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Trends in artisanal fisheries in a tropical man-made lake, Taboo hydroelectric lake in Ivory coast of West Africa

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Abstract

Changes in Taboo Lake fisheries were studied in order to provide scientific data for sustainable management. Inter-annual evolution of catch, yield, fishing effort, gears efficiency and catch composition were analyzed since the 80s until the 2000s. An Average of annual catch declined dramatically from 386.41 tons (during 1979-1995) to 67.14 tons (during 2004-2006). The corresponding mean yields for these periods were 66.60 kg ha⁻¹ yr⁻¹ and 19.41 kg ha⁻¹ yr⁻¹ respectively. The fishing effort ranged from 3.57 to 4.54 fishers km⁻² during 1992-1995 and was 4.39 fishers km⁻² in 2004-2006. Landings were dominated by gillnets catches (289.5 kg day⁻¹) accounting for 75.35% of total daily catch. During 2004-2006, Taboo Lake fisheries were mainly supported by two fish groups: *Chrysichthys* spp. and tilapiine fish. Invasive aquatic plants were found to be the major responsible of the decrease of fishing yields in this lake.

Keywords: Fish yield, Fishing effort, Gears efficiency, Catch composition, Taboo Lake, West Africa.

1. Introduction

Dams built on African rivers are important tools for development through hydroelectricity generation, water supply for farming activities and even for household needs^[1].

The resulting artificial lakes favor the development of fishing activities which are socio-economic issues for the surrounding communities. Indeed, fishing creates jobs and represents a livelihood for many people. Moreover, in several African countries, fish is a more accessible food resource for people because of its lower cost compared to meat^[2]. However, lakes undergo various perturbations including those related to overfishing^[3, 4].

Daget^[5] and Laë^[6] indicated that exploitation of fish populations had increased dramatically due to the high population growth prompting increased demand for protein, the exploitation of new media and new species and use of more efficient fishing gear. According to Lévêque and Paugy^[1] and Laë and Lévêque^[2], this situation is very pronounced in developing countries.

Taboo Lake remains the latest lake among the five major man-made lakes in Ivory Coast. Its fish fauna had been the least studied. This reservoir had been faced for a decade with a considerable increase in aquatic vegetation (fixed and floating) consecutive likely to enrichment of the water by nutrients (nitrates, phosphates) from the watershed subject to agricultural activities. More than 36% of the lake area was invaded by macrophytes^[7]. This situation is detrimental to the exploitation of fisheries resources through the reduction of fishing area.

Given the socio-economic interest of Taboo Lake, strategies for sustainable management of stocks should be developed to ensure and sustain fishing activities. The aim of this study is to show the changes in the fisheries of Taboo Lake since the 80s until the 2000s in order to provide input data useful for improved and effective management of fisheries resources.

2. Materials and Methods

2.1. Study area

The study was carried out on Taboo hydroelectric reservoir (06°20'N-06°40'N and 5°W-5°30'W). This lake was established in 1978 by the impoundment of the Bandama River, one of the four important rivers of Ivory Coast (Fig. 1). Taboo Lake has a main channel total length of 16 km and an area of 69 km² at the average operating level of the dam (124 m).

At this level, average water volume is around $625\,106\text{ m}^3$. It encompasses a catchments area about $58\,700\text{ km}^2$ and a mean annual flow of about $128.7\text{ m}^3\text{ s}^{-1}$. Data were provided by the

operator of the hydroelectric energy [8]. Macrophytes were very abundant in this artificial lake [7].

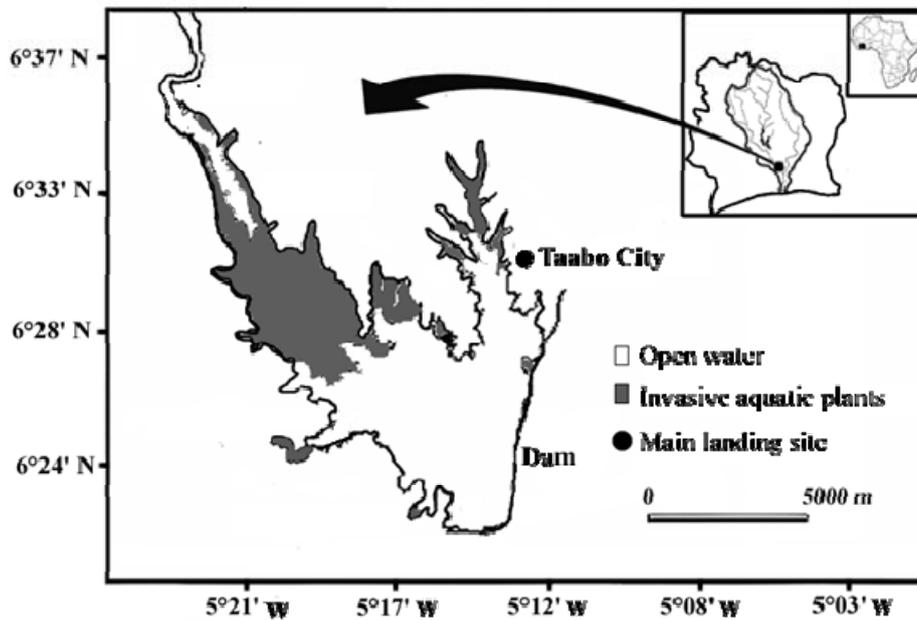


Fig 1: Map of Taboo Lake

2.2. Data collection

This study is based on historical data from Traoré [9] and current data from the Fishery Office of Taboo Reservoir (FOTR). Data from Traoré [9] concerned annual catch from 1979 to 1995, the fishing area of the lake and number of fishers. Data from FOTR were about three years: 2004, 2005 and 2006. These data concerned annual catch, number of fishers, fishing gears and catch composition.

2.3. Data analysis

Annual catches from Traoré [9] and FOTR were used to analyze changes in fish production in Taboo Lake since 1979 until 2006. Annual yields were deducted as annual catch per hectare of fishing area ($\text{kg ha}^{-1}\text{ yr}^{-1}$). Fishing effort was estimated as number of fishers per km^2 . According to Laë [10], this variable remains the only index applicable to the structural heterogeneity in tropical artisanal fisheries.

3. Results

3.1. Annual changes in catch and yield in Taboo Lake fisheries

During the period 1979-1995, fish annual production ranged from 202 to 462 tons with an average of 386.41 tons (Table 1). The lowest annual production was recorded in 1992, while the highest was obtained in 1991. The corresponding yield varied between 32.06 and $92.65\text{ kg ha}^{-1}\text{ yr}^{-1}$ with an average of $66.60\text{ kg ha}^{-1}\text{ yr}^{-1}$. During the period 2004-2006, the annual catches ranged from 54.70 (in 2005) to 76.10 tons (in 2004). The average was 67.14 tons. Annual yield fluctuated between 15.80 (2005) and 21.99 (2004) $\text{kg ha}^{-1}\text{ yr}^{-1}$ and the average was $19.41\text{ kg ha}^{-1}\text{ yr}^{-1}$.

Table 1: Annual catch and yield in Taboo Lake fisheries

Year	Annual catch (tons)	Fishing area (ha)	Yield ($\text{kg ha}^{-1}\text{ yr}^{-1}$)
1979	433	6130	70.64
1980	391	6120	63.89
1981	395	5650	69.91
1982	345	5680	60.74
1983	380	4920	77.24
1984	416	4490	92.65
1985	400	5970	67.00
1986	431	5870	73.42
1987	429	5190	82.66
1988	401	6500	61.69
1989	418	6150	67.97
1990	397	5700	69.65
1991	462	6150	75.12
1992	202	6300	32.06
1993	328	6500	50.46
1994	363	6150	59.02
1995	378	6500	58.15
2004	76.09	3460	21.99
2005	54.68	3460	15.80
2006	70.67	3460	20.42

3.2. Estimated fishing effort during 1992-1995 and 2004-2006

During 1992-1995, the fishing effort recorded in Taboo Lake fluctuated between 3.57 and 4.54 fishers km^2 . These extreme values were obtained in 1992 and 1994 respectively. More recently, during 2004-2006, the fishing area was estimated at 34.6 km^2 and the number of professional fishers had remained constant at 152 individuals. The corresponding fishing effort was 4.39 fishers km^2 (Table 2)

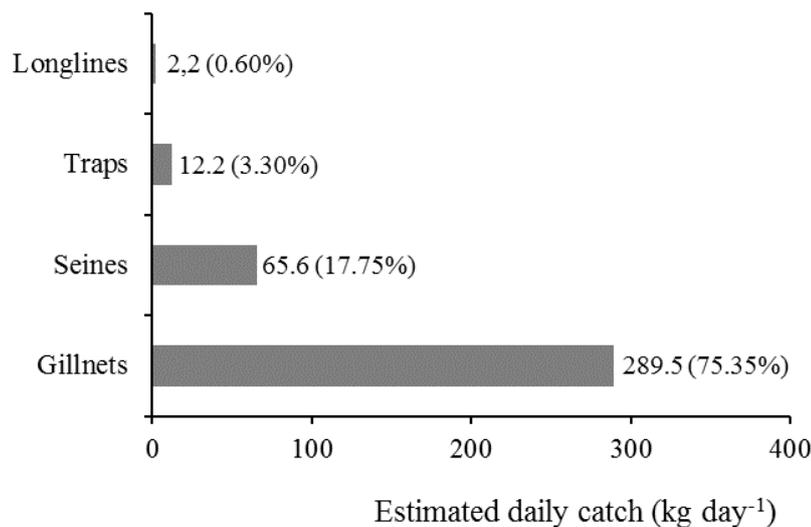
Table 2: Changes in fishing effort during 1992-1995 and 2004-2006 in Taboo Lake fisheries

Year	Fishing area (km ²)	Number of fishers	Fishing effort (Fishers km ⁻²)
1992	63	225	3.57
1993	65	293	4.51
1994	61.5	303	4.93
1995	65	295	4.54
2004-2006	34.6	152	4.39

3.3. Fishing gears efficiency by captures weight during 2004-2006

Average catch rates (kg) per gear per day in Taboo Lake is illustrated by figure 2. Fishers operating at Taboo Lake

consistently used four gear types: gillnets, seines, traps and longlines. Gillnets catches (289.5 kg day⁻¹) accounted for the majority of landings (75.35%) followed by seines (65.6 kg day⁻¹), traps (12.2 kg day⁻¹) and longlines (2.2 kg day⁻¹).

**Fig 2:** Gears efficiency in Taboo Lake fisheries

3.4. Catch composition during 2004-2006

The annual production by fish group during 2004-2006 is given in table 3. During these years, *Chrysichthys* spp. and tilapiine fish were the most targeted fishes in Taboo Lake with a cumulative percentage of catches ranging between 87.72 and 98.17%.

The annual production varied between 33 597 to 45 934.2 kg for *Chrysichthys* spp. and 19 305.6 to 31 585.1 kg for tilapiine fish. Apart from these two main groups, catches in Taboo Lake were also constituted by *Clarias* spp. (251.5 to 4 153.2 kg), Mormyrids (98.5 to 1 418.75 kg), *Heterotis niloticus* (432 to 1 322.65 kg), *Schilbe* spp. (75.5 to 1 182.5 kg) and *Labeo* spp. (118.22 to 240.5 kg).

4. Discussion

The analysis of inter-annual evolution of total catch in Taboo Lake and its yield showed a marked decrease of these two parameters from the period 1979-1995 to 2004-2006. This trend is likely a result of the reduction in the fishing area, leading to a decline in the number of fishers and correspondingly a drop in catches. A similar situation of falling catches was observed in Ayame Lake (Bia Basin, Ivory

Coast) following the decline of the fishing effort caused by the departure of Bozo professional fishers [11].

A comparison with yields obtained in other lakes in Ivory Coast and Africa indicates that for the period 1979-1995, the average of yield in Taboo Lake (66.60 kg ha⁻¹ yr⁻¹) was quite high. In contrast, the yield recorded more recently (2004-2006) was low (Average: 19.41 kg ha⁻¹ yr⁻¹). Estimates of yield for major lakes of Ivory Coast had given 80 kg ha⁻¹ yr⁻¹ in Ayame Lake, 76.92 kg ha⁻¹ yr⁻¹ in Buyo Lake, 106.67 kg ha⁻¹ yr⁻¹ in Kossou Lake, 36 kg ha⁻¹ yr⁻¹ in Fae Lake [12]. In 59 African lakes with different operating levels, the annual catch per unit area estimated by Laë *et al.* [13] ranged from 1.2 to 252.9 kg ha⁻¹ yr⁻¹ with an average of 59.1 kg ha⁻¹ yr⁻¹.

The fishing effort in Taboo Lake had changed little since the 1990s until 2006, despite the decline in the number of fishers operating in the reservoir. This is due to the considerable reduction in the fishing area by invasive aquatic plants that occupied about 36% (in 2004-2006) of the total area of the lake in 2006. Fishers density observed on the lake (3.57 to 4.93 fishers km⁻²) was greater than the FAO standard which is 2-3 fishers km⁻² [14, 15].

Table 3: Catch composition by weight in landed fish from Taboo Lake during 2004-2006

Year	Fish group	Annual Catch (kg)	Percentage	Cumulated percentage
2004	<i>Chrysichthys</i> spp.	45 934.2	60.37	60.37
	Tilapiine fish	20 812.9	27.35	87.72
	<i>Clarias</i> spp.	4 153.2	5.46	93.18
	Mormyrids	1 418.75	1.86	95.05
	<i>Heterotis niloticus</i>	1 322.65	1.74	96.78
	<i>Schilbe</i> spp.	1 182.5	1.55	98.34
	Mixed fish	974.5	1.28	99.62
	<i>Labeo</i> spp.	240.5	0.32	99.94
<i>Distichodus rostratus</i>	49	0.06	100	
2005	<i>Chrysichthys</i> spp.	33 597	61.45	61.45
	Tilapiine fish	19 305.6	35.31	96.76
	<i>Clarias</i> spp.	599.5	1.10	97.85
	<i>Heterotis niloticus</i>	432	0.79	98.64
	<i>Schilbe</i> spp.	230.7	0.42	99.06
	Mixed fish	212.1	0.39	99.45
	<i>Labeo</i> spp.	159.5	0.29	99.74
	Mormyrids	100.6	0.18	99.93
<i>Distichodus rostratus</i>	39.5	0.07	100	
2006	<i>Chrysichthys</i> spp.	37 791.45	53.48	53.48
	Tilapiine fish	31 585.1	44.69	98.17
	<i>Heterotis niloticus</i>	646	0.91	99.08
	<i>Clarias</i> spp.	251.5	0.36	99.44
	<i>Labeo</i> spp.	118.22	0.17	99.61
	Mormyrids	98.5	0.14	99.75
	Mixed fish	80.5	0.11	99.86
	<i>Schilbe</i> spp.	75.5	0.11	99.97
<i>Distichodus rostratus</i>	22.5	0.03	100	

Greater fishing efforts were recorded in another lake of Ivory Coast and elsewhere in Africa: Ayame Lake in Ivory Coast (6.1 fishers km⁻²) and the Central Niger Delta where fishing effort was between 3 and 6 fishers km⁻² [16]; Itasy Lake in Madagascar (28,6 fishers km⁻²) or Nyumba in Tanzania (10 fishers km⁻²) [17].

However, the use of fishers density as an indicator should be approached with caution for artisanal fisheries because fishing units are distributed among professional, seasonal and casual fishers; thereby making comparisons difficult between different systems.

The analysis of gears efficiency showed a predominance of gillnets with a daily catch estimated to 289.5 kg, accounting for 75.35% of total daily production. According to Albaret and Laë [18], the predominance of gillnets catches is the sign of a more professional fishing activities and a more intense fishing pressure. This observation is common to the vast majority of African man-made lakes [17].

Catch composition showed a predominance of *Chrysichthys* spp. and the tilapiine fish. Other fish such as *Clarias* spp., Mormyrids, *Heterotis niloticus* and *Schilbe* spp. were fairly well represented. Da Costa and Diétoa [19] also observed a predominance of *Chrysichthys* spp. and tilapine fish (*Tilapia zillii* and *Sarotherodon melanotheron*) in Fae Lake (Ivory Coast). These two fish groups and *Brycinus* spp. accounted for the majority of landed captures in Ayame Lake [20]. Historical data on catch composition of Taboo Lake indicates that landings were dominated by three taxa: *Oreochromis niloticus*, *Heterotis niloticus* and *Chrysichthys* spp. [9].

5. Conclusion

This study allowed a glimpse of changes in Taboo Lake fisheries since the 80s until the 2000s. Data showed a drastic drop in catches and yields from the period 1979-1995 to 2004-

2006. Fishing pressure expressed as the number of fishers per km² was higher than that recommended by FAO. Gillnets were the most used fishing gears with catches accounting for 75% of total landings. Catch composition indicated a predominance of groups of fish: *Chrysichthys* spp. and tilapiine fish. However, the lack of data for the long period from 1996 to 2003 did not allow further analysis. In addition, it is recommended to fight against invasive aquatic plants in order to improve fishing yields.

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