

Type of the Paper (Article, Review, Communication, etc.)

Ichthyological biodiversity and the fish value chain in the fishing basins of Bamingui, Bangoran, Koukourou and Ndélé, partly in the Protected Area zones of the Central African Republic (CAR).

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Abstract: The 4 fishing basin heads of Bamingui, Bangoran, Koukourou and N'délé (BBKN), contain a significant fish fauna, although this remains little studied. Fish are caught by artisanal methods using gillnets, followed by pirogues and longlines. Fishing takes place over two seasons: the dry season (February to July) and the rainy season (August to November). The methodology used is based on the analysis of ichthyological biodiversity. The fish were identified using the determination key of Blache (1964) and Stiassny (2007). Information on the fish value chain was collected using the VC4AD method, FAO (2021). Catch per unit of fishing effort (CPUE) was calculated to determine the average quantity of fresh fish caught per day and per month in the dry and rainy seasons. The objective of this study is to analyze the ichthyological biodiversity and fish value chain in the fishing basin of Bamingui, Bangoran, Koukourou and Ndele. The results obtained show that the catch-per-unit-effort (CPUE) is 17 kg/day, or 510 kg/month in the dry season, and 4 kg/day, or 120 kg/month in the rainy season. The ichthyological fauna caught and marketed by fishermen includes 18 families of fish, with the Mochokidae family, followed by the Cichlidae family and Alestidae, Clariidae and Mormyridae. The results reveal benefits for players in the value chain, with a net monthly income of \$1334 for retailers, \$1112 for wholesalers, \$889 for fishmongers, \$667 for restaurateurs, \$445 for transporters and \$223 for fishermen.

Citation: To be added by editorial staff during production.

Academic Editor: Firstname Last-name

Received: date

Revised: date

Accepted: date

Published: date



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Keywords: fish biodiversity; fish value chain; fishery basin; Central African Republic

1. Introduction

Global fisheries and aquaculture production reached a record 223.2 million tonnes, including 185.4 million tonnes of aquatic animals and 37.8 million tonnes of algae (FAO, 2020). Fishing is an important source of wealth for many coastal and island developing countries (OECD, 2009). The fishing and fish farming sectors in the Central African Republic (CAR) employ 98,000 fishermen and 8,500 fish farmers respectively (FAO, 2014). This study that we are conducting is based on the ichthyological biodiversity and fish value chain of Bamingui, Bangoran, Koukourou and Ndele. The Value Chain is a series

of required activities that takes a product or service from its creation to marketing towards the end consumer (Kaplinsky and Morris, 2001, Masirika et al., 2020). It has never been the subject of a study in the area, which is why it is important to master it to make the exploitation of the fishery resource sustainable while promoting a sustainable income for the actors. Understanding the value chain (VC) provides policy-makers and fishing company managers with a systematic tool for understanding the various sector/company processes, and in particular the costs associated with the different stages of this value chain. By understanding the value chain, from catching a fish to the customer, the sustainable revenue growth is ensured (D.Russell and S.Hanoomanjee, 2012). The fishing value chain of the Congo Basin and particularly those of the Central African Republic (CAR) have not been significantly studied (Moelants, 2015; Harrison et al., 2016; Mukabo et al., 2020). The literature shows that in the north of the Central African Republic, very few studies have been carried out on ichthyological biodiversity and the fish value chain of Bamingui, Bangoran, Koukourou and Ndele. Samba (2017), having worked in the ichthyological biodiversity of Bamingui, Bangoran, Koukourou and Ndele, and he had identified 123 species in the Bamingui basin and the Koukourou, 121 species in the Bangoran, 107 species in the Manovo for 21 families. Likewise Breuil, (1996) estimated the ichthyological potential of the Bamingui, Bangoran, Koukourou and Ndele basin at 195 species for 27 families. However, neither author was able to establish a collection of fish. The fish value chain in the Bamingui, Bangoran, Koukourou and Ndele has never been studied by these same authors. This is why we are conducting this study to complete the list of families, species and genera of fish that the other researchers mentioned above have been able to find in the past but also to study the fish value chain. The initial hypothesis is that ichthyological biodiversity is diverse but little studied, in addition the fish value chain of the area is not developed. Therefore, the objective of this study is to investigate fish biodiversity and the fish value chain.

2. Materials and Methods

2.1 Zone of Study

The study was carried out in the fishery basins of Bamingui, Bangoran, Koukourou and Ndele, in the commune of Vassako and its villages: Koukourou, Balouba, Bamingui, Niango, Vata, Dangavo, Bakolekpa, Kovongo Mia, Bangoran, Kaka and Ndélé, and partly in the Protected Area Complex of the northeastern Central African Republic and their functional landscape (CAP-Nord-Est) covering an area of 115.716 km², or around 17% of the country's total surface area (figure 1). The fishing basin of Bamingui, Bangoran, Koukourou and Ndele (BBKN) are located in the North-East Protected Areas complex of the Central African Republic (CAR). They present a wide diversity of plant formations, ranging from wooded savannah, shrub savannah and grassy savannah to dense dry forest. Five main soil groups have been identified in the region. The region is located in two bioclimatic zones, the Sudano-Guinean climate zone and the Sudanian zone. Annual rainfall ranges from 800 to 1,300 mm, with two seasons: a dry season from late November to early May, and a rainy season from mid-May to late November. Average annual temperatures range from 25 to 30°C, with extremes close to 40°C. The region's fauna includes: Lion, leopard, hyena, wild dog, derby eland, hyppotrague, hartebeest, giraffe, hylochera, bush-pig, etc. (WCS., 2021). The Chari basin is made up of numerous permanent rivers, including the Bamingui (300 km) and the Bangoran (270 km) (Breuil., 1996).

