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Fishing activities in the South of lake Toho in Benin West Africa

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Abstract
This study was conducted in four villages of the municipalities of Lokossa and Houéyogbé and aimed at understanding the fishing activities in the South of Lake Toho. Data were collected from 129 fishing households and analyzed using descriptive statistics. The results showed that fishing gears used on Lake Toho include nets, creels, landing nets, and the basket ''Gôdô'', but are not appropriate as they harvest Small-Size fish. Fish are preserved using various local techniques, including preservation in containers, smoking, salting, and frying. Harvested fish are sold through two major channels. In the first that encompasses only two links, both local and foreign consumers come directly to buy fish at the lakeshore. At this point, fish are sold in heaps or individually. In the second marketing channel, there are intermediaries who are retailers. Fishing by hand, the use of landing nets, nets, creels with tight mesh, and chemical fertilizers used in crop production at the lakeshore were the major fishing problems identified on Lake Toho. The development of income-generating activities other than fishing, including agriculture, livestock farming, trade, etc., the use of regulated nets (medium-mesh or large-mesh nets), and the development of fish farming or aquaculture are the most developed strategies to cope with fishing Problems on the lake.

Keywords: Lake Toho, fishing techniques, adaptation strategies

1. Introduction
In Benin, fishing is an important economic activity for the population, especially those bordering lakes, rivers, and water bodies (UEMOA, 2002) [17]. Despite its traditional character, it is of great socio-economic importance for the local population. Indeed, it contributes 75% to national fishery production and accounts for nearly 40% of national consumption of animal protein (UEMOA, 2002) [17]. Lagoon fishing is carried out by about 40,000 professional fishermen as well as 13,000 seasonal workers (MAEP, 2009) [11]. It feeds more than 300,000 people (fishmongers, canoe manufacturers, sellers of various fishing equipments) (MAEP, 2009) [11]. Fish in Benin are mainly sourced from streams and water bodies. In recent years, the needs of the population in fish have increased, while catches have dropped from 47,572 tons (2014) to 36,477 tons (2015) (INSAE, 2016) [7]. Thus, fish demand outstrips supply. Since fishing is one of the main human activities affecting aquatic ecosystems (Mushagalusa *et al*., 2015) [15], this excess demand leads to a very strong pressure on water bodies. The pressure is exacerbated by an uncontrolled fishing effort, widespread non-selective practices and use of fishing equipments and, above all, the absence of a sustained policy for orienting fishermen towards untapped or under-exploited fishery resources and alternative activities. This is the case of Lake Toho, one of the largest lakes of the alluvial valley of the Mono basin, representing the main source of water and fish resource for the inhabitants of the Mono department (MAEP, 2009) [11]. For years, several studies have been carried out on the fish fauna of Lake Toho, particularly on the biology and knowledge of fish (Ahouansou *et al*., 2015; Lederoun *et al*., 2015) [1, 9], on ecology, and production of fish (Ahouansou 2003) [3]. This paper is aimed at analyzing fishing activities in the South of Lake Toho in Benin to enable policy makers and other non-governmental organizations or institutions to make decisions for an efficient and sustainable fishing on Lake Toho.

2. Study Area
The study was carried out in Vèha, Logbo, Tohonou, and Tokpa, four villages located on Lake Toho (Figure 1). Lake Toho (6°35 - 6°40 N and 1°45 - 1°50 E) is in southern Benin.

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Its surface varied between 9.6 km² and 15 km² with an average depth of 2.1 m. It has an average length of 7 km, a southern width varying between 0.5 and 2.5 km and a northern width of about 500 m (Ahouansou, 2008). The valley of the river Sazué serves as an outlet during the flood period through two seasons. This valley also serves as a tributary during the flood of the River Mono. The river is overflowing water. The surrounding aquaculture basins belong to the local population. Due to its geographic location, Lake Toho is influenced by a subequatorial climate characterized by the following four distinct seasons: (1) a long rainy season from mid-March to mid-July; (2) a dry season from mid-July to mid-September; (3) a short rainy season from mid-September to mid-November; (4) a long dry season from mid-November to mid-March dominated by continental winds and harmattan. The annual rainfall varied between 544 mm and 1.376 mm while the temperature is between 20.6 and 33.5 °C with an average of 28°C. The relative moisture is very high and varies from 65% in January to 80.6% in June (Lederoun and *al.*, 2015) [9].
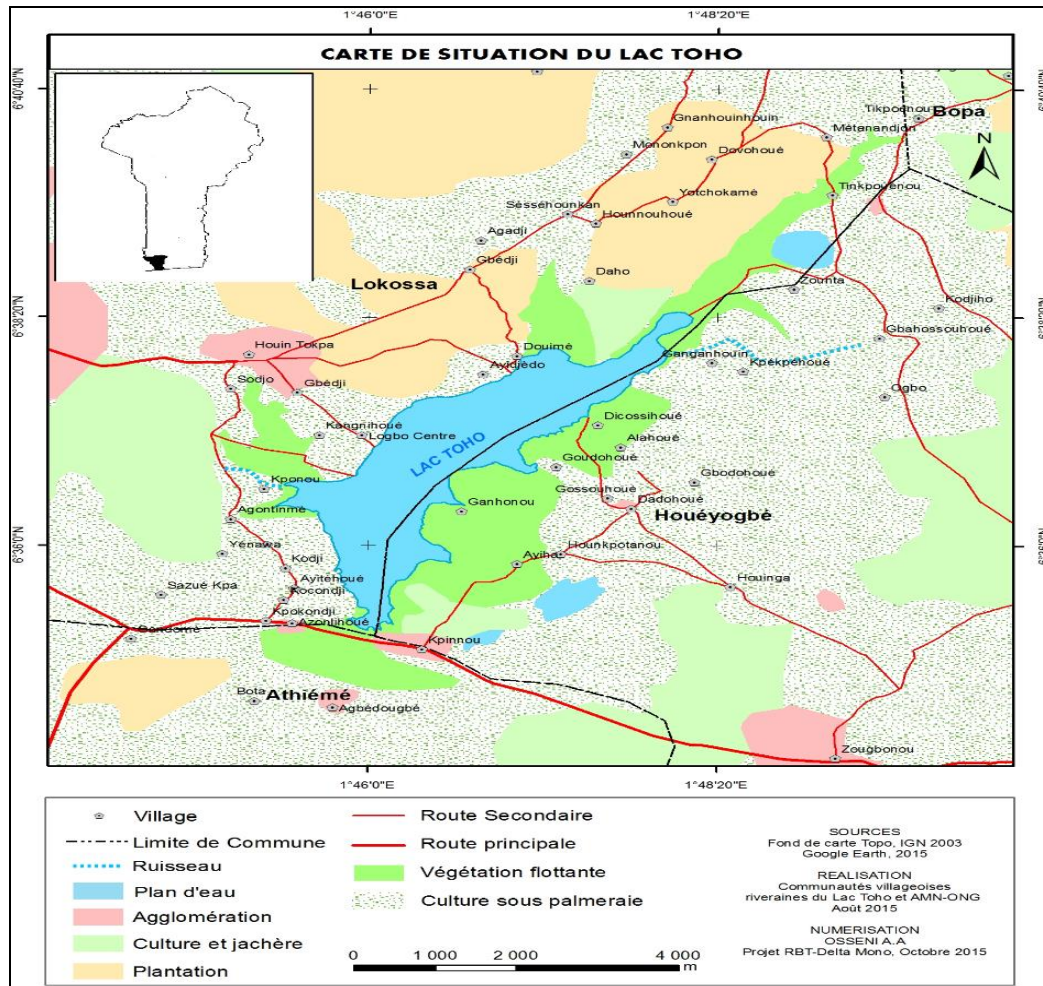

Fig 1: Location of Lake Toho and study villages

3. Methodology
3.1 Data Collection
Data collection consisted of the exploratory and in-depth investigation phases. The exploratory phase identified the villages involved in fishing activities on Lake Toho. During the in-depth investigation, the sample size was selected followed by primary data collection. Vèha and Logbo in the Commune of Lokossa and Tokpa and Tohonou in the Commune of Houéyogbé were the four selected villages. The selection of villages took into account among others the dominant activity having an impact on fishery resources, the demographic weight of each village, the geographic position to the Lake and the prevailing socio-cultural groups involved in fishing on the Lake. In total, 241 households were selected as follows: 43 fishing households in Vèha; 45 in Logbo; 93 in Tokpa; 60 in Tohonou. The Progress out of Poverty Index (Schreiner, 2012) [16] method was applied to determine the overall size of the sample that was 129, equivalent to a sampling rate of 53%. With this rate, the sample per village was finally 23 in Vèha, 23 in Logbo, 50 in Tokpa and 33 in Tohonou. Then the heads of fishermen's households responded to a questionnaire, which allowed to collect primary data. The key points of the questionnaire include Socio-economic Characteristics of fishermen, identification of fishing modes, gears and techniques, methods of fish preservation and processing, Markets and Marketing channels, Problems with Fishing Activity on Lake Toho, and Adaptation and management Strategies developed.

3.2 Methods of data analysis
The analyses were mainly qualitative. Thus, the fishing typology on Lake Toho was made considering the fishing period, gender, and the mode of fishing, fishing engines, techniques, and fish preservation methods. Then, we proceeded with the identification and analysis of markets and marketing channels of Lake Toho, the identification of various fishing problems and the fishers' adaptation strategies. These analyses that relied on proportions' tables were

combined with figures (frequency histograms). The frequency histograms were made with Microsoft Excel 2016.

4. Results
4.1 Fishing typology
The first section of the results is the typology of fishing on Lake Toho. It was based on the fishing period, gender, the fishing modes, the fishing techniques and gears, and the methods of preservation of fish.

4.1.1 Fishing period
Fishing on Lake Toho has regularly been influenced by the above-mentioned four seasons of the year. During rainy seasons, lake Toho is overflowed. In these seasons, most of fish and other fish resources of the lake moved to lakeshore and formed their ecological niches. This allows fishermen to fish at the banks of the lake, using either dip nets, hooks or creels. The rainy seasons were characterized by an abundance of fish, especially large fish. In contrast, during dry seasons, the level of water considerably drops, forcing fish to remain in the center of the lake and forming their ecological niches at the bottom of the lake. As a result, fishermen travel long distance before fishing. The lake's surface was hit by the sun, making the wind dry and forcing fish to remain in the deepest part of the lake for freshness.

4.1.2 Gender
On Lake Toho, only men do fishing, while women and children are mainly involved in processing activities such as smoking and drying.

4.1.3 Fishing modes
On Lake Toho, fishery was either active (86% of the fishermen) or passive (14% of the fishermen) depending on the technique used. Active fishing has been the one that puts more pressure on the available fish stock. The fishing techniques in this case were ''hawk nets'', gillnets, pocket nets, dip nets and ordinary creels. However, passive fishing is the one that exerts less pressure on the fishery resources. The fishing techniques used for the latter are: creels, gill nets, surface drift nets. The fishing technique in the study villages depended on the type of species to be caught and the biological environment in which the species lives. In the deep areas of the lake and tributaries, fishermen are involved in gillnetting, fishing with small landing nets and creels. On the other hand, in the shallower areas of the lake, fishermen fish with creels, big landing nets, and practice ''hawk fishing'' and net fishing.

4.1.4 Fishing gears
The ecological complexity of Lake Toho and its tributaries and the characteristics of each fish required the use of a variety of fishing gears depending on the environment and type of fish to be caught. Human and financial resources are needed for this purpose. The gears used by fishermen on lake Toho include: nets, creels, landing nets, mosquito nets and the basket ''Gôdô''.

4.1.5 Nets
There are various forms of nets, each corresponding to the size of fish. These include ''hawk nets'' and gillnets. The ''hawk nets'' are conical in shape and variable in mesh; they are used for fishing during dry seasons when water level falls. At the base of these nets exist some pieces of lead. The gillnets used on Lake Toho are: "*Gbagbaloulou*" and "*Tohounga*" (Figures 3 and 5). The first is a net of variable meshes which is stretched in the lake using two wooden rods at both ends. It captures all fish that try to cross it and as such is a destructive gear of fishery resources. It is used in dry seasons the second is a dormant net with variable mesh fixed between two stakes driven into the mud. Floats are attached at the top and leads at the bottom. The net is stretched in the Lake. This fishing technique used in the rainy seasons leave the small fish escape, but catches big fish. It is a fishing gear that has favored the development and sustained growth of small fish.

4.1.6 Creels
They use two types of creels on Lake Toho (Figure 6). These are ordinary creels and net creels. Ordinary creels are used in dams and stop all fish species. They are open at both ends. Net creels are about the shape of hairstyling basket. The bottom is closed and the net portion has one or more horizontal openings functioning as valves. Bait (palm nuts, oilcakes, etc.) are put inside to attract fish. Once inside, they cannot get out.

4.1.7 The landing nets
Two types of landing nets are used on Lake Toho: one small and one large (Figure 4). The small landing net (Sèguè) is made up of 25 mm or 30mm long meshes attached to an oval shaped wood of about 1m as diameter, all forming a conical pocket about 1m high. It has a handle 3 m long and about 3 cm in diameter. The wood of plant species such as *Zanthoxylum xanthoxyloides, Azadirachta indica* is used in the manufacture of the handle and the circle is made of *Mallotus oppositifolius* wood. Fishing is done by two people (a boatman and a technician) or alone. At two, during fishing, the boatman propels the canoe and the technician forcefully plunges the net into the water up to the mud, scrapes the bottom in a rowing motion and pulls out the gear. Alone, the technician plays both roles. The large landing net is the same as the small one, but it differs from the latter by its dimensions. The length of the handle and the diameter of the circle vary between 1.5 m and 2.5 m. The wood used for the handle is the same as the small, but the wood of *Lecaniodiscus cupanioides* is used for the circle. Fishers use two large landing nets on lake Toho. The first is called *Congo*. This landing net is used to fish under floating vegetation. The diameter of the thread of the net is relatively larger, this allows the net to resist the aggression of roots and plant residues. The second named *Adjakpoou Kounkouin* is the largest landing net which involves fishing at two.

4.1.8 Mosquito nets
Fry fishery with mosquito nets does not respect the existing regulation on fishing. It destroys not only the spawning grounds, but also contributes to the capture of fry and immature growing fish (Figure 2). However, no decision is made to address this issue.

4.1.9 ''Gôdô''
''Gôdô'' is a fishing gear that is commonly used on Lake Toho when fishing by hand (Figure 7). It is a cylindrical basket flattened from 20 to 30 cm in height and 30 to 40 cm in diameter. At both ends of the basket is attached the same rope that fishermen put on when fishing by hand.

Fig 2: Mosquito nets « Zalouido »

Fig 3: Gillnets «Tohounga »

Fig 4: landing nets « Sèguè »

Fig 5: Pocket traps nets « Ethion »

Fig 6: *Ordinary creels*

Fig 7: «Gôdô» used by fishery bay hand

4.1.10 Fishing techniques
The use of fishing gear requires a specific fishing technique. The fishing gear most used by fishermen on Lake Toho is "Gôdo" (78%). This fishing gear made it possible to fish by hand. It's a fishing technique that consisted of going to the bottom and spending 5 to 10 minutes there depending on the fisherman. It is often done in groups. When the fishermen are there, they form a circle and use their hands to search for fish holes. Fish are caught from the holes when trying to escape.

4.1.11 Fish preservation methods
Figure 8 illustrates the proportions of fishermen according to preservation methods. The analysis of the graph revealed that 93.6% of the fishermen keep fish fresh, 74.5% fry them, 56% smoke them and 45.8% use salting method for preservation. Fishermen use these methods because of the great distance that separates Lake Toho from the markets and the lack of big containers to preserve fish.

4.1.12 Preservation through containers
Fishermen only use lake water fetched with containers to preserve live fish. These containers serve as the first preservation technique for fish such as *Clarias guariepinus*, *Oreochromis niloticus* and *Ctenopoma kingsleyae*. This way of preserving allows live fish to be shipped to major marketing centers of Lokossa and Comé.

4.1.13 Preservation by smoking
This is done with respect to the size of the fish caught. Thus, two types of smokehouse are used: the log smokehouse and the simple smokehouse. The log smokehouse is often used in the camp for medium and large size fish. This method consists in placing the smokehouse at a height of 1 m from the ground supported by four stakes. The fresh fish are placed on the first shelf of a rectangular shape and covered with palm leaves to prevent smoke from coming out. Smoking with this type of smokehouse is done with a gentle fire. The simple smokehouse is used to smoke small fish and is often installed in the houses of fishermen at a height of 1 m from the ground. Unlike the log smokehouse, the simple smokehouse receives intense fire for more than two hours before it is reduced to a mild fire emitting a huge amount of smoke. Generally, for both methods, the smoking duration is on average 5 days and requires the fisherman and his family an important time for harvesting the wood and monitoring fish during the operation. The wood is usually harvested in the surrounding bush of the lake. The population explosion as well as the need for large quantities of wood during smoking are additional source of pressure on the nature.

4.1.14 Preservation by salting
Fish salting is a less-used technique for preservation. The reason given is the high cost of production because of the scarcity and price of salt in the fishing area. The salting method consists first of all in cleaning the fresh fish. Then a reasonable amount of salt is spread on the skeen and inside the fish. Finally, fish are laid on a basket of spherical shape, ready for drying. It is worth mentioning that the process takes three days and allows fishermen to maximize revenue.

4.1.15 Frying as a preservation method
It is the second most common fish preservation technique, which uses peanut oil or palm oil. As in the case of smoking technique, it is a preservation technique that requires firewood. 75% of the fishing households that preserve their

fish by frying, use peanut oil against 25% that use palm oil. Thus, according to the perception of fishermen, this difference in proportion is due to the fact that customers prefer fish fried with peanut oil to palm oil.
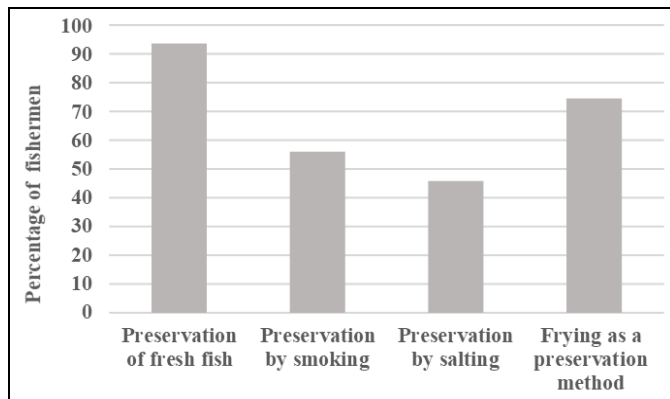

Fig 8: Fish preservation methods

4.1.16 Markets and marketing channels of fish on Lake Toho

Fish from Lake Toho are sold in local and urban markets. Local markets include: Logbo, Houin and Vèha. These are markets located in the district of Houin, Commune of Lokossa. The major urban markets for fish include Lokossa, Dogbo and Comé. There are two major channels of fish marketing. In the first that comprises only two links, both local and foreign consumers come directly to buy fish on the edge of the lake. At this point, fish are sold in heaps or individually. In the second marketing channel, there are intermediaries who are retailers. These retailers then deliver the fish to consumers in detail, either from house to house or in local and urban markets. The unit of measure at this level is most often the basket.

4.2 Fishing problems related to Lake Toho

Figure 9 depicts the problems related to fishing on Lake Toho. Its analysis reveals that fishermen face five major problems: -i-fishing by hand (96.8%), -ii- use of dip nets (86.7%), -iii- use of nets and tight-mesh nets (79.9%), -iv- pollution due to chemical fertilizers used for growing crops near the lake (75%) and -v- population pressure or the increase in the number of fishermen (63.5%).
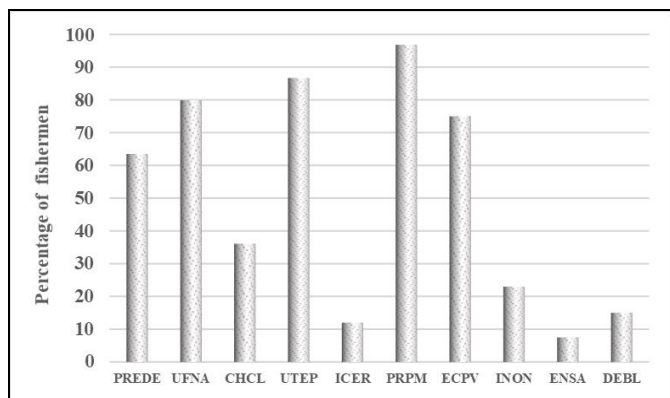

Fig 9: Fishing problems related to Lake Toho

4.3 legend Prede

Population pressure / Increase in the number of fishermen; UFNA: Use of nets and tight-mesh nets (meshes less than 40 mm); VChCl: Variability and climate change; UTEP: Use of

landing nets; ICER: Insufficient knowledge about the state of the lake's fisheries resources; PRPM: Fishing by hand; ECPV: Chemical fertilizers used for crop production; INON: Floods; ENSA: Lake silting; DEBL: Clearing of the banks around the lake.

4.4 Management and coping strategies

Figure 10 illustrates the strategies developed by fishermen to cope with the problems they face. The development of income-generating activities other than fishing (agriculture, livestock farming, trade, etc.), the use of regulated nets (medium-mesh or large-mesh nets) and the development of fish farming or aquaculture are the most developed management practices and adaptation strategies respectively accounting for 89%, 53.5%, and 31.6%.
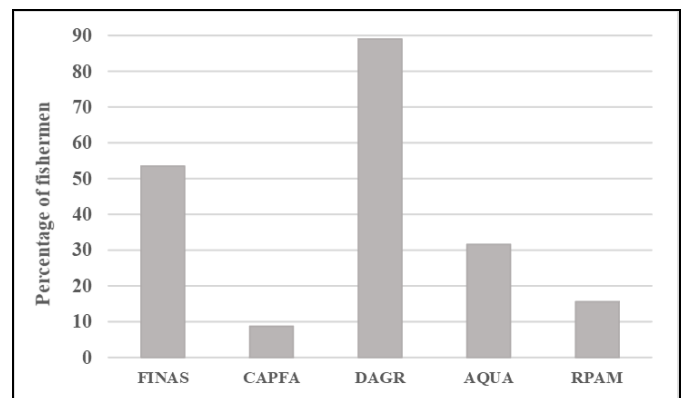

Fig 10: Coping strategies developed for fishing problems on lake Toho

4.5 Legend

FINAS: Use of regulated nets (medium or large mesh nets); CAPFA: Capture at times favoring the reproduction and sustained growth of fish; DAGR: Development of income-generating activities other than fishing (agriculture, husbandry, trade, etc.); AQUA: aquaculture/fish farming; RPAM: decrease of fishing by hand.

5. Discussions
5.1 Fishing characteristics and analysis of fishing problems related to Lake Toho

The systemic approach advocates the understanding of nature in its entirety, in all its complexity and considers the whole natural process in the form of a system for building a living relationship with nature. This requires us to manage Lake Toho's fisheries resources in a sustainable manner.

Lake Toho offers enormous opportunities for contributing to food security, particularly because of its fishing potential and still rudimentary tools mainly individually used during active or passive fishing. Nevertheless, there is among the gear used, those that are likely to threaten the lake's resources in the long term, and undermine its potential. Among these practices, fishing with nets and nets with tight mesh (meshes smaller than 40 mm), landing nets, mosquito nets and " Gôdô " can be mentioned. The latter is used during fishing by hand. It is a fishing technique that compromises the reproduction and renewal of fish species (Mukabo Okito *et al*, 2017) [14]. The nets used on Lake Toho are generally variable mesh gillnets. They catch big fish as well as small ones, depending on the size of the mesh. As for the creels used, they are usually ordinary and allow to catch all species of fish. Two forms of landing nets (small and large) are used on Lake Toho

(Ahouansou, 2003) [3]. On lake Mai-Ndombe in the Democratic Republic of Congo, most of the fishing techniques used endanger the Lake's fishery resources and undermine its potential as a result of the non-selective and non-regulatory nature of the fishing gear used. These include mosquito nets, fishing with *ichthyotoxic* (*Blighia welwitschii "Mbaka"*) plants, small-mesh gillnets and seine with mosquito net (Luhusu *et al.*, 2013) [10]. Empirical evidences from lake Tanganyika suggests that fishing with destructive gear is a significant threat to biodiversity and the maintenance of fish stocks. This is the case of beach seines presenting too small mesh and mosquito nets used in the spawning grounds and nurseries, which is particularly destructive for fish stocks, because everything is caught, including larvae, fry, etc. In addition, beach seines are particularly dangerous because they scrape the bottom, return the substrate, thus obstructing food sources and fish nests (Mukabo Okito *et al.*, 2017) [14].

It is quite clear that overfishing and fishing with destructive methods have negative socio-economic effects as it causes job losses and livelihoods in the very short term (Bongeba, 2012) [5]. The use of certain fishing gear such as creels leads fishermen to concentrate in the same fishing area. The consequences of this are negative both from the fishing and social point of view, because they result in the reduction of the profitability of the fishing effort as the same stock of fish is exploited by too many fishermen, and ultimately conflicts arise (Miyalu, 2003) [12]. Other empirical studies carried out on the River Ouémé in Benin also highlight that one of the factors that lead to the degradation of fish stocks is the destructive fishing gear and techniques used (Lalayè *et al.*, 2005) [8]. Thus, Attingli *et al.* (2017) [4] points out that fishing gears such as gillnets that are the most used in the fishery zones located downstream and in the center of the lower Ouémé valley (TU: 0.350 to 0.502) have a high nuisance index (IN: 0.209 each) on the fish fauna. The influence of fishing gear and techniques (II: 0.126 to 0.146) also affect the relative abundance of fish species (AR: 2.45 to 3.723). Another study, Montchowui *et al.* (2008) [18], conducted on the same river reveals that four types of fishing gears are used in the valley of the Ouémé river: the gill net, the ''hawk'' net, the small seine or Akpelou and the creels. This study reveals a very severe overfishing with strong fishing pressure on 0 + juveniles from reproduction and immature fish, which jeopardizes the renewal of fish. ''hawk'' nets and gill nets capture more fish than other fishing techniques and may result in a decline in fishery resources (Luhusu *et al.*, 2013) [10]. The various fishing gears (''hawk'' nets, gill nets, creels and longlines) used on the lakes are largely responsible for fish stock depletion (Mukabo Okito and al., 2017) [14] most used fishing gear on lakes in Benin are gillnets (nets with mesh sizes smaller than 3mm) that catch a large amount of fish (Miyalu, 2003) [12].

On Lake Toho, fishing modes (active or passive) depend on fishing gear and fishing areas. In contrast, on lake Mai-Ndombe in the Democratic Republic of Congo, purse seine fishing, beach seine fishing, ''hawk'' fishing and seine fishing with mosquito nets are the most widely modes in the Democratic Republic of Congo in shallow places (banks); while fishing with gillnets and angling are practiced in deep places. As for the creels, they are used either in the deep places beside the aquatic meadows containing Echinochloa (creel "Longobe"); or are placed in swamps with small dikes ("Boleke'' and ''Bombanzi" traps) (Luhusu Kutshukina *et al.*, 2013) [10].

Despite the use of these destructive fishing tools and techniques, fishermen keep the fish fresh, by smoking, by salting or by frying. The advantage of keeping fish fresh using lake water is to allow fish to continue to live in their aquatic ecosystem. The disadvantage of this mode is that if fish live longer, they may lack the nutrients necessary for their growth and development as these are produced in the lake. Fish frying is made with peanut oil or palm oil. Fish fried with peanut oil are more sold than those fried with palm oil because of consumers' preference of peanut oil. The smoking method used for preservation is very appreciated by the customers because it makes it possible to preserve the smoked fish longer than fish preserved by frying and by salting.

5.2 Analysis of the management strategies developed in response to fishing problems

To address fishing problems, fishermen develop non-fishing income-generating activities (agriculture, livestock, trade, etc.), use regulated nets (medium-mesh or large-mesh nets) or develop fish farming or aquaculture. The use of regulated nets adapted to each species of fish for fishing in lakes and lagoons allows small fish to grow and reproduce before being harvested (Ekouala, 2013) [6]. The implementation of activities other than fishing allows fishermen to diversify their income sources and thereby enables the increase in lifespan of fish (Attingli *et al.*, 2017) [4]. Fish farming or aquaculture is a strategy that fishermen consider good and effective. Sustainable management of fishery resources and their ecosystems requires the development of fish farming (Montchowui and *al.*, 2008) [13]. In the current study, fish farming is done with or without lake water. The most commonly raised fish species are *Clarias gariepinus* and *Tilapia galilea*. On Lake Mai-Ndombe, the biological rest for fish as a management strategy has been variously appreciated (Luhusu Kutshukina *et al.*, 2013) [10]. Biological rest is a good management strategy since it allows regeneration and preservation. Either the privatization of the lake, or the concerted management or co-management with the involvement of regulators (Mukabo Okito *et al.*, 2017) [14] could be possible solutions to the decline of the fishery resources.

6. Conclusion

The objective of this study was to understand the fishing activities in the South of Lake Toho. Data were collected from heads of fishermen's households as follows: 23 in Vèha, 23 in Logbo, 50 in Tokpa, and 33 in Tohonou. The results showed that the fishing gears used on Lake Toho include nets, creels, landing nets, and the basket ''Gôdô''. These gears are not appropriate because they are designed to capture even small fish. Once fish are captured, they are preserved using various local techniques. These include preservation in containers, smoking, salting, and frying. Fish are sold through two major channels. In the first that encompasses only two links, both local and foreign consumers come directly to buy fish on the edge of the lake. At this point, fish are sold in heaps or individually. In the second marketing channel, there are intermediaries who are retailers.

Fishermen face five major problems: fishing by hand, use of dip nets, use of nets and tight-mesh nets, pollution due to chemical fertilizers used for growing crops near the lake, and population pressure or the increase in the number of fishermen. To cope with the fishing problems, fishermen develop other income generating activities, comprising agriculture, livestock farming, etc.

7. Recommendations

In a participatory approach, the government, local authorities, Non-Governmental Organizations, and the populations should: (i) conduct concerted management or co-management of the fish resources, with the involvement of the supervisory authorities themselves; (ii) Diversify economic activities to enable the population to diversify their sources of income; (iii) Set up a quality control system for fish before and after processing; (vi) ensure effective participation and empowerment of local communities and socio-professional fishing organizations in the design, implementation, control and monitoring of fishing activities; (v) facilitate public awareness sessions of the populations on environmental education so as to enable them to take ownership of the conservation of this very important ecosystem and (vi) build basic social infrastructures to provide the lakeside populations with a quality biophysical environment.

8. Acknowledgement

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