

Original Research Paper

Exploitation of Fish Resources and Perceptions of Natural Hybridization Among Fishermen in the Mbô Floodplain, Cameroon

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Abstract

The Mbô floodplain in Cameroon is home to traditional fishing communities whose livelihoods and food security are increasingly threatened by declining fish stocks, environmental pressures, and limited socioeconomic opportunities, highlighting the need to understand their characteristics and challenges to inform sustainable fisheries management. The aim of this study was to characterize the fishing communities of the Mbô floodplains, West region of Cameroon, to identify their specific characteristics and challenges they face. The work was conducted in the Mbô floodplains, Santchou Cameroon from February and June 2022. Data on socio-demographic characteristics, fishing practices and economic reliance on fishing were collected using structured questionnaires and random sampling techniques in four localities, namely Bamia, Mankang, Mbôngo and Nteingue, from 49 fishermen who had at least two years of fishing experience. Quantitative continuous variables were summarized using means and standard deviations, while categorical variables were described using frequency tables. The results showed that the fishing community consists entirely of men and is predominantly of the Mbô ethnic group (73.5%). Most fishermen are married (87.8%), with almost half (49%) between 31 and 40 years old. The level of education is relatively low, only 46.9% have a secondary education, while a clear majority (85.7%) rely on fishing as their main source of income. 83.7% of fishermen primarily use fish products for self-consumption. Fishing activities occur predominantly in lakes (83.7%) and rivers (93.9%) and are influenced by resource availability (73.5%). Fishermen fish an average of four times per week, with an average catch of 21 kg per trip. The fish is sold at an average price of 1163 Fr CFA per kilogram. A common concern among the fishermen is the decline in fish stocks, attributed by fishermen to overfishing (67.3%) and pesticide use (26.5%). All fishermen (100%) were aware of natural hybridization between *Clarias gariepinus* and *Clarias jaensis*, with 55.1% reporting having caught hybrids exhibiting mixed traits. The fishermen were classified into four distinct classes based on age, income reliance on fishing, training opportunities, and fishing methods. These insights highlight the urgent need for targeted interventions to promote sustainable fishing practices and enhance community resilience against environmental changes, ensuring the long-term viability of fisheries and local livelihoods.

Keywords: Characterization; Fishing communities; Sustainable fisheries; Mbô floodplain; Cameroon.

Introduction

Governments and international development organizations worldwide are beginning to recognize the role inland fisheries play in providing various economic and social benefits to developing countries. In large river basins like the Amazon, Congo, Ganges, Mekong, Niger, and others, it has been noted that millions of people rely on river and floodplain fisheries for their livelihoods (Neiland *et al.*, 2008). Inland fisheries are essential to the livelihoods, cultural identity, and food security of hundreds of millions of people worldwide. According to Andrew *et al.* (2007) and Loring *et al.* (2019), fisheries play a crucial role in sustaining local food systems, particularly in coastal and river fishing communities of low-income countries where access to nutritious fish is essential. The potential for inland fisheries to enhance global food security is significant, especially as they align with the principles of the emerging blue economy, which emphasizes sustainable use of inland resources (Arthur *et al.*, 2022; FAO, 2024). Fish caught from small-scale capture fisheries are not only a primary source of protein but also provide essential micronutrients that are often lacking in the diets of vulnerable populations (Mensah and Quatey, 2002; Loring *et al.*, 2019). The increasing prevalence of small and medium-scale fisheries further complements these contributions, particularly in low-income countries like Cameroon where it serves as a critical resource for food security and economic stability (Nyawung *et al.*, 2022; Nyawung, 2023).

The fishing sector significantly impacts Cameroon's economy, food security, and local livelihoods. In 2016, the fisheries sector employed over 240,000 artisanal fishermen, including thousands of women who rely primarily on the fish trade for their livelihoods, and it contributed 3% of Cameroon's estimated \$35 billion gross domestic product (Beseng, 2021). More than 25% of the animal protein consumed by millions of Cameroonians comes from fish, and fishing is a social activity for some coastal and rivers fishing communities because it is an integral part of their sociocultural system, influencing both individual and collective behavior (Gallois and Duda, 2016).

The inland fisheries sector in Cameroon generally depends heavily on the country's hydrological characteristics and in particular on the floodplains, which serve as vital ecological zones that harbor rich biodiversity and provide important resources for local communities (Marchand, 1987). But despite its great potential, Cameroon's inland fisheries sector faces major challenges that threaten its sustainability and the livelihoods of those who depend on it. Illegal, unreported and unregulated fishing is a major concern, and monitoring and control systems are inadequate (Beseng, 2021). This has led to overfishing and habitat degradation, resulting in economic and fish biodiversity losses. In addition, the socio-economic impacts are severe as many local communities depend on fishing for their livelihoods, and the depletion of fish stocks has led to a reduction in their income and an increase in the price of fish products (Andrew *et al.*, 2007). Addressing these issues requires a comprehensive approach that includes understanding fishermen dynamics. By understanding the demographics, fishing practices, and socioeconomic conditions of local fishermen, policymakers can tailor interventions that strengthen community commitment to sustainable practices.

Among the various ecological and socio-economic factors affecting inland fisheries sustainability, natural hybridization between fish species has emerged as a potentially significant but understudied phenomenon. In the Mbô floodplain, natural hybridization between *Clarias gariepinus* and *Clarias jaensis* may affect fish stock dynamics, biodiversity, and fishing practices, presenting both risks and opportunities for sustainable management. Understanding fishermen's awareness and perceptions of this phenomenon is therefore critical to developing adaptive strategies that balance conservation and livelihoods.