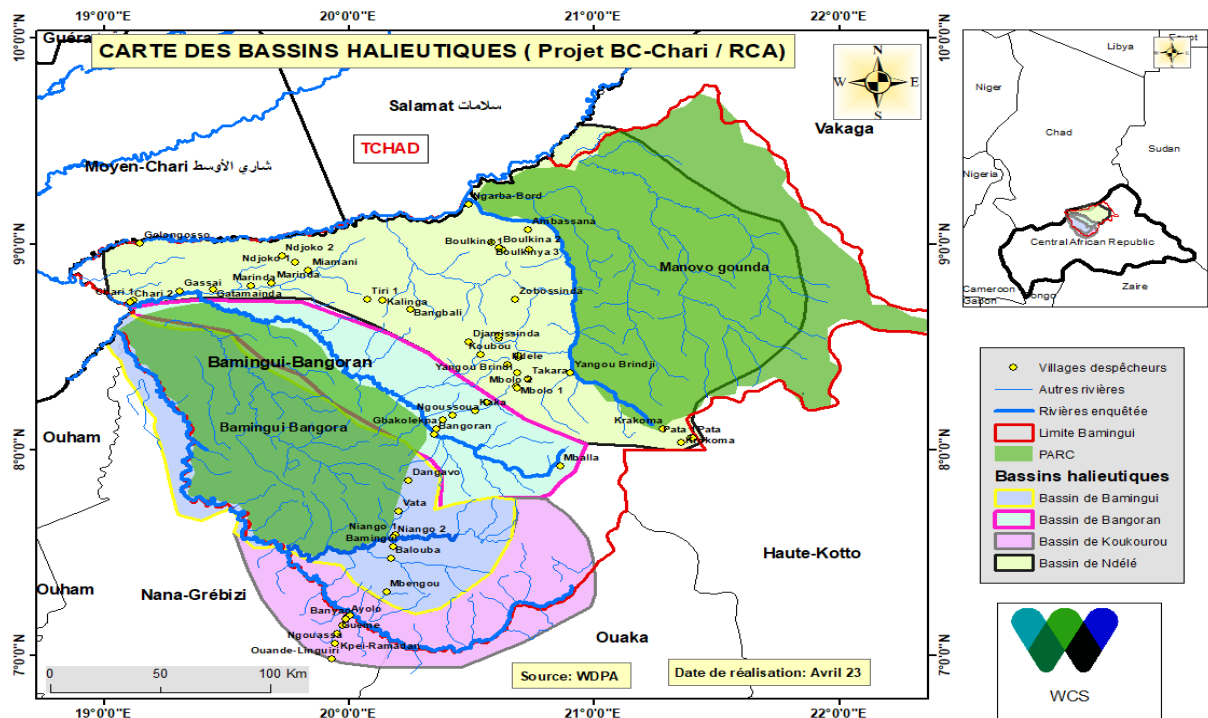


Figure 1. Location of the fishery basins of Bamingui, Bangoran, Koukourou and Ndelé in the Protected Area Complex of the northeastern Central African Republic and their functional landscape (CAP-Nord-Est) (WCS, 2022).

2.2 Method

The equipment used to collect the data consisted of: Garmin 64s GPS, itel Android phone, survey sheets and interview guides. To achieve the objectives formulated in this study, various methods, both qualitative and quantitative, were used. These methods were combined with other techniques such as survey questionnaires, direct interviews, focus groups and direct observations. The non-probability purposive sampling method was used to sample 250 stakeholders in 12 villages in the 4 fishing basins of the BBKN, namely Koukourou, Balouba, Bamingui, Niango, Vata, Dangavo, Bakolekpa, Kovongo Mia, Bangoran, Kaka, N'délé and Manovo.

