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PERCEPTIONS OF THE ATTRIBUTES OF FISH FARMING IN FLOATING CAGES ON LAKE TOHO IN SOUTHERN BENIN: THE CASE OF FISHERMEN

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ABSTRACT

Fishing is an economic activity that generates significant added value, contributes to job creation and improved food and nutritional security. For several years however, it has been confronted for several years with a decline in halieutic resources in the face of which fish farming in floating cages constitutes an optimal management solution. The objective of this article is to analyze the perceptions of the attributes of fish farming in floating cages by fishermen. The study involved a random selection of 210 fishermen from the three municipalities (Lokossa, Houéyogbé and Athiémé) of Toho lake. Analyzes of variance and correlation followed by principal component analysis were used to analyze the data. The results showed that there are three groups of fishers with different perceptions of floating cage fish farming. Fishers who perceived fish farming in floating cages as a form of fish farming that is efficient and very demanding but less suitable in the long term represent the first group. For the second group of fishermen, there are markets for the sale and sale of fish reared in floating cages, but there is difficulty in finding inputs (provend, veterinary products and antibiotics) of fish in floating cages. The third group perceived that fish farming in floating cages is a very flexible, rigid and efficient activity compared to other fish farming techniques. According to this study, it is important that the Government of Benin take into account the perceptions of fishermen before installing floating cages on Lake Toho.

Key words: attribute, fish farming, fishermen, perceptions

INTRODUCTION

The nations of the world through target 2 of the sustainable development goals, have set themselves the challenge by 2030 of eliminating hunger, ensuring food security, improving nutrition and promoting sustainable agriculture. This challenge requires the contribution of various sectors of activity, including fishing. Fishing is an economic activity that generates significant added value and contributes to job creation (FAO, 2014). Fish is the main source of animal protein for some 200 million people on the African continent (FAO, 2020). Fishing also provides income for more than 10 million Africans, and between five and ten times more people practice fishing as a secondary activity and thus contribute to food security in rural areas (FAO, 2020). More specifically, continental artisanal fishing depends largely on the presence of fishery resources in water bodies (FAO, 2020). But, for some years now, the fisheries sector has been confronted with a serious problem of a growing decline in fishery resources (FAO, 2018).

Indeed, of the inland fisheries fish stocks monitored by the FAO worldwide in 2020, 50% are fully exploited, 34% are over-exploited while only 6% are under-exploited (FAO, 2020). The fraction of fish stocks that are at sustainable exploitation levels is steadily declining, from 81.4% in 1990 to 66.9% in 2015 (FAO, 2018). This trend is worrying since the number of over-exploited stocks continues to increase. The share of fish stocks exploited at a biologically sustainable level globally has fallen from 90% in 1974 to 65.8% in 2017 (FAO, 2018). The evident over-exploitation of important fish stocks and changes in ecosystems threaten the sustainability of fishery resources and their contribution to food supply (FAO, 2018). Like the rest of the world, fish catches from African rivers and large lakes are steadily declining (N'dri, 2018; Leite *et al.,* 2019; Machado *et al.*, 2019). Indeed, the current trends in the evolution of fish stocks (reduction in the average size of fish caught, reduction in catches per unit of effort of several species mainly freshwater species) show worrying signs (Muawanah *et al.,* 2018).

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In Benin, despite the contribution of fishing to agricultural gross domestic product (GDP) of 8.04% in 2019 (DSA, 2021), the fishery resources of the various continental water bodies are victims of great over-exploitation. The production inland artisanal fishing decreased from 45,762.00 to 36,631.00 tonnes from 2019 to 2021 (DSA, 2021). Benin is confronted with a worrying problem of sustainability of coastal fisheries resulting from an irrational exploitation of halieutic resources thus jeopardizing the balance of coastal ecosystems. The current situation does not guarantee an expansion of activities based on the exploitation of fishery resources and risks compromising the chances of future generations. If current generation wish to bequeath a livable planet to future generations, it would be urgent and necessary to preserve biological diversity as much as possible and to implement good management of fishery resources (Cury and Miserey*,* 2008).

Several empirical studies have analyzed management strategies for the management of fishery resources in inland fisheries. These include the use of regulated nets (Codjo *et al.,* 2018), establishment of artificial reefs (Machado *et al.*, 2019), adoption of the ecosystem approach to fisheries management (Muawanah *et al*., 2018), use of canoe and boat monitoring systems (Ekouala, 2013), setting of individual transferable quotas (Mahé and Ropars, 2001; Cindy, 2009; Berkowitz and Clarke*,* 2014), development of aquaculture (Zaghdoudi, 2013). Thus, in its government policy to combat the over-exploitation of fisheries resources and to increase them, Benin adopted in July 2018 Decree No. 2018-334 of July 25, 2018 setting the conditions and procedures for exercising the aquaculture in the Republic of Benin. For Rurangwa *et al.* (2014), fish farming makes it possible to reduce the pressure on natural fish resources, conservation of which is one of the global challenges of preserving the environment.

In the above perspective, the National Program for the Development of the Aquaculture Sector through Inlande Aquaculture Sustainable Development Program (PDDAC) has retained fish farming in floating cages as the production method capable of rapidly achieving the objective (produce 20,000 tonnes of fish by 2025 against 5,000 tonnes in 2016) of the because of the hydrographic wealth available to the country (PDDAC, 2019). How do fishermen (key person in the management of water bodies) perceive the implementation of fish farming in floating cages? The objective of this article was to make a socio-economic analysis of the perceptions of fish farming in floating cages on Lake Toho in order to facilitate its proper implementation.

LITERATURE REVIEW ON FISH FARMING IN FLOATING CAGES

This literature review was made to have a general view of the different attributes or characteristics of fish farming in floating cages. Fish farming in floating cages is the rearing of fish in an enclosure that allows free movement of fish (Femenias *et al.,* 2008). It is a relatively simple structure comprising a rigid floating pontoon supporting a soft mesh bag containing the fish (Rahman *et al.,* 2006). According to Coche (1978) and Beveridge (1996), cages can be classified into four types viz (*i*) fixed cages, resting at shallow depth on the bottom of the aquatic environment, (*ii*) floating cages, on the surface of water, (*iii*) submerged cages, resting deep on the bottom of the aquatic environment and (*iv*) submersible cages, which can occupy the surface or the bottom of the aquatic environment. The first three types are mainly used in continental waters (fresh and brackish) while the last type is much more used for fish farming in marine waters. The main advantages of cages floating, compared to fish production techniques (fish farming in ponds or tanks), lie in the adaptability of the structure and the direct use of water from the natural environment (Bazir, 1994).

Fish farming in floating cages is a technique for farming fishery resources with the aim of minimizing the use of land, water resources and providing large quantities of food products to the population (Zaghdoudi, 2013). It is a fishing production method which confers a variable zootechnical expression to the fish according to the ecological quality of the body of water, size of the water mass, depth and potential for renewal of water (De Carvalho Gomes *et al.,* 2006; Rahman *et al.,* 2006, Rowland *et al.,* 2006; Garcia de Souza *et al.,* 2015). Fish farming in floating cages is a profit-generating activity whose performance is influenced by four main factors, namely: (*i*) the number of cages placed by the promoter, (*ii*) the type of fry, (*iii*) the frequency of feeding and (*iv*) stocking weight (Garcia de Souza *et al.,* 2015).

Blow and Leonard (2009) showed that harvest yield obtained after six months of breeding *Oreochromis niloticus* varies between 11.46 and 16.27 kg m^{-3} while that of *Clarias gariepinus* varies between 11.00 and 11.33 kg m^{-3}. The yield for *Oreochromis niloticus* on Lake Victoria in Kenya is 200.00 kg m^{-3}, 100.00 kg m^{-3} on Lake Victoria in Uganda and 20.00 kg m^{-3} in Zambia on Lake Kariba (Islam *et al.,* 2016). This variation in yield is related not only to the depth of water bodies, the quality of strain of fish reared and the density used by fish farmers (Faye *et al.,* 2018). The cost of installing floating cages with a density of 100.00 m^{-2} is 17,260,000.00 FCFA ($27,616.00) for a gross profit margin of 598,000.00 FCFA per year ($956.80) over a period of 10 years (MMEJF and MAEP, 2009).

On the other hand, the studies by Onyekuru *et al.* (2019) on the socioeconomic and profitability analysis of catfish production showed that total cost of catfish production is ₦584,968.041 ($1,614.73) for an average production cycle of 7 months generating a net margin of ₦1,672,129.96 ($4,615.70). Generally, fish production costs are influenced by (*i*) quality and price of the feed, (*ii*) distance between the hatchery and the cage site, (*iii*) zootechnical quality of the fry. These factors significantly influence the variation in profitability economics of fish farming in floating cages (Onyekuru *et al.,* 2019). The economic profitability of production in floating cages also depends on the size and type of cage (Huguenin, 1997; Gooley *et al.,* 2000).

The impacts of fish farming, more specifically that in floating cages, have been highlighted in empirical studies. For instance, Gurung *et al.* (2010) have shown that the practice of fish farming in floating cages at the level of a water reserve housing a hydroelectric system enabled the inhabitants who live around to convert become fish farmers. This allows a better education of actors' children up to the university level. The study of Hidayati *et al.* (2018) have revealed that cage aquaculture in the Jatiluhur reservoir (Indonesia) improves the food security not only of the surrounding populations but also those of neighboring regions. For Blow and Leonard (2009), cage aquaculture contributes to reducing the unemployment rate through the direct and indirect jobs it offers (200 directs employees for Zimbabwe and 90 for Uganda). Fish farming in cages is a means of increasing the ability to access food, protein food production, improving the purchasing power of households, especially in rural areas in West Africa (Jamu and Chimatiro, 2004; Blow and Leonard, 2009). Fish farming in cages is emerging in sub-Saharan Africa with the creation of many indirect jobs in the sense that women are mainly involved in the manufacture of nets and in the processing of harvested products (Abery *et al.,* 2005; Yoboue *et al.,* 2018).

Apart from these positive impacts, the practice of fish farming has some negative impacts on the environment in the sense that fish farming in floating cages is associated with the release of organic matter into the ecosystem (Schenone *et al.,* 2011; Gorlach-Lira *et al.,* 2013; Yoboue *et al.,* 2018). Beveridge (1984) showed that each ton of tilapia produced releases 23.00-29.00 kg of total phosphorus into the environment. The organic matter released influences the physical and chemical balance of the aquatic ecosystem (Degefu *et al.,* 2011) and leads to eutrophication or even a loss of biodiversity (Mama *et al.,* 2011; Vodougnon *et al.,* 2018; Yoboue *et al.,* 2018). Organic matter causes global warming through the production of greenhouse gases under the action of bacteria (Beveridge, 1984; Davidson *et al.,* 2015; Deemer *et al.,* 2016; Yang *et al.,* 2019).

MATERIALS AND METHODS

Study Environment

This study was conducted in three surrounding municipalities of Lake Toho (Figure 1). These are the communes of Athiémé, Houéyogbé and Lokossa.

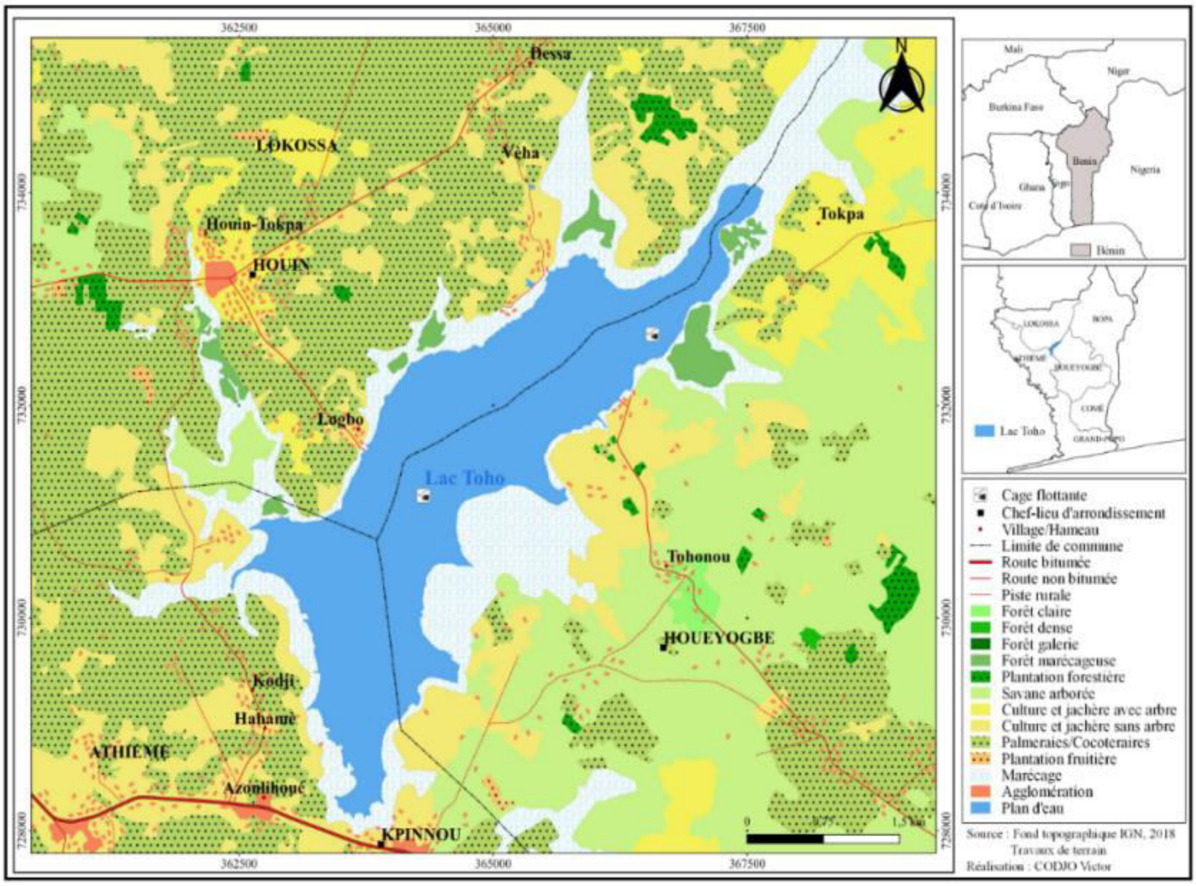

Figure 1: Map of Lake Toho

Sampling

The sampling universe is all fishermen involved in the fishing activity on Lake Toho and residing in the communes of Lokossa, Houéyogbé and Athiémé. The statistical unit is the fisherman. It should be noted that the sampling first consisted in the selection of the villages which have a real impact on Lake Toho and then in the random selection of fishermen in the selected villages. Thus, the villages Kpinnou, Azonlihoué, Hahamè and Kodji were selected in the commune of Athiémé while Houin Tokpa, Vèha, Logbo and Dessa were selected in the commune of Lokossa. In the commune of Houéyogbé, Tokpa and Tohonou were the selected villages.

To constitute the sample, data from the National Census of Agriculture (DSA, 2021) made it possible to estimate the number of fishermen per village selected. This made it possible to find 38, 40, 39 and 42 fishermen, respectively in the villages of Kpinnou, Hahamè, Azonlihoué and Kodji. At the level of the villages of the commune of Lokossa, 43, 97, 22 and 147 were the estimated numbers, respectively in the villages of Houin Tokpa, Vèha, Logbo and Dessa. In the commune of Houéyogbé, 128 and 80 are the estimated numbers in the Tokpa and Tohonou villages. The size of the population of interest amounts to 675 fishermen for all three municipalities.

To determine size of the sample corresponding to this population, the Progress out of Poverty Index (PPI) method was used. With this method, the sample size (n) of households to be surveyed is fixed with a level of confidence (1 – c) % = 95%. The sample size n formula defined in the PPI is (PPI, 2010):

$$n = N \times \frac{z^2 \times \alpha^2 \times p\,(1-p)}{z^2 \times \alpha^2 \times p\,(1-p) + c^2 \times (N-1)}$$

$$c = \pm z \times \alpha \times \sqrt{\frac{p\,(1-p)}{n}} \times \sqrt{\frac{(N-n)}{N-1}};$$

where N is the size of the total population; z is 1.96, represents the value of the normal random variable U for a confidence interval equal to 0.05; c (confidence interval) is 0.05; p is the percentage of people fishing in fishing areas (it is assumed that $\hat{p}$ is 50%); $\hat{p}$ is 67%); α (confidence intervals for the PPI) is 0.95. So, for N = 675, we have n = 210. To find the size of the sub-samples in each village selected, the proportionality method was used for this purpose. To do this, a coefficient k, called the polling or sampling rate, was calculated, such that $k = \frac{n}{N}$; where n is the size of the sample and N that of the population). This coefficient multiplied by the numbers of the villages respectively gives the numbers of the sub-samples presented in Table 1.

Since the list of fishermen is not available in each community, the data collection agents, in close collaboration with the village chief, assisted by a few advisers and certain members of the local water committee and repression committee, who master the configuration and the slicing each have drawn up a list of 100 fishermen per village. The names of these fishermen thus identified are numbered from 1 to m per village. Systematic sampling was carried out. The principle consisted in first calculating the sampling step $r = m / n_v$ per village. n_v represents the sample size per village. Then, d a natural integer between 1 and r was randomly chosen. The fisherman whose number corresponds to d was the first fisherman selected on the list in the village concerned. To select the other fishermen in the same village, we add to d the "step" of the survey r. The fishermen chosen were then those whose numbers correspond to d, $d+r$, $d+2r$, $d+3r$, $d+4r$, and so on. This process is repeated in each village in order to have the sample size.

Methods and Tools for Collecting, Processing and Analyzing Data

Data collection method

The data used in this study were collected by means of a questionnaire administered to heads of fishermen. The measurement level for questions relating to perceptions of the characteristics/ attributes of floating cage fish farming on Lake Toho is ordinal, with 1 indicating that the attribute or characteristic is considered very important; 2 indicating important; 3 indicating unimportant; and 4 indicating very unimportant. The information from the questionnaire was supplemented by data from focus groups and semi-structured interviews with strategic players (local water committee and repression committee, groups and associations of fishermen and processors, fishing non-governmental organizations, local authorities) in the fishing sector. Thus, 13 characteristics/attributes were presented to the heads of the fishing household in the questionnaire. They were asked to assign a degree of importance to each characteristic/attribute on a scale of 1 to 4. They were asked how each characteristic/attribute can be considered in the process of adopting floating cage fish farming as means of combating the decline in fishery resources.

Table 1: Sampling details

Survey rate	Villages	Number of fishermen per village (population)	Number of fishermen (sampling)
$K = \frac{210}{675} \cong 0.311$	Kpinnou	38	12
	Hahamè	40	12
	Azonlihoué	39	12
	Kodji	42	13
	Houin Tokpa	43	13
	Vèha	97	30
	Logbo	22	10
	Dessa	147	46
	Tokpa	128	40
	Tohonou	80	22
Total		675	210

Field Survey (September, 2022)

Data processing and analysis method

To analyze fish farmers' perceptions of fish farming in floating cages, descriptive statistics such as arithmetic mean, and absolute frequency were used. The analysis of variance (ANOVA) was used to determine the differences in mean values. In a second step, a correlation analysis was performed between characteristics/attributes using the ordered rank correlation coefficient (Spearman's Rho) as because the variables are measured on an ordinal scale (Khawla, 2022). In order to simplify the interpretation of the characteristics/attributes, a principal component analysis was carried out in a third step using the factor rotation method of maximum variance (Kaiser, 1958). The Kaiser varimax method is one of the most widely used procedures to facilitate the interpretation of factor axes (Kaiser, 1958; Berger, 2021). In order to retain the number of axes (principal components) to be considered in the analysis, the Kaiser rule or Mineigen criterion suggesting to consider only the components whose Eigen values are greater than 1 was used. The information storage efficiency of a principal component is measured by the proportion of its eigen value to the sum of all Eigen values. The number of components to be retained for such an analysis is also a function of the accumulation of the proportions of information stored by the principal components. The number of components to retain is the number of components that explain at least 50% of the total variation included in the initial variables (Abson *et al.,* 2012; Cinner *et al.,* 2013). In addition, a characteristic or an attribute is considered to be well represented on a principal component when its correlation coefficient with the latter is in absolute value greater than or equal to 0.30 or 30%. The SPSS version 20.0 software was used to calculate the correlation coefficients and the various associated probabilities while the Minitab 16 was used to perform the Principal Component Analysis (PCA). This method was used in the empirical studies of Assogbadjo *et al.* (2008), Gnanglè *et al.* (2009), Teka and Vogt (2010), and Lobos *et al.* (2018).

RESULTS AND DISCUSSION

Correlations between Characteristics/Attributes of Fish Farming in Floating Cages

The correlation matrix Spearman's Rho of the 13 characteristics/attributes of fish farming in floating cages is presented in Table 2. Results showed significant relationships among the different attributes of fish farming in floating cages. This correlation was significant and positive at the $p \leq 0.05$ level between manipulability and the attributes flexibility, efficiency and availability with respective correlation coefficients of 0.190, 0.184 and 0.373. This reflected that, the more the techniques of pre-fattening, fattening of fry, harvesting of reared fish, among others were easy to carry out at the level of the floating cages, the more the latter were flexible, efficient in their use and there was a wide availability of spare parts and repair of the floating cages (pipes, cans, ropes, nets, etc.). It also showed a significant negative relationship at $p \leq 0.05$ between the attributes rigidity and flexibility (r = –0.501). That is, the stiffer the floating cages were, the less flexible they were compared to other fish farming techniques such as fish pens, fish ponds; back above ground, and so on. Conversely, there was a significant positive correlation ($r = 0.189^{**}$) between the attributes stiffness and durability. This meant that the more rigid the floating cages are in their use, the more durable they are in the long term. A significant positive correlation was also observed between the attributes availability of inputs (provend, food supplements, veterinary products and antibiotics) and the attributes existence of a market for sale of fish from floating cages and effectiveness of fish farming in floating cages compared to fish farming techniques (pens, ponds, back above ground). In addition, the results of the Barlett sphericity test and of the Kaiser-Meyer-Olkin (KMO) sample adequacy index (Table 2) made it possible that the correlation matrix is not an identity matrix and the partial correlations between the variables are (relatively) small. Therefore, the factorial model for perceptions of attributes of floating cage fish farming appears significant at the 1% level and adequate.

Factor Analysis of the Attributes of Fish Farming in Floating Cages

The results of the factor analysis applied to the data from the study of the 13 characteristics/attributes of fish farming in floating cages have been projected in Figure 2. The first two factorial axes of Figure 2 respectively explained 38.15% and 27.63% of the information contained in the table of attributes. The accumulation of these eigen values (65.78%) being greater than 50%, then the first two axes were a priori sufficient to summarize the essential information related to the different characteristics/ attributes of fish farming in floating cages. The analysis of Figure 2 has shown that all the attributes of fish farming in floating cages have been taken into account by the two axes retained. The attributes DURAB, REVE, and GOUT (negatively correlated to axis 1) and EFFICA and EXIGE (positively correlated to axis 1) formed a first group of attributes. The attributes EXIST, ENTRE1 and MANI (positively correlated to axis 2) and the attributes DISPO1 and DISPO2 (negatively correlated to axis 2) formed the second group of attributes. The third group is composed of the attributes EFFICI, SOUPL and RIGI. The first group of attributes characterized fishermen who perceived that floating cage culture was a form of fish farming that was very efficient and demanding but less sustainable at long term. To these fishermen, those who cultivate fish in cages not only produce fish that often do not taste good for consumption but also obtain low income after sale.

Table 2: Spearman's rho correlation matrix for characteristics/attributes of fish farming in floating cages

		MANI	DISPO1	DISPO2	ENTRE1	RIGI	SOUPL	DURAB	EXIGE	EXIST	GOUT	REVE	EFFICA	EFFICI
MANI	Coef. Corr.	1.000	0.373**	0.184**	0.223**	–0.015	0.190**	0.069	0.073	–0.193**	0.095	0.225**	0.184**	0.063
	P		0.000	0.008	0.001	0.825	0.006	0.322	0.293	0.005	0.171	0.001	0.008	0.362
DISPO1	Coef. Corr.	0.373**	1.000	0.288**	0.147*	0.216**	0.045	0.269**	0.041	–0.248**	0.259**	0.274**	0.218**	0.062
	P	0.000		0.000	0.033	0.002	0.515	0.000	0.558	0.000	0.000	0.000	0.001	0.368
DISPO2	Coef. Corr.	0.184**	0.288***	1.000	0.181**	0.470**	–0.367**	0.240**	0.090	–0.137*	0.239**	0.250**	0.081	–0.217**
	P	0.008	0.000		0.009	0.000	0.000	0.000	0.192	0.048	0.000	0.000	0.240	0.002
ENTRE1	Coef. Corr.	0.223**	0.147*	0.181**	1.000	0.072	0.047	0.098	-0.229**	–0.263**	0.196**	0.320**	0.184**	0.088
	P	0.001	0.033	0.009		0.301	0.502	0.155	0.001	0.000	0.004	0.000	0.007	0.206
RIGI	Coef. Corr.	–0.015	0.216**	0.470**	0.072	1.000	–0.501**	0.189**	0.057	–0.270**	0.103	0.174*	0.099	–0.170*
	P	0.825	0.002	0.000	0.301		0.000	0.006	0.410	0.000	0.135	0.011	0.151	0.014
SOUPL	Coef. Corr.	0.190**	0.045	–0.367**	0.047	–.0501**	1.000	–0.098	0.006	–0.070	0.084	–0.008	0.095	0.309**
	P	0.006	0.515	0.000	0.502	0.000		0.156	0.934	0.316	0.228	0.913	0.171	0.000
DURAB	Coef. Corr.	0.069	0.269**	0.240**	0.098	0.189**	–0.098	1.000	–0.109	–0.155*	0.190**	0.045	0.069	0.148*
	P	0.322	0.000	0.000	0.155	0.006	0.156		0.114	0.025	0.006	0.516	0.323	0.032
EXIGE	Coef. Corr.	0.073	0.041	0.090	–0.229**	0.057	0.006	–0.109	1.000	0.050	0.066	0.069	–0.072	–0.070
	P	0.293	0.558	0.192	0.001	0.410	0.934	0.114		0.474	0.343	0.321	0.302	0.309
EXIST	Coef. Corr.	-0.193**	-0.248**	–0.137*	–0.263**	-0.270**	–0.070	–0.155*	0.050	1.000	–0.301**	–0.243**	–0.375**	–0.284**
	P	0.005	0.000	0.048	0.000	0.000	0.316	0.025	0.474		0.000	0.000	0.000	0.000
GOUT	Coef. Corr.	0.095	0.259**	0.239**	0.196**	0.103	0.084	0.190**	0.066	–0.301**	1.000	0.344**	0.245**	0.313**
	P	0.171	0.000	0.000	0.004	0.135	0.228	0.006	0.343	0.000		0.000	0.000	0.000
REVE	Coef. Corr.	0.225**	0.274**	0.250***	0.320***	0.174*	–0.008	0.045	0.069	–0.243**	0.344**	1.000	0.351**	0.098
	P	0.001	0.000	0.000	0.000	0.011	0.913	0.516	0.321	0.000	0.000		0.000	0.159
EFFICA	Coef. Corr.	0.184**	0.218**	0.081	0.184**	0.099	0.095	0.069	–0.072	–0.375**	0.245**	0.351**	1.000	0.445**
	P	0.008	0.001	0.240	0.007	0.151	0.171	0.323	0.302	0.000	0.000	0.000		0.000
EFFICI	Coef. Corr.	0.063	0.062	–0.217**	0.088	–0.170*	0.309**	0.148*	–0.070	–0.284**	0.313**	0.098	0.445**	1.000
	P	0.362	0.368	0.002	0.206	0.014	0.000	0.032	0.309	0.000	0.000	0.159	0.000	

Barlett's sphericity test approximate Chi-square = 357.690***; KMO sample adequacy index (Kaiser-Meyer-Olkin) = 0.825***; **significant at 5%, *significant at 10%.
MANI - handling (techniques for pre-fattening, fattening of fry, harvesting of reared fish) of floating cages; DISPO1 - availability of spare and repair parts for floating cages (pipes, cans, ropes, nets); DISPO2 - availability of inputs (feed, food supplements, veterinary products and antibiotics) for fish farming in floating cages; ENTRE1 - maintenance of floating cages; RIGI - rigidity of floating cages compared to other fish farming techniques (pens, ponds; back above ground); SOUPL - flexibility of floating cages compared to other fish farming techniques (pens, ponds, back above ground); DURAB - long-term durability of floating cages; EXIGE - requirement for floating cages compared to other fish farming techniques (pens, ponds, back above ground); EXIST - existence of a market for the sale of fish reared in floating cages; GOUT - taste of fish reared in floating cages in the household diet; REVE - income of fish farmers from floating cages; EFFICA - efficiency of fish farming in floating cages compared to fish farming techniques (pens, ponds, back above ground); EFFICI - efficiency of fish farming in floating cages compared to fish farming techniques (pens, ponds, back above ground); *P* - value of the probability associated with the correlation test; Coef. Corr. - correlation coefficient value

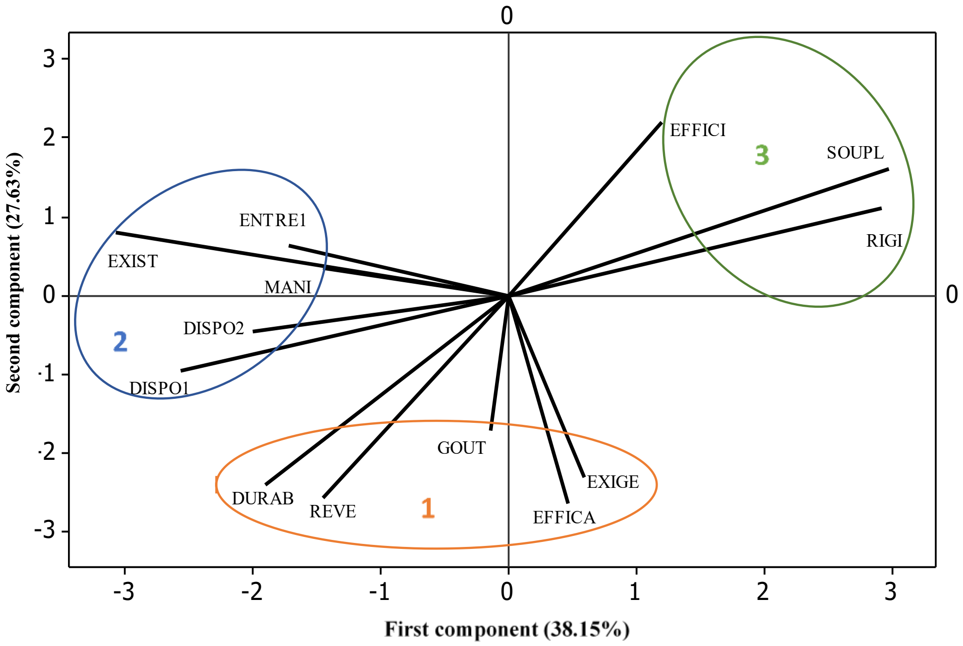

Figure 2: Principal Component Analysis of perceptions of characteristics/attributes of fish farming in floating cages

MANI - handling (techniques for pre-fattening, fattening of fry, harvesting of reared fish) of floating cages; DISPO1 - availability of spare and repair parts for floating cages (pipes, cans, ropes, nets); DISPO2 - availability of inputs (feed, food supplements, veterinary products and antibiotics) for fish farming in floating cages; ENTRE1 - maintenance of floating cages; RIGI - rigidity of floating cages compared to other fish farming techniques (pens, ponds; back above ground); SOUPL - flexibility of floating cages compared to other fish farming techniques (pens, ponds, back above ground); DURAB - long-term durability of floating cages; EXIGE - requirement for floating cages compared to other fish farming techniques (pens, ponds, back above ground); EXIST - existence of a market for the sale of fish reared in floating cages; GOUT - taste of fish reared in floating cages in the household diet; REVE - income of fish farmers from floating cages; EFFICA - efficiency of fish farming in floating cages compared to fish farming techniques (pens, ponds, back above ground,); EFFICI - efficiency of fish farming in floating cages compared to fish farming techniques (pens, ponds, back above ground).

Concerning the second category of fishermen, they perceive that the operations of pre-fattening, fattening of fry, harvesting of reared fish, and maintenance of the floating cages were often easy tasks to do. To this category of fishermen, there was a market for the sale of fish reared in floating cages, while it was a bit difficult to find the inputs (provend, food supplements, veterinary products and antibiotics) and spare and repair parts (hoses, drums, ropes, nets) during the culture of fish in floating cages. This is explained by the fact that these inputs were often imported and that there were very few companies or local structures that manufacture fish farming inputs (Jamu and Chimatiro, 2004; Omeje *et al.,* 2020). In addition, the purchase price of fish farming inputs is often not within the reach of small fish farmers (Yoboue *et al.,* 2018; Ajagbe*,* 2020). Consequently, Abery *et al.* (2005) and Blow and Leonard (2009) recommended that actors in the agricultural sector, especially fishermen, should form groups or cooperatives in order to benefit easily and get a lower cost from technological innovations. The third group of fishermen perceived that fish farming in floating cages is a very flexible, rigid and efficient activity compared to other fish farming techniques (fish pens, fish ponds, back above ground). These results agree with those of Hidayati *et al.* (2018) and Pelebe *et al.* (2020) who showed that fish farming in floating cages has a good yield than fish farming in fish pens.

CONCLUSION

The analysis of perceptions of the attributes of fish farming in floating cages on Lake Toho in southern Benin has made it possible to understand the logic used by fishermen in appreciating floating cages. It found that there are three different groups of fish farmers with varying perceptions of floating cages. The fish farmers in the first group perceived fish farming in floating cages a form of fish farming which is very efficient and very demanding but less sustainable in the long term. For the fishermen in the second group, there is a market for the sale and sale of fish reared in floating cages, while it is a bit difficult to find inputs such as provend, food supplements, veterinary products and antibiotics, amongst others spare and repair parts (hoses, drums, ropes, and nets) during the culture of fish in floating cages. The third group of fishermen perceived that fish farming in floating cages is a flexible, rigid and efficient activity compared to other fish farming techniques (fish pens, fish ponds, back above ground, and so on). This study will allow policy/decision makers to better direct the actions within the framework of the establishment of cages on Lake Toho.

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