The aim of this study was to characterize the Mbô floodplain fishing communities in order to identify their specific features and challenges they face. Understanding these dynamics is crucial for developing adaptive strategies that enhance resilience among fishing communities in the face of environmental changes.

Materials and Methods

Period and study zone

The study was conducted from February to June 2022 in the Mbo floodplain, West region of Cameroon, particularly in Santchou, located on the right bank of the Menoua River in Cameroon. The area lies at 5°16'55" North latitude and 9°58'27" East longitude and is accessible via the provincial road P17. Santchou is bordered by Dschang subdivision to the north, Melong to the south, Bandja to the west, and Nguti to the east. Santchou comprises 28 villages and is watered by three main rivers: Black Water, Menoua, and Nkam. These rivers, fed by springs and runoff from highlands, overflow during the rainy season, causing flooding that varies annually depending on rainfall intensity and frequency.

Survey design and sampling

The target population consisted of all fishermen operating on the Mbo floodplain with at least two years of fishing experience to ensure adequate knowledge relevant to the study objectives. According to the official registry from the Subdivisional delegate of the Ministry of Livestock, Fisheries and Animal Industries, 49 fishermen met this criterion. Given the small population size, an exhaustive stratified census was conducted to include all eligible fishermen, eliminating sampling error and ensuring comprehensive coverage. Stratification was based on locality, focusing on four villages with the highest fishing activity as identified by MINEPIA (DAEPIA): Bamia, Mankang, Mbongo, and Nteingue. All fishermen within each stratum who met the inclusion criteria were surveyed. Data collection involved structured questionnaires administered by appointment, consisting of both open and closed questions. These questionnaires gathered socio-economic and technical information (ethnicity, gender, age, religion, education, main activity, professional experience, fishing training, use of harvested fish) as well as fishermen's endogenous knowledge about natural hybridization in Clariidae. The questionnaire was administered to fishermen by appointment using the KoboCollect app (Lakshminarasimhappa, 2022).

Statistical analysis

All data was downloaded from the Kobo-Tool-Box server as an Excel file, processed, transferred and analyzed using the FactoMineR package of the R software version 4.2.3. Data on fishermen's socio-demographic and economic characteristics, knowledge and perceptions of natural hybridization of Clariidae in the Mbô floodplain were analyzed

Results in Table 1 show that the fishing population is predominantly male (100%), with an important proportion (73.5%) identifying as Mbô ethnic group members despite the presence of ethnic diversity. Fishermen between the ages of 31 and 40 are the most represented (49%) in the age distribution. The percentage of married fishermen was 87.8%, while the percentage of single or divorced fishermen was only 8.1% and 4.1%, respectively. Christianity was the predominant religion (69.4%), followed by atheism (26.5%).

Table 2 presents the distribution of fishermen according to their level of education, main activity, professional experience, fishing training, and reasons for lack of training.

Table 2. Distribution of fishermen according to the level of education, the main activity, the professional experience, the fishing training, and the reason for lack of training.

Characteristics	Locality				
	Bamia, N = 15	Mankang, N = 12	Mbongo, N = 8	Nteingue, N = 14	Overall, N = 49
Level of education					
Not Educated	2 (13.3%)	3 (25.0%)	2 (25.0%)	4 (28.6%)	11 (22.4%)
Primary	5 (33.3%)	4 (33.3%)	2 (25.0%)	4 (28.6%)	15 (30.7%)
Secondary	8 (53.3%)	5 (41.7%)	4 (50.0%)	6 (42.9%)	23 (46.9%)
Main Activity					
Agriculture	4 (26.7%)	1 (8.3%)	0 (0.0%)	2 (14.3%)	7 (14.3%)
Fishing	11 (73.3%)	11 (91.7%)	8 (100.0%)	12 (85.7%)	42 (85.7%)
Professional experience					
> 5[	4 (26.7%)	3 (25.0%)	3 (37.5%)	5 (35.7%)	15 (30.6%)
[5 -10[	8 (53.3%)	8 (66.7%)	2 (25.0%)	6 (42.9%)	24 (49.0%)
[10 < [	3 (20.0%)	1 (8.3%)	3 (37.5%)	3 (21.4%)	10 (20.4%)
Fishing training					
Yes	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
No	15 (100.0%)	12(100.0%)	8 (100.0%)	14 (100.0%)	49(100.0%)
Reason lack of training					
Lack of Information	4 (26.7%)	1 (8.3%)	1 (12.5%)	1 (7.1%)	7 (14.3%)
Lack of financial Means	11 (73.3%)	11 (91.7%)	7 (87.5%)	13 (92.9%)	42 (85.7%)

n(%):Count (Percentage of the total in that column)

In Table 2 the results indicate that the fishermen in the Mbô floodplains predominantly have a low level of education, with only about 46.9% having completed secondary education. In contrast, 22.4% are not educated, and 30.7% have only primary education. The primary occupation for these individuals is fishing, with 85.7% identifying it as their main activity, none reported receiving any formal training. Professional experience varies among the fishermen, with 49.0% having between 5 and 10 years of fishing experience in the field. Financial constraints were cited as the primary reason for lack of training by 85.7% of fishermen.

Table 3 summarizes key aspects of fishermen's practices and economic reliance, including the primary use of fish products, dependence on fishing as the main source of income, membership in peasant organizations, fishing locations and reasons for their choice, fishing frequency per week, and average catch per fishing trip (kg).

Table 3 shows that in the Mbô floodplain in Cameroon, there is a strong tendency towards self- consumption of fish products harvested by fishermen: a total of 83.7% of fishermen consume fish mainly for personal use, while only 16.3% sell the fish immediately after harvesting. For 85.7% of fishermen, fishing is the primary source of income while 42.9% indicated membership in peasant organizations. Fishing activities predominantly occur in lakes (83.7%) and rivers (93.9%). The main reason for choosing fishing locations is the availability of fish resources, cited by 73.5% of respondents, while ease of access was mentioned by only 26.5%. Fishing frequency varies, from 3 to 6 times a week, and the average catch per fishing trip is approximately 21 kg. The average price per kilogram of fish sold is around 1163 Fr CFA.

Table 3. Distribution of fishermen according to the primary use of fish product, fishing as primary source of income, membership of peasant organization, fishing location, reason for choosing fishing location, fishing frequency /week, product harvested /fishery (kg).

Characteristics	Locality				
	Bamia, n = 15	Mankang, n = 12	Mbongo, n = 8	Nteingue, n = 14	Overall, n = 49
Primary use of fish products					
self-consumption	11 (73.3%)	10 (83.3%)	8 (100.0%)	12 (85.7%)	41 (83.7%)
Sale	4 (26.7%)	2 (16.7%)	0 (0.0%)	2 (14.3%)	8 (16.3%)
Fishing as primary source of income					
Yes	10 (66.7%)	12 (100.0%)	8 (100.0%)	12 (85.7%)	42 (85.7%)
No	5 (33.3%)	0 (0.0%)	0 (0.0%)	2 (14.3%)	7 (14.3%)
Membership of peasant organization					
Yes	8 (53.3%)	7 (58.3%)	3 (37.5%)	3 (21.4%)	21 (42.9%)
No	7 (46.7%)	5 (41.7%)	5 (62.5%)	11 (78.6%)	28 (57.1%)
Fishing location - Lake					
Yes	11 (73.3%)	12 (100.0%)	6 (75.0%)	12 (85.7%)	41 (83.7%)
No	4 (26.7%)	0 (0.0%)	2 (25.0%)	2 (14.3%)	8 (16.3%)
Fishing location - River					
Yes	14 (93.3%)	12 (100.0%)	7 (87.5%)	13 (92.9%)	46 (93.9%)
No	1 (6.7%)	0 (0.0%)	1 (12.5%)	1 (7.1%)	3 (6.1%)
Reason for choosing fishing location					
Availability of fish	13 (86.7%)	9 (75.0%)	7 (87.5%)	7 (50.0%)	36 (73.5%)
Ease of access	2 (13.3%)	3 (25.0%)	1 (12.5%)	7 (50.0%)	13 (26.5%)
Characteristics	Locality				
	Bamia, n = 15	Mankang, n = 12	Mbongo, n = 8	Nteingue, n = 14	Overall, n = 49
Fishing frequency /week					
Three	2 (13.3%)	2 (16.7%)	0 (0.0%)	2 (14.3%)	6 (12.2%)
Four	5 (33.3%)	1 (8.3%)	3 (37.5%)	5 (35.7%)	14 (28.6%)
Five	5 (33.3%)	3 (25.0%)	2 (25.0%)	5 (35.7%)	15 (30.6%)
Six	3 (20.0%)	6 (50.0%)	3 (37.5%)	2 (14.3%)	14 (28.6%)
Product harvested /fishery (kg)	22.8 ± 8.2	20.1 ± 6.4	22.3 ± 10.6	18.35 ± 8.1	20.8 ± 8.3
Price per kg of fish sold (Fr CFA)	1167 ± 244	1250 ± 261	1188 ± 259	1071 ± 182	1163 ± 236

n(%):Count (Percentage of the total in that column)

Technical characteristics and exploitation of fish products

Table 4 summarizes fishermen’s fishing gear, equipment origin, fish conservation methods, harvested and preferred fish products, and their observations and reasons for fish stock decline.

The results in Table 4 indicate that all fishermen reported using gill nets, traps, and fishing rods for fishing activities. Casting net is also widely utilized, with 73.5% of the fishermen using it, while 55.1% reported using trouble nets, showing a notable variation in fishing equipment among different localities. For 81.6% of fishermen the fishing equipment were self-made. In terms of product conservation, 64.3% utilize storage tanks, while freezing and usage of storage ponds are used by 14.3% and 20.4% of fishermen, respectively. The principal products harvested by all the fishermen were crabs (locally called “Eyang”), *Clarias gariepinus* (locally called “Ngonda”), *Oreochromis niloticus* (locally called “Megueng”), *Labeobarbus batesii* (locally called “Sapak”), *Parachanna obscura* (locally called “Viper fish”), and *C. jaensis* (locally called “Black fish”). *C. jaensis* was preferred for self-consumption by 51.0% of respondents overall, particularly in Nteingue (85.7%), followed by *C. gariepinus* (32.7%), while *Labeobarbus batesii* was less preferred by fishermen (16.3%). The reasons mentioned by fishermen for choosing *C. jaensis* as preferred products for self-consumption largely center on availability (34.7%), taste (28.6%), and low-fat content (36.7%). This means that among the different fish products, *C. jaensis* is more readily available in natural environment, tastes better, and has the lowest fat content. Notably, all fishermen observed a decrease in fish products, primarily attributed to over exploitation (67.3%) and the use of pesticides (26.5%) in plantations near of the various fishing spots.

Table 4. Distribution of fishermen according to the fishing equipment, origin of fishing equipment, product conservation method, harvested fish products, preferred product for self-consumption, reason for choosing preferred product, observation of decrease in fish products, reason for decrease in fish products.

Characteristics	Locality				
	Bamia, n = 15	Mankang, n = 12	Mbongo, n = 8	Nteingue, n = 14	Overall, n = 49
Gill net					
Yes	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
No	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Trap					
Yes	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
No	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Casting net					
Yes	12 (80.0%)	8 (66.7%)	5 (62.5%)	11 (78.6%)	36 (73.5%)
No	3 (20.0%)	4 (33.3%)	3 (37.5%)	3 (21.4%)	13 (26.5%)
Fishing rod					
Yes	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
No	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Trouble net					
Yes	10 (66.7%)	9 (75.0%)	2 (25.0%)	6 (42.9%)	27 (55.1%)
No	5 (33.3%)	3 (25.0%)	6 (75.0%)	8 (57.1%)	22 (44.9%)
Origin of fishing equipment					
Self-made	11 (73.3%)	11 (91.7%)	7 (87.5%)	11 (78.6%)	40 (81.6%)
Purchase	4 (26.7%)	1 (8.3%)	1 (12.5%)	3 (21.4%)	9 (18.4%)
Product conservation method					
Storage Tank	10 (66.7%)	8 (66.7%)	6 (75.0%)	8 (57.1%)	32 (65.3%)
Locality					
Characteristics	Bamia, n = 15	Mankang, n = 12	Mbongo, n = 8	Nteingue, n = 14	Overall, n = 49
Freezing	3 (20.0%)	1 (8.3%)	1 (12.5%)	2 (14.3%)	7 (14.3%)
Storage Pond	2 (13.3%)	3 (25.0%)	1 (12.5%)	4 (28.6%)	10 (20.4%)
Harvested fish products					
Crabs	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
<i>Clarias gariepinus</i>	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
<i>Oreochromis niloticus</i>	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
<i>Labeobarbus batesii</i>	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
<i>Parachanna obscura</i>	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
<i>Clarias jaensis</i>	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
Preferred product for self-consumption					
<i>Labeobarbus batesii</i>	4 (26.7%)	0 (0.0%)	3 (37.5%)	1 (7.1%)	8 (16.3%)
<i>Clarias gariepinus</i>	6 (40.0%)	4 (33.3%)	5 (62.5%)	1 (7.1%)	16 (32.7%)
<i>Clarias jaensis</i>	5 (33.3%)	8 (66.7%)	0 (0.0%)	12 (85.7%)	25 (51.0%)
Reason for choosing preferred product					
Availability	6 (40.0%)	9 (75.0%)	0 (0.0%)	2 (14.3%)	17 (34.7%)
Better Taste	4 (26.7%)	1 (8.3%)	3 (37.5%)	6 (42.9%)	14 (28.6%)
Low Fat	5 (33.3%)	2 (16.7%)	5 (62.5%)	6 (42.9%)	18 (36.7%)
Observation of decrease in fish products					
Yes	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
No	0(0%)	0(0%)	0(0%)	0(0%)	0(0%)
Reason for decrease in fish products					
Environmental destruction	0 (0.0%)	0 (0.0%)	1 (12.5%)	2 (14.3%)	3 (6.1%)
Over exploitation of resources	10 (66.7%)	9 (75.0%)	6 (75.0%)	8 (57.1%)	33 (67.3%)
Use of pesticides in plantations	5 (33.3%)	3 (25.0%)	1 (12.5%)	4 (28.6%)	13 (26.5%)

n(%):Count (Percentage of the total in that column)

Endogenous knowledge and perceptions on natural hybridization by fishermen

Table 5 details fishermen's knowledge of natural hybridization, their capture of Clariid hybrids, methods for identifying these hybrids, and their preferred catfish species.

Table 5. Distribution of fishermen according to the knowledge on natural hybridization, capture of Clariid hybrids, identification of the hybrid catfish caught, preferred catfish

Characteristics	Locality				
	Bamia, <i>n</i> = 15	Mankang, <i>n</i> = 12	Mbongo, <i>n</i> = 8	Nteingue, <i>n</i> = 14	Overall, <i>n</i> = 49
Knowledge on natural hybridization					
Yes	15 (100.0%)	12 (100.0%)	8 (100.0%)	14 (100.0%)	49 (100.0%)
No	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Caught Clariid hybrids					
Never	0 (0.0%)	11 (91.7%)	5 (62.5%)	6 (42.9%)	22 (44.9%)
Rarely	15 (100.0%)	1 (8.3%)	3 (37.5%)	8 (57.1%)	27 (55.1%)
Identify the hybrid catfish caught					
Taste	4 (26.7%)	0 (0.0%)	2 (66.7%)	4 (50.0%)	10 (37.0%)
skin color	3 (20.0%)	1 (100.0%)	0 (0.0%)	2 (25.0%)	6 (22.2%)
Fish size	8 (53.3%)	0 (0.0%)	1 (33.3%)	2 (25.0%)	11 (40.7%)
Preferred catfish					
<i>C. jaensis</i>	8 (53.3%)	1 (100.0%)	2 (66.7%)	4 (50.0%)	15 (55.6%)
Hybrid	7 (46.7%)	0 (0.0%)	1 (33.3%)	4 (50.0%)	12 (44.4%)



A: *Clarias gariepinus*



B: *Clarias jaensis*



C: *Parachanna obscura*



D: *Oreochromis niloticus*



E: *Labeobarbus batesii*



F: Crab

Figure 2. Harvested fishing product

All the fishermen (100%) are aware of the phenomenon of natural hybridization between *C. gariepinus* and *C. jaensis*, which they interpreted as merely the accidental crossing of fish from the same family. Although rare, 55.1% of fishermen reported having caught Clariidae that were distinct from the two

species found in this region (*C. gariepinus* and *C. jaensis*) and shared characteristics with both species. In contrast to Mankang, where 91.7% of fishermen reported never seeing these hybrids, 100% of fishermen in Bamia acknowledged occasionally catching them. Fishermen were able to identify hybrids from their parent species primarily based on fish size, taste, and skin color. Fish size was the primary criterion for distinguishing hybrids, especially among Bamia fishermen (53.3%), whereas taste was the primary criterion for Mbongo fishermen (66.7%). Based on the diverse descriptions obtained from fishermen, it seems that the hybrids that were collected had skin patterns similar to those of *C. jaensis*, but their total length was greater than what was typically seen in the parents of *C. jaensis*. Regarding preferences for consumption, 44.5% of fishermen who had already harvested these hybrids preferred hybrids, compared to 55.6 % who preferred *C. jaensis*.

Typology of fishermen in the Mbô floodplain

The principal component analysis (PCA) resulted in the extraction of 4 dimensions, 2 of which had an eigenvalue of variance greater than 1, and which alone explained a total of 64.5% of the overall variability within the surveyed population of fishermen. Dimensions 1 and 2 explain 37.1 and 27.4% of the total variance respectively (Fig. 3). Variables such as Fishing frequency per week, Price per kg of fish sold, Product harvested/fishery. (kg), Fishing gear acquisition costs, are the primary factors that create diversity among fishermen.

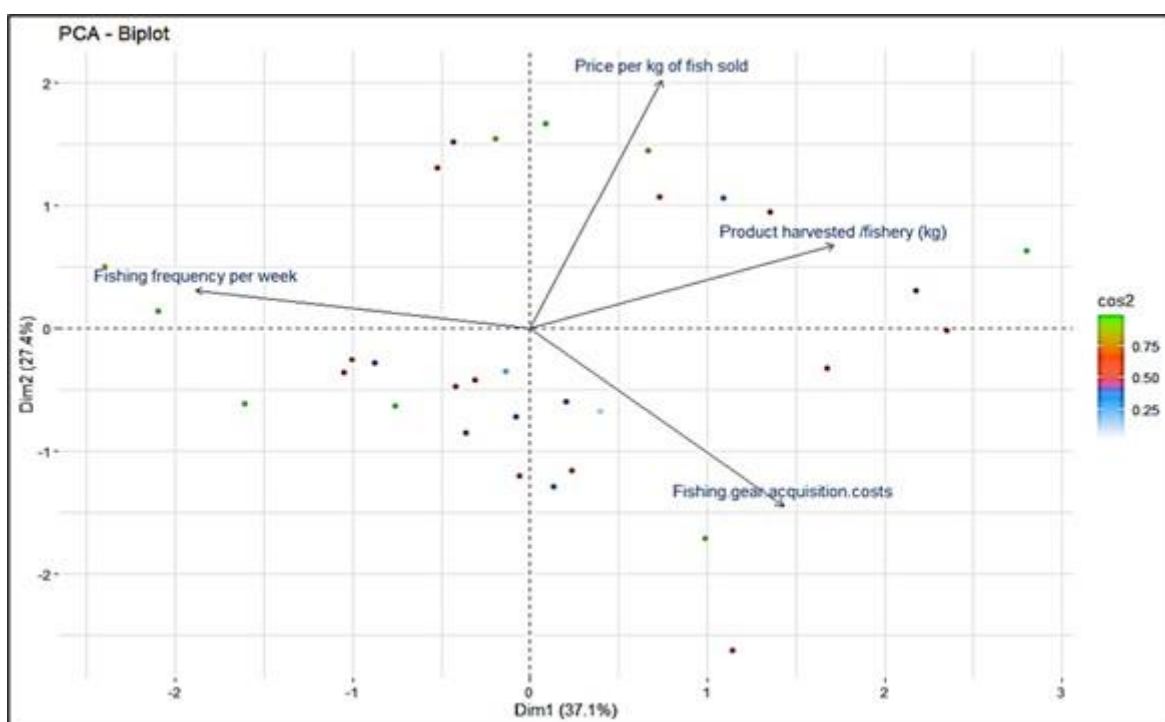


Figure 3. Position of variables and individuals on the first and second axes (Dimension 1 and 2) of the principal components analysis

The hierarchical ascending classification (CAH) carried out on the individuals allowed the fishermen to be divided into four classes according to the variables that best characterize them. As a result, 4 classes (Fig. 4) were identified on the basis of the distances calculated between individuals.

Class 1 consists of fishermen between the ages of 31 and 40 for whom fishing is the main activity and source of income. Fishermen of this class have not received any training in fishing, mainly due to lack of financial resources. These fishermen have low values for the quantity of products caught per fishery, although the frequency of fishing per week is higher for them. The main fishing gear used by fishermen of this class is gill nets, and the main use of fish products is home consumption. Fishermen of this class rarely caught hybrids resulting from natural crosses between *C. gariepinus* and *C. jaensis*. *C. jaensis* is the fish product preferred by fishermen for consumption. Fishermen in this class practice fish farming.

Class 2 is composed of individuals aged from 21 to 30 years, who also have fishing as their main activity with the professional experience less than 5 years, although it is not the main source of income for fishermen in this class. Individuals in this class do not practice fish farming due to lack of financial means. These fishermen have not received training in fishing, due to lack of information. The main fishing equipment used by fishermen in this class are fishing rods and cast nets. The fish products harvested are sold, and the price per kilo of fish sold is the highest in this class. Fishermen

in this class have never observed hybrids resulting from natural crosses between *C. gariepinus* and *C. jaensis*.

Class 3, on the other hand, is made up of individuals who practice fishing as a secondary activity with agriculture as their main activity. Individuals in this class do not practice fish farming. Cast nets, traps and fishing rods are the main fishing equipment used by fishermen in this class. Fishermen in this class sell the harvested fish products. Individuals in this class prefer *C. jaensis* as a food fish among all the fish products harvested. None of the individuals in this class have received training in fishing due to lack of financial means. Individuals in this class have the highest values for the acquisition costs of fishing equipment.

Class 4 corresponds to individuals whose main activity and source of income is fishing. The age range varies from 31 to 40 years and the professional experience varies between 5 and 10 years. Fish farming is not practiced here and fishermen have not received any training in fishing due to the lack of financial means. The main fishing equipment used in this class are gill nets. The fish products are used mainly for self-consumption. Fishermen belonging to this class reported having caught Clariidae that were distinct from the two species found in this region (*C. gariepinus* and *C. jaensis*) and shared characteristics with both species. Within this class we find individuals who have high values for the quantities of fish harvested despite the fact that this class contains fishermen with the lowest fishing frequencies per week.

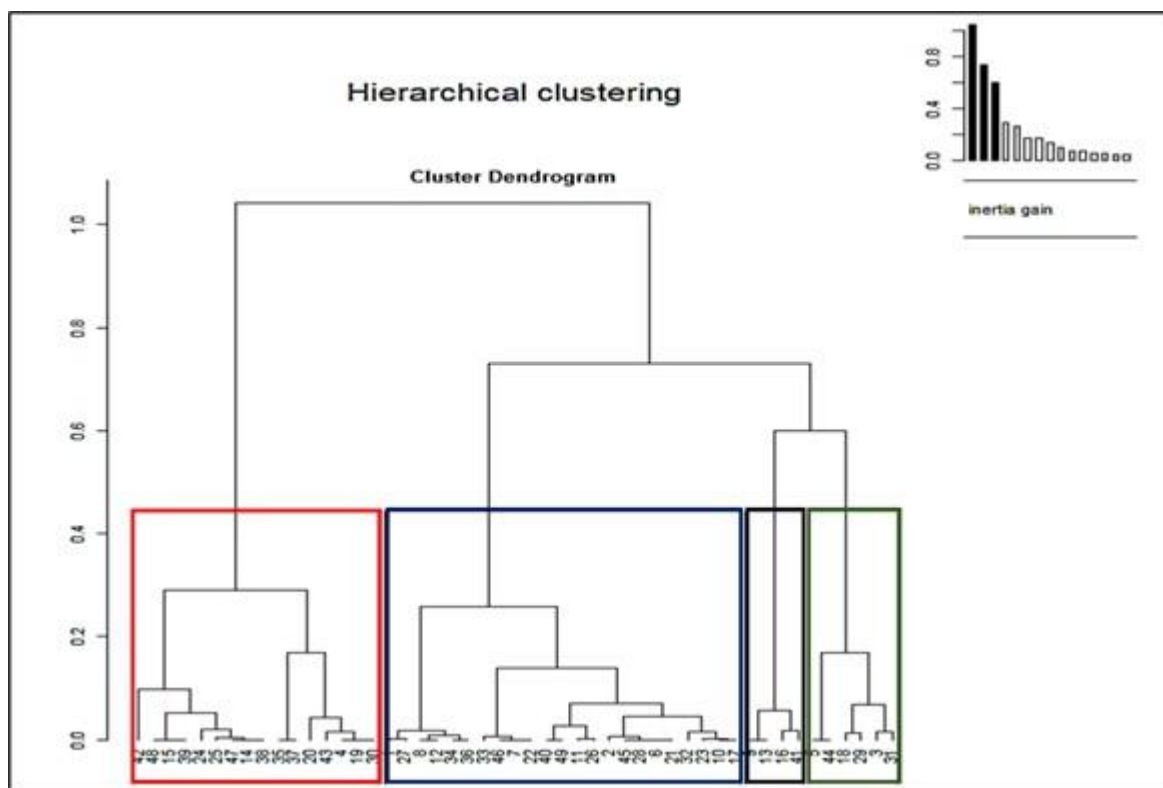


Figure 4. Dendrogram of the fishermen classes identified in the Mbô floodplain

Discussion

The majority of fishermen in the Mbô floodplain of Santchou are men under the age of 40. This is consistent with a study conducted by Allagbe *et al.* (2020), which found that in South-East of Benin, the majority of fishermen (82%) were men of whom 75% were less than 50 years of age. The absence of women in this activity can be explained by several interrelated socio-economic and cultural factors, such as: the physical demands of fishing which is often a physically demanding task that requires strength and endurance, which younger men are usually better able to do. The labor-intensive nature of fishing activities, such as handling nets and boats, favors younger people who can handle these tasks more effectively (Frangoudes and Gerrard, 2019). According to Gopal *et al.* (2020) another explanation could be the fact that younger men may be more likely to engage in fishing as a primary source of income, particularly in areas where other employment opportunities are limited. The need to support families or contribute to household income may encourage younger men to enter this profession, where fishing can provide immediate financial gain.

The majority of fishermen have only secondary education, suggesting that there may be a lack of educational opportunities that could limit their access to formal fishing training, which none of the respondents had due to financial constraints, this

result was in contradiction with the findings of Adienin *et al.* (2023) who showed that fishermen in Jacqueville Department were mostly uneducated. In the Mbô floodplain in Cameroon West region, fishing is not just the primary source of income for the majority of fishermen but also their primary means of subsistence compare to agriculture and livestock. Similar to the Mbô floodplains, the Waza-Logone floodplains host a significant fishing community that relies heavily on seasonal flooding, and fishing is also considered the main livelihood here compared to agriculture and livestock (Ziebé, 2015).

A notable trend toward self-consumption is indicated by the fact that the majority of the fishermen use fish products primarily for their own consumption as opposed to selling. These results were in accordance with those of Allagbe *et al.* (2020) who showed that self-consumption was the primary use of fish products in the District of Adjohoun in southern Benin. The choice of fishing locations is heavily influenced by resource availability, underscoring the importance of sustainable practices in these areas as highlighted by (Ziebé, 2015). Additionally, the average product harvested per fishery is approximately 21 kg, with a market price of around 1163 Fr CFA per kilogram, reflecting the economic viability of fishing as a livelihood despite the challenges faced. Similar dynamics are observed in other regions of Africa where small-scale fisheries operate under comparable conditions. For instance, in the coastal areas of Senegal, fishing is a primary source of income for many households, with fish prices fluctuating based on availability and market demand. The economic importance of fisheries in these regions is underscored by studies indicating that small-scale fisheries can generate significant income, contributing to household food security and local economic growth (Bartley *et al.*, 2015; Xu *et al.*, 2023).

In terms of fishing habits and preferences, the findings in the Mbô floodplain are consistent with more general patterns found in other research on small-scale fisheries. For example, the widespread use of fishing rods, gillnets, traps and cast nets in the Mbô floodplain highlights the resourcefulness of fishermen in low-income areas and is consistent with patterns observed in coastal fishing communities where homemade gear is typical (Tietze, 2016). The preference for *C. jaensis* among Mbô floodplain fishermen, attributed to factors such as availability and taste, is consistent with findings from other regions where local fish species are preferred for their nutritional and economic value (Pouomogne, 2008). Furthermore, reported declines in fish stocks due to overfishing and pesticide use reflect global concerns about the sustainability of small-scale fisheries, which are often vulnerable to environmental changes and anthropogenic pressures (Mikolasek *et al.*, 2009).

In this study, all fishermen were familiar with the phenomenon of natural hybridisation of *C. gariepinus* and *C. jaensis*, which is in line with the findings of other studies emphasizing the importance of local knowledge in fisheries management. Mulla and Chavan (2016) highlighted that fishermen's understanding of species interactions is crucial for sustainable practices in mangrove ecosystems, where local fishermen also recognize the importance of biodiversity for their livelihoods. In Bamia village, all fishermen reported catching fish that had characteristics of both parent species, in contrast to the fishermen of Mankang village, where few had observed such hybrids. This observed variation in hybrid occurrence likely stems from regional differences in water physicochemical properties across distinct fishing locations, consistent with the findings of Ayisi *et al.* (2023), who demonstrated that geographical factors significantly influence fishing patterns and species interactions in their natural environment.

Fishermen identified hybrids based on size, taste, and skin color. This preference for sensory end morphological attributes is consistent with other studies indicating that local fishermen often rely on experiential knowledge when identifying and preferring species, which is crucial for both consumption and market dynamics (Tietze, 2016). Furthermore, consumption preference for hybrids compared to *C. jaensis* suggests a more nuanced understanding of fish hybridization and its effects on fish quality, similar to other regions where perceptions of fish quality significantly influence fishing practices and economic outcomes.

The results of the cluster analysis provide important insights into the socio-economic dynamics of the Mbô floodplain fishing communities, particularly in terms of age, experience and resource use. HCA complements PCA by allowing the classification of individuals based on their similarities across multiple dimensions (Coronado *et al.*, 2020; Kande *et al.*, 2024). This classification is essential for tailoring interventions and support mechanisms to specific groups within the fishing community. Delgado-Ramírez *et al.* (2023) and Kande *et al.* (2024) demonstrated similar uses of HCA in classifying fishing households based on their livelihood strategies and efficiency levels, highlighting how such classifications can inform policy decisions aimed at enhancing community resilience. In this study, HCA identified four distinct classes of fishermen, each characterized by unique socioeconomic profiles and fishing practices.

Class 1 fishermen are mostly between the ages of 31 and 40, and fishing is their primary occupation and source of income. Despite their dedication to fishing, a large number of individuals in this class lack formal training because of financial limitations, which has a substantial negative influence on their productivity and fishing efficiency. Since access to educational resources is frequently restricted in small-scale fisheries, this lack of training is a prevalent problem

(Nyawung, 2023). Tan *et al.* (2021) highlighted how financial limitations can hinder skill development in fishing communities, leading to lower efficiency in catch rates despite increased effort. These fishermen predominantly use gill nets and report a higher frequency of fishing trips per week compared to other classes. However, this increased effort does not correlate with higher catch quantities, as they tend to have lower quantity of harvested products per fishery. Kolding *et al.* (2014) indicate that without adequate training and access to better fishing gear, even increased effort can result in suboptimal outcomes. According to Chiwaula *et al.* (2011), the reliance on self-consumption of their fish products highlights the socio-economic challenges they face, as many of these fishermen prioritize subsistence over commercial sales. Fishermen of this class have reported rarely catching hybrids resulting from natural hybridization between *C. gariepinus* and *C. jaensis*. This observation may reflect both the ecological dynamics of local fish populations and the limited ability of fishermen to adapt their practices to changing environmental conditions (Rice *et al.*, 2012). Their preference for *C. jaensis* as a food fish underscores the cultural significance of local species in their diets, aligning with findings of FAO (2024), that emphasize the importance of traditional knowledge and local biodiversity in sustaining rural livelihoods.

Younger fishermen in the class 2 consider fishing as their primary activity as well, but they do not depend on it as their main source of income. Their experience ranges from 0 to 5 years, and they mostly use cast nets and fishing rods. They have the most expensive costs of acquisition of fishing gear among the classes, and they have rarely caught across hybrids issued from the natural hybridization of *C. jaensis* and *C. gariepinus*. The lack of training opportunities noted in this class align with the research of Maddox (2007) indicating that young fishermen often face barriers to accessing educational resources, which can limit their professional growth. Moreover, the high price of a kilogram of fish products sold suggests a market-driven approach that may not prioritize sustainability or skill enhancement, as indicated by the economic pressures faced by younger fishermen who often depend on fluctuating market conditions for their income (Inoni and Oyaide, 2007).

Class 3 fishermen engage in fishing as a secondary occupation, primarily relying on agriculture for their main livelihood. This dual engagement reflects a common trend in rural communities where multiple income sources are essential for economic stability (Allison and Ellis, 2001). The preference for *C. jaensis* among these fishermen aligns with results of Tietze (2016), highlighting the significance of local fish species in the diets of rural populations. This reliance on local species not only fulfills nutritional needs but also supports cultural practices surrounding food consumption (Adewumi and Olaleye, 2011). However, the absence of training opportunities can limit their ability to optimize fishing techniques and improve catch efficiency. Research indicates that access to training and resources is crucial for enhancing the skills of small-scale fishermen, enabling them to adopt more sustainable practices (Tietze, 2016). Furthermore, the high acquisition cost of fishing equipment represents a significant barrier for these fishermen. Initial investments in fishing equipment can be prohibitive, especially for those whose primary source of income is not fishing (Sreekanth *et al.*, 2017). This financial constraint can discourage individuals from fishing more seriously or investing in better equipment that could increase their productivity.

Fishermen in Class 4 are characterized by their experience, ranging from 5 to 10 years, and they rely on fishing as their primary source of income. This class consists of individuals aged 31 to 40, who have developed a significant understanding of local fishing practices and market dynamics. The high quantities of fish harvested by fishermen of this class, despite having the lowest fishing frequency per week, suggest a strategic approach to fishing. According to Kolding *et al.* (2014) and Tietze (2016), experienced fishermen often prioritize quality over quantity, focusing on optimal fishing conditions and techniques that maximize their catch when they do fish. This aligns with findings from research indicating that seasoned fishermen are more adept at selecting the best times and locations for fishing, which can lead to higher yields even with less frequent outings (Sutton and Rudd, 2016). Interestingly, fishermen in this class report catching Clariidae hybrids that differ from the two predominant species in the Mbo floodplain (*C. gariepinus* and *C. jaensis*). This observation may indicate a diversification in local fish populations or adaptations in fishing practices that allow these fishermen to exploit different ecological niches (Jennings *et al.*, 2014). Such adaptability is crucial for sustaining livelihoods in changing environmental conditions, as highlighted by the importance of biodiversity in fisheries management (FAO, 2020). Despite their experience and higher catch quantities, the lack of formal training among these fishermen remains a concern. Many have not received any training due to financial constraints, which can limit their ability to adopt more sustainable fishing practices or improve their operational efficiency (Sreekanth *et al.*, 2017). This gap underscores the need for targeted educational programs that can enhance skills and promote sustainable practices among experienced fishers.

Conclusion

The characterization of fishermen in the Mbo floodplains revealed critical insights into their socio- demographic and economic characteristics, as well as their fishing practices. The study highlighted the central role of fisheries in the Mbo floodplains, serving as a cornerstone of local fishermen's livelihoods. These predominantly male fishermen were largely from the Mbo ethnic group and rely heavily on fishing as their main source of income, highlighting its importance in their

daily lives. The study showed that most fish caught were consumed by families rather than sold, highlighting a deep-rooted reliance on subsistence fishing practices that support households. However, this dependence also brings to light critical challenges, including declining fish stocks due to overfishing and environmental change. Classifying fishermen into different groups based on age, income dependency and fishing methods provided valuable insight into their unique characteristics and needs. This segmentation is critical for formulating targeted interventions that promote sustainable fishing practices and strengthen community resilience. In summary, fishing in the Mbo floodplains is not only an important source of income but also a lifeline for local fishermen. The long-term stability of their livelihoods and the ecological well-being of the region depend on addressing the socio-economic issues they face and promoting sustainable practices.

Author's Contributions

All authors contributed to the writing of the document. Ntsoli J. and Joos Nyemb Ntomb I. collected the data. Ntsoli J. analyzed the data. Nana T. A. reviewed the paper. Meutchieye F. and Eyango Tabi T. O. contributed to the study design.

Ethics

The authors declare that no ethical issues could arise after the publication of this manuscript.

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