Table 1: Stakeholders interviewed by fish value chain operating site in the Bamingui, Bangoran, Koukourou and N'dele fishing basins between February and March 2023 (W=Women; M=Men)

Sites	Fishermen		Wholesalers		Retailers		Input suppliers		Restaurateurs		Consumers	
	M	W	M	W	M	W	M	W	M	W	M	W
Ndele	43	20	4	10	0	42	3	1	0	3	1	1
Bamingui	13	10	4	1	0	22	3	1	0	3	1	1
Bangoran	5	3	1	0	0	15	2	0	0	3	1	1
Koukourou	7	7	1	0	0	14	9	2	0	0	1	
Total	108		21		93		11		9		8	

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The VC4AD (Value Chain for Development Analysis) method is a tool funded by the European Commission and implemented in partnership with AGRINATURA for the European Commission (FAO, 2021). It highlights the functional analysis of the value chain as objective 2 of the present study, which in turn highlights the economic, social and environmental analysis of the value chain. As part of the FISH4ACP program, FAO has joined forces with the European Commission (EC), OACPS and Agrinatura, to develop a Value Chain analysis and development approach based on FAO's Sustainable Food Value Chain Development (CVAD) and Agrinatura's Value Chain Analysis for Development (VCA4D) methodologies. Developing sustainable value chains for aquatic products has four main components: functional analysis, sustainability assessment, upgrading strategy development and implementation planning. The approach is highly participatory, involving public and private sector value chain stakeholders from the outset to ensure national ownership. Functional analysis examines the current structure of the Value Chain, the dynamics that explain how and why this structure is changing, and the capabilities and incentives that determine the behavior of Value Chain players. Based on in-depth analysis of a wide range of primary and secondary data, the functional analysis presents a detailed map of the Value Chain and systematically analyzes the nature of the different elements of the CV across four layers, namely (1) the core CV actors, (2) the input and service providers, (3) the societal environment and (4) the natural environment. This analysis includes the constraints and opportunities associated with the different CP elements and their links. Thanks to this in-depth, systemic approach, functional analysis identifies the constraining obstacles in the CV and their root causes, as well as the leverage points for maximum impact that will enable us to critically design an upgrading strategy that will produce the desired economic, social and environmental impacts. Sustainability assessment then uses a series of quantitative and qualitative indicators to measure the performance of the value chain in its economic, social and environmental dimensions. Six areas of social sustainability (inclusion, gender equality, food and nutrition security, decent employment, social and cultural capital, and institutional strength); and seven areas of environmental sustainability (climate impact, water footprint, sustainability of fish stocks, biodiversity and ecosystems, animal health and welfare, toxicity and pollution, and food loss and waste), (FAO,2023).

2.3 Data collection

Interviews with fishermen, fish traders, fishing input suppliers, restaurateurs and consumers took place during February and March 2023. These exchanges enabled us to describe them and define their roles in fish production and marketing. The focus group with fishermen provided information on the techniques used for fishing, the equipment used and the fishing calendar. Observations at fishing sites and markets enabled us to describe the production, processing and marketing of fish in the fishery basins. The Fish base (Froese, Pauly. 2019) and the identification keys of Blache et alii, 1964, Lévêque et al. (1990) and Stiasny et al. (2007) were used to identify the fish.

2.4 Data analysis

The identification key of Blache (1964) and Stiasny (2007) made it possible to identify the fish. Yield or CPUE measurements are very practical indices for monitoring populations for regular users of the resource (Moller et al., 2004). They are also easy to collect (Maunder et al., 2004). Theoretically, for a given species, a drop in density implies an increase in distance travelled and/or time spent searching for catches, and therefore a reduction in hourly yields (Kitson, 2004). While CPUE enables inexpensive and socially acceptable monitoring, using it as an index of fluctuation in the exploited population requires several conditions to be met (Verdoit et al., 2003; Smith et al., 2003; Maunder et al., 2006; Kleiber et al., 2008). Hence the formula: Initial fishing hypothesis:

Variable:

C: Catch (in numbers)

Q: Capturability (constant)

N: Abundance (in numbers)

$C = q \times E \times N$ (1)

Consider yields as CPUE: $CPUE = C / E$ (2)

$CPUE = q \times N / (1 + EC \times N)$ (3)

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3 Results

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Fish biodiversity of the Bamingui, Bangoran and N'délé basin. Our descent into the fishery basins of Bamingui-Bangoran, Koukourou and Ndélé enabled us to identify the fish encountered and cited by the fishermen themselves. This involved identifying the family, genus and scientific name of the fish (table 1).

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Table 2. List of fish identified in the fishery basins of Bamingui, Bangoran, Koukourou and Ndélé.

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Families-Breeds-Species	Chari Basin			
	Bamingui River	Bangoran River	Koukourou River	Manovo River
Polypteridae				
<i>Polypterus bichir</i>				
<i>Polypterus senegalus</i>	+	+	+	+
<i>Polypterus endlicherii</i>	+	+	+	+
Arapaimidae				
<i>Heterotis niloticus</i>	+	+	+	+
Mormyridae				
<i>Hyperopisus bebe</i>				
<i>Marcusenius senegalensis</i>				
<i>Mormyrus rume</i>	+	+	+	+
<i>Gnathonemus petersii</i>	+	+	+	+
	+	+	+	+
	+	+	+	+
Cyprinidae				
<i>Labeo coubie</i>				
<i>Labeo senegalensis</i>	+	+	+	+
	+	+	+	+
Citharinidae				
<i>Citharinus latus</i>				
<i>Citharinus citharus</i>	+	+	+	+
	+	+	+	+
Alestidae				
<i>Alestes baremