them are the fishermen cooperatives working in their respective fishing zones, 8% reported to work as individual operators and other 6% reported to work as domestic companies (Figure 3). All cage operators were engaged in only grow-out Tilapia. Therefore, the current tilapia cage operators were mostly (86%) the fishermen cooperatives operating fishing activities in the same lake.

A total of 656 tilapia cages were recorded from all cage sites; only 19.5% of them were active cages and 80.5% of installed cages were not restocked. A big number of cages was counted in lake Kivu (225), which is the largest lake followed with lake Burera (215) (Figure 4).

The majority of respondents; 85%, 67%, 65% and 56 % in lakes Ruhondo, Kivu, Burera and Muhazi respectively, reported to manage medium size of cage farms. Large cage farms with more than 50 cages each were found only in lake Kivu (33% of respondents from lake Kivu). Also no small size of cage farms found in lake Kivu, they were all located in three lakes: Muhazi; Burera; and Ruhondo. There were several large cage farms that found in these three lakes. Thus, the majority of tilapia cage operators from all lakes were managing 10 to 50 cages of 8 cm3 each (i.e. 2m x 2m x2m). The large farms of more than 50 tilapia cages were recorded only in lake Kivu (Figure 5). All cages were used for tilapia grow out system.

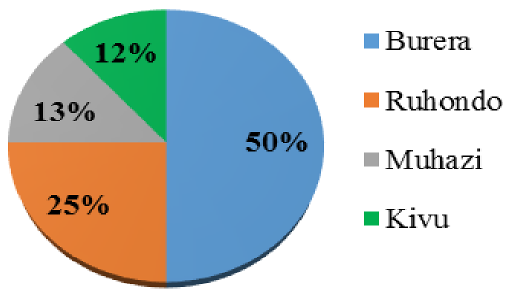

Fig 2: Repartition of tilapia cage operators in lake Kivu, Ruhondo, Burera and Muhazi. Rwanda, 2014

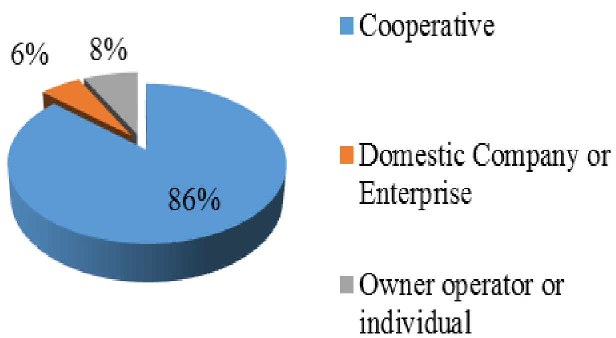

Fig 3: Organization of tilapia cage operators in lake Kivu, Ruhondo, Burera and Muhazi. Rwanda, 2014

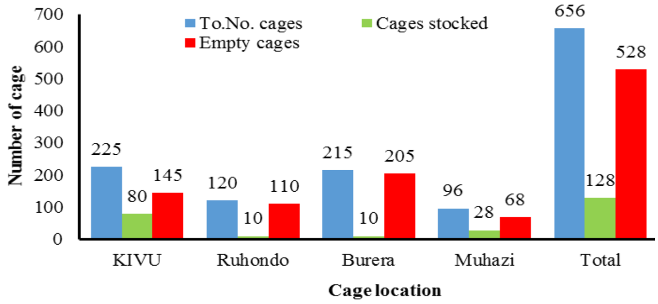

Fig 4: Repartition of tilapia cages in lakes Kivu, Ruhondo, Burera, Ruhondo and Muhazi. Rwanda, 2014

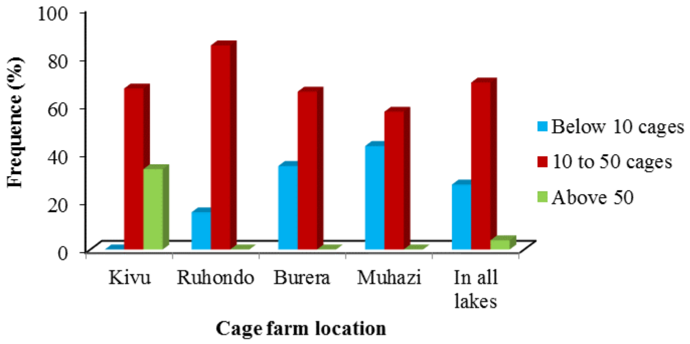

Fig 5: Proportion of tilapia cage farm size among 52 operators in lake Kivu, Ruhondo, Burera and Muhazi. Rwanda, 2014.

3.2. Management practices currently applied

The management practices currently applied in tilapia cage culture were found to be vary from one operator to another and from one location to another. But the operators within cage-based park were characterized by common management practices and approach. From all locations, the majority of them were characterized by a lack of innovative and best management practices (BMPs) such as optimum stocking (Table 1), cage inspection and maintenance, water quality and environmental monitoring (Table 2), stock manipulations, sexing and grading (Table 3), adequate feeding Table 4) which effects lead to big loss, fish escape, high mortality rate, low growth; thus low productivity.

The results from Table 1 showed that the majority (88.4%) of tilapia cage operator continued to respect a stocking density of 1501 to 2000 tilapia fingerlings per cage of 8m3 as recommended. The size of stocked fingerlings was varied from 10 to 30 g average weight in most of the operators (94.2%) while few respondents (5.8%) reported to stock bigger size fingerlings of 50 to 100g per head. Most of the fingerlings stocked were produced from Kigembe hatchery (92.3% of respondents). Due to lack of SRT seed in Kigembe hatchery, few cage operators reported to stock MST fingerlings collected from their own pond-reared tilapia (1.9%) and 5.8% of tilapia cage operators from all lakes reported to stock bigger MST fingerlings bought from other pond-based farmers. The price of fingerlings from the latter varied between 50 to 100Rwf per head of 50 to 100g of individual weight.

Furthermore, the Table 2 showed that almost 46.1% of respondents in all lakes reported to practice of cage inspection only when there is a problem such as fish not responding to feeding. 38.5% and 15.4% of respondents from all lakes inspected their cages monthly and biweekly, respectively. Surprisingly, some respondent (17.3%) did not clean the cage nets at all while 25.0% cleaned the nets after harvest. The majority (57.7%) mentioned that the frequency of cleaning depends on the accumulated stuff. The reasons were that during culture period, the cage operators or hired labor feared to dive and inspect or repair the nets; however cage nets inspection, cleaning and fixation were done by lifting up the nets from the water. This technique stressed the fish and that why most of the operators waited to do that after harvest or when there is a problem. Consequently, at the time of the survey, some cage operators reported to face the fish losses cases related to irregularity or absence of cage inspections; even though the majority (59.6%) of respondents in all lakes reported any loss due to lack of cage inspection and maintenances, a big loss of fish was caused by net rupture (21.2% of respondents). Poaching was also reported to cause fish loss (15.4% of respondents) by cutting the net and trapping the fish that going out of cage net. As mentioned by respondents (3.8%), predators (otters and carnivorous fish) caused fish loss by also cutting the nets or jumping into the cage net.

The Table 3 also illustrated that most of the respondents from all lakes reported to practice fish sampling once per crop (55.8%) and twice per crop (34.6%) during stocking and/or harvest while few cage operators (9.6%) reported to practice fish sampling monthly. The stock manipulation was mostly aimed to determine stocking density, fish growth and harvesting size. The Pearson Correlation revealed that the frequency of stock manipulation and sampling was negatively affected by the education level of the operator ($r = -0.49$, $P < 0.01$). Most of the tilapia cage operators stocked MST seed which grow at different rates, for that reason they had to be sexed manually and graded by size to prevent slower growers from competition and to allow similar size of fish at harvest. Surprisingly, only 7.4% of respondents from all lakes reported to grade their fish and 4% of respondents reported to practice stock manipulation aimed to diagnose and treat fish diseases. Fish infection commonly known by most (100%) of the tilapia cage operators was fungal infection which is easily diagnosed by naked eye based on its clinical signs. A big number of tilapia cage operators in all lakes reported a high mortality rate of fish occurred during the first month after stocking and during bad weather. Such mortality rate was fluctuated from 11 to 20% (36.5% of respondents), 31 to 40% (28.8% of respondents) and above 60% (34.6% of respondents from all lakes). The high mortality rate after stocking was resulted from fish stress and wounds caused by transportation and stocking practices.

However, feeding was done daily by broadcasting the feed over the surface of the water in stocked cage. A floating ring about 30 to 50 cm of width, made on mosquito net and fixed on upper portion of the cage net wall were used to stop the feed spread out the cage by winds. No feed tray used for sinking feed. Daily feeding frequency varied from twice (67.3% of respondents from all lakes) to thrice (32.7 %) a day (Table 4). Most (80.8%) of the respondent reported to feed their fish by fish response. This means that all tilapia cage operators observed the fish behaviors during feeding practices; when fish did not actively eat a given feed, the operator stop feeding in order to minimize the wastes of feed. The recommended optimal feeding rate was not respected reasoning to unskilled labor employed to feed the fish. Only few operators (19.2% of respondents from all lakes) respected to feed the fish based on the biomass whereas the amount fed were varied from 1% to 11% of the biomass.

Table 1: Stocking and seed supply

Parameter	Lake Kivu (n=6) %	Lake Ruhondo (n=13) %	Lake Burera (n=26) %	Lake Muhazi (n=7) %	Total (n=52) %
Stocking density (No. of fish per cage of 8m^3)					
1000- 1500 fingerlings	0.0	23.1	0.0	0.0	5.8
1501- 2000 fingerlings	50.0	76.9	100.0	100.0	88.4
2001- 2500 fingerlings	50.0	0.0	0.0	0.0	5.8
Size of fingerlings (g/head)					
10 – 30g	100.0	92.3	100.0	71.4	94.2
50 – 100g	0.0	7.7	0.0	28.6	5.8
Source of fingerlings					
Kigembe hatchery	83.3	92.3	100.0	71.4	92.3
Own fish ponds	16.7	0.0	0.0	0.0	1.9
Neighbor farmers	0.0	7.7	0.0	28.6	5.8

Table 2: Cage inspection and maintenances

Parameter	Lake Kivu (n=6) %	Lake Ruhondo (n=13) %	Lake Burera (n=26) %	Lake Muhazi (n=7) %	Total (n=52) %
Frequency of cage inspections:					
Biweekly	16.7	0.0	15.4	42.9	15.4
Monthly	33.3	30.8	42.3	42.9	38.5
When there is a problem	50.0	69.2	42.3	14.2	46.1
Frequency of cage nets cleaning:					
Not done	0.0	7.7	19.3	42.8	17.3
After harvest	16.7	23.1	26.9	28.6	25.0
Depends on the fouling organisms	83.3	69.2	53.8	28.6	57.7
Cause of occurred fish losses/escapes:					
Not happened	50.0	100.0	53.8	14.3	59.6
Poaching	16.7	0.0	11.5	57.1	15.4
Net rupture	0.0	0.0	34.7	28.6	21.2
Predators	33.3	0.0	0.0	0.0	3.8

Table 3: Fish sampling and stock manipulation purposes

Parameter	Lake Kivu (n=6) %	Lake Ruhondo (n=13) %	Lake Burera (n=26) %	Lake Muhazi (n=7) %	Total (n=52) %
Frequency of fish sampling					
Monthly	33.3	7.7	0.0	28.6	9.6
Twice per crop	50.0	30.8	30.8	42.8	34.6
Once per crop	16.7	61.5	69.2	28.6	55.8
Stock manipulation purpose					
Stocking	27.3	29.5	30.2	30.4	29.7
Determination of fish growth	27.3	29.5	30.2	30.4	29.7
Grading	13.6	6.8	4.7	13.1	7.5
Diagnosis/treat of fish disease	4.5	4.5	4.7	0.0	4.0
	27.3	29.7	30.2	26.1	29.1

Harvest					
Average fish mortality per crop					
11 - 20%	33.3	0.0	42.3	85.7	36.5
31 - 40%	33.3	23.1	38.5	0.0	28.8
Above 60%	33.3	76.9	19.2	14.3	34.7
Period of high mortality rate:					
First month after stocking	83.3	7.7	53.8	85.7	50.0
During bad weather	16.7	92.3	46.2	14.3	50.0

Table 4: Feeding practices

Parameter	Lake Kivu (n=6) %	Lake Ruhondo (n=13) %	Lake Burera (n=26) %	Lake Muhazi (n=7) %	Total (n=52)%
Frequency of daily feeding					
Twice	33.3	84.6	73.1	42.9	67.3
Thrice	66.7	15.4	26.9	57.1	32.7
Estimation method of feeding rate					
Varied amount based on biomass	33.3	46.2	0	28.6	19.2
Varied amount based on fish response	66.7	53.8	100.0	71.4	80.8

3.3. Harvesting practices and marketing system of harvested fish

The grow out period was found to be prolonged from 6 to 12 months, from stocking to harvesting and averaged to 9 months in all study area; this was lead to one crop per year. Due to lack of transport means and storage conditions, partial harvesting system was applied to minimize post-harvest losses. Also because of mixed sex fingerlings stocked, selective harvesting was practiced due to the presence of big and small size fish in the same cage (Table 5). Harvesting of marketable size tilapia was done by lifting up the cage net until the fish were reached then a scoop net was used to transfer the fish from the cage to the basket or boat. Tilapia was removed in a selective manner; fish with desired or marketable size have been removed from the cage and sold while fish with small size or undesired were left in the cage for one or more months until they reached the desired market size. All harvested fish were sold at farm gate to the retailers and individual consumers. As reported by most of the respondents (58.8%), 4 fish/kg equivalents to 250 g average weight of fish were harvested after 9 months. Most of the harvested fish were sold at farm gate market (60.8% of the respondents from all lakes) where the price was varied between 1500 to 2000Rwf per kg of fish. Few cage operators whose cage farms are located near the city or town reported to sell their fish at 2500 to 3000Rwf/kg. The maximum production recorded by some tilapia cage operators was 600kg per cages of $8m^3$ equivalent to 75 kg/m^3 after 9 months of grow out; which was smaller than what expected before starting the business (minimum of 800kg per cage of $8m^3$ after 6 months of grow out).

3.4. Economic efficiency of the current tilapia cage production system

Some economic parameters have been calculated to reveal the true economic picture of the current tilapia cage culture venture in Rwanda. The values shown in Table 5, Table 6 and Table 7 were calculated for a cage farm unit of 10 tilapia cages of $8m^3$ each, some of these values were from the findings of this survey and others were found from the field technician reports.

Table 5: Investment required in tilapia cage culture (unit of 10 cages)

Item	Total Cost (Rwf*)	Life span (yrs)	Depreciation (Rwf)
Cages	3,310,000	10	331,000
Guard and Store house	250,000	10	25,000
Equipments	95,000	5	19,000
Total	3,655,000		375,000

*Rwf is local currency which 680Rwf equivalent to 1 US$

Table 6: Operating costs used in tilapia cage culture (unit of 10 cages)

Items	Unit	Quantity	Unit cost (Rwf)	Total Cost (Rwf)
Wages for labor and guards	Monthly	9	40000	360,000
Seeds (pcs)	Pcs	20000	35	700,000
Feeds (kg)	Kg	10,000	1,000	10,000,000
Depreciation	Yearly			375,000
Total				11,435,000

Table 7: Economic indicators of current tilapia cage culture

Indicators	Value (Unit of 10 cages)
Investment costs (Rwf)	3,655,000
Operating costs (Rwf)	11,435,000
Revenue (Rwf per crop)	12,000,000
Profit (Rwf per crop)	565,000
Pay-back period (number of crops)	6.5
Break even volume (kg/10cages)	5,718
Break even selling price (Rwf per kg)	1,906
Return on investment (%)	15.4
Profit margin (%)	4.7

3.5. Constraints affecting the current tilapia cage culture production in Rwanda

The over leading constraints to low performance of current tilapia cage production system were identified from different points of view provided by current tilapia cage operators, key informants and stakeholders.

The percentages of constraints/problems frequencies showed in Figure 6 below are based on multiples responses provided by respondents. The results showed that both lack of inputs (seed and feed) and know-how skills were most common constraints among all tilapia operations in Rwanda.

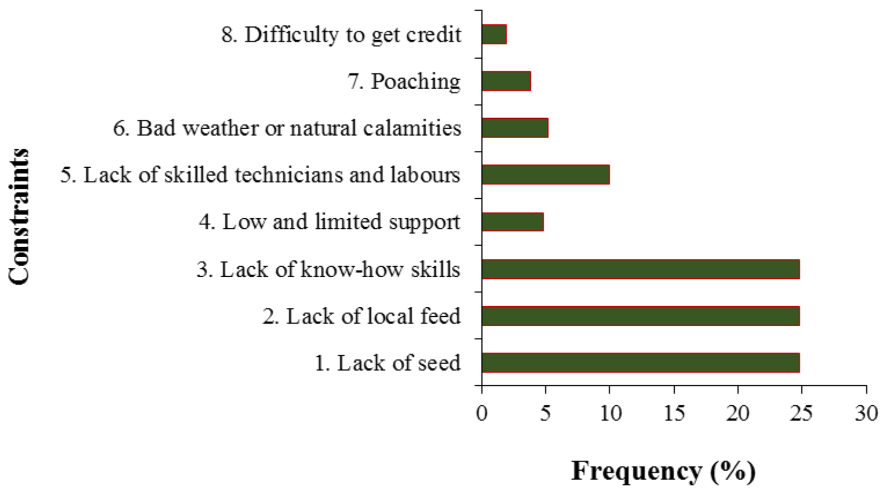

Fig 6: Constraints affecting current tilapia cage culture production in Rwanda, 2014

4. Discussion

The current tilapia cage farmers were the pioneer operators sensitized by PAIGELAC project to start tilapia cage culture business through technical and financial support provided. The project purpose was to serve as demonstration and piloting tilapia cage culture production for the whole community.

The results are consistent with the recommendations of aquaculture master plan [8] that cage culture production in Rwanda would be developed through demonstration of viable technology in all potential zones and through provision of essential inputs to all pioneer operators.

For developing cage culture production in Rwanda, in only three lakes (Kivu, Burera and Ruhondo), Rwanda Aquaculture and Fisheries Master Plan has conservatively estimated the optimum carrying capacity of 140,000 floating cages that can be grouped in 28 cage-based parks of 5,000 cages each.

Kigembe hatchery under the management of Rwanda Agriculture Board (RAB) is the only seed suppliers for the whole country. The results from Table 1 showed that the majority (88.4%) of tilapia cage operators applied a stocking density of 1501 to 2000 tilapia fingerlings per cage of 8m3 (equivalent to 180 – 250 fingerling/m3). Schmittou *et al.* [12] recommended a minimum stocking density of 80 fish/m3 for 15g average weight of tilapia fingerlings.

The optimum density may be limited by the carrying capacity of water body. High stocking density of reached carrying capacity will result in increased fish stress, disease and mortality, reduced feed conversion efficiency, low growth rate and profit [11-13].

A big number of tilapia cage operators in all lakes recorded a mortality rate of fish above to 60% which was occurred during the first month after stocking and during bad weather or sporadic natural calamities such as heavy rains, strong winds, low dissolved oxygen of water, etc. The high mortality rate after stocking was resulted from fish stress and wounds caused by transportation and high stocking rate.

The reasons were that during culture period, the cage operators or hired labor feared to dive and inspect or repair the nets; however cage nets inspection, cleaning and fixation were done by lifting up the nets from the water. This technique stressed the fish and that why most of the operators waited to do that after harvest or when there is a problem.

Feeding was done daily by broadcasting the pellets over the surface of the water in stocked cage. A floating ring about 30 to 50 cm of width, made on mosquito net and fixed on upper portion of the cage net wall were used to stop the feed spread out the cage by winds. Daily feeding frequency was varied from twice to thrice a day. Most used feed were commercial floating pellets of imported from Uganda (UGACHICK and SAMANYA) and Israel (RAANAN).

According to McGinty and Rakocy [17] tilapia are fed a ratio varied along the reared period from 1.5 to 11% of the body weight, daily given in 2 to 5 times a day and re-adjustable daily, weekly or every two weeks based on fish growth or according to weather or environmental conditions. Juvenile fish are fed higher protein diet at greater frequency than adult fish [7].

As recommended by different aquaculture economists, potentials fish farm operators must also invest enough time and effort to determine as accurately as possible the cost and return of their operations. For that accurate record keeping were mostly required to help the producers to actualize figures for every operation system or probably for every production cycle [6, 14-17].

Considering the maximum production of 600kg/ cage of 8m3 recorded by some producers, the results shown in table 7 revealed a gross return of Rwf 12,000,000 per crop generated from harvested fish sales at Rwf 2,000/kg (farm gate price). This result indicates that in a short run, one production cycle tilapia cage operator was able to pay all operating costs of Rwf 11,435,000. The profit, amount left after paying all operation costs was too low as reported by most of the operators (Rwf 565,000 per crop); though, in order to cover all investments required as well as paying all expenses, the operator must undertake many production cycles (6.5 crops of 9 months length) which can be achieved after 4.8 years of operations (pay-back period). The break-even price was Rwf 1,906 per kg of fish; which was calculated as total operating costs divided by the quantity of production and break-even volume which calculated as total operating costs divided by the unit price of production was 5,530 kg per 10cages equivalent to 553 kg/cage or 69kg/m^3. These indicate that the fish market price could be above to break-even price while the quantity of fish produced could be above to break-even volume in order to make more profit.

These results corroborate with the opinions of Halwart and Moehl [4] and Halwart *et al*. [5] saying that feed and seed quality and availability are the major constraints for cage aquaculture development in sub-Saharan Africa.

A lack of know-how skills among cage owners, technicians and man-powers was another major constraints reported by most of the current cage operators.

Both bad weather and natural calamities sporadically occurred were other problems contributed to high mortality and poor growth of caged fish. The natural calamities related to the volcanoes activities, were frequently reported in lakes Burera, Ruhondo and Kivu which have an interconnection with the northern volcanoes. The cage operators from these lakes were concerned with occasionally upwelling of natural gases (methane and sulfur compound) which lower the DO in the upper layers of the lake.

The volcanic region is known to be too cold; the optimum temperature falls below 10ºC during cold seasons, temperature in which tilapia could not grow. Lack of capital investment due to difficulty to get credit and low or limited government support was also another limitation to the new tilapia cage adopters.

Poaching was another serious problem reported by few cage operators who failed to take control and surveillance of their cage farms carefully. Theft was constantly done either by some cooperative members or by other fishermen operating in the same lake due social conflicts.

All discussed constraints that hold back the development of aquaculture sector are still common among all sector operators in Rwanda. All tilapia cage producers interviewed have reported that without continuous government or NGOs interventions, on their own, they do not believe to achieve a sustainable development of tilapia cage culture. Because tilapia cage culture is a new technology in Rwanda, the dependence on outside supports and interventions were still observable in the mindset of the current cage operators. Therefore, several needs for future development of tilapia cage culture in Rwanda are necessary.

Irrespective to their importance, possible solutions have been highlighted by different stakeholders and were varied from one to another. Quality seed and quality feed production through government or NGOs projects and private investments, related hands-on skills and technology transfer to local people as alternative livelihood development and consistent extension services concurrent to research and development of the sector were the mostly prospective interventions brought to a close of every discussion, meeting and interview with all stakeholders.

A gene bank should be set up at national level to function as certified broodstock management and quality seed supply centre, while at district level some kind of satellite hatcheries or seed depositories should be established to function as seed multiplication or collection stations. The satellite stations should be exclusively operated by seed multipliers and have an open door to the fish growers. They could also be served as transitional seed tanks, where before distribution to cage operators, fingerlings are deposited for conditioning, nursing and treatment prior to cage stocking in order to minimize post stocking mortality and losses.

The development of commercial cage culture depends on the commercial good quality fish feed. Since the raw materials to make commercial floating pellets is still very expensive and heavy investment costs in feed making machine especially extruder, the production of floating pellets in Rwanda will always have obstacles. Meanwhile tilapia producers should simply utilize locally available fish feed. RAB should expand and intensify the production of good quality homemade feed using the equipment installed in different sites by PAIGELAC project. Cage operators must be taught to make a good quality feed by using local ingredients and proper feeding techniques which minimize feed fouling in the environment.

In research and development, there are various urgent needs such determination of the optimum cage volume and stocking density for LVHD system suitable to local conditions, evaluation of growth performance of tilapia and its other biological and economic performances, review of harvesting, post-harvest and market strategies in order to relate the harvested fish to market need.

Since tilapia cage culture is a new industry underway of adoption with new non-experienced and unskilled operators, education and training through demonstrations and illustrations would be more effective. However, it is more imperative for RAB/MINAGRI to build up a core training of trainers program to provide the extension services on a regular and sustained basis at cage park level. Particular training should be given to both cage operators and RAB extension officers and it would be oriented in specific areas such as cage design and construction, cages and nets maintenance, seed production and handling, fish disease and control, BMPs, harvesting and post-harvest techniques, environmental assessment and management, etc. RAB should deploy its trained staff at district level.

The present system of grouping cage operators in potential aquaculture parks should be maintained. In the future, there had to be in each aquaculture park a strong management committees and policies. The cage park committees should be grouped together to form at national level a “Cage Operators Development Committee” who will help to instil in cage parks the BMPs, monitoring and evaluation system.

5. Conclusion

The current production system could not lead to profit maximization. The results of previous culture system have also contributed to the failure of entirely expansion of tilapia cage culture in all potential zones of Rwanda. The observed and reported big loss of fish, fish escape, high mortality rate cases and small size of fish at harvest are the consequence of the absence of innovative and adequate management practices in tilapia cage farm. A lack of innovative and adequate management practices were significantly correlated with the lack of knowledge or know-how skills among the currents tilapia cage operators. Unless improved management and measures are taken; a lack of quality inputs (seed and feed), lack of research based BMPs application will continue to hold back the performance of tilapia cage culture in Rwanda.

6. Acknowledgement

In a special way I thank the Director General of RAB/MINAGRI and particularly the Fisheries and Aquaculture Program Manager, Dr. Wilson RUTAGANIRA for accepting me into their group members and for providing me all facilities and services needed for this research. I am grateful to all Fisheries and Aquaculture Officials in lakes Burera, Kivu, Muhazi and Ruhondo for accepting to work closely with me during my fieldwork. Thank you for the reports and facilities you rendered. I also acknowledge the support got from all respondents of this survey and interviews. Thanks for the information, data and facilities you provided.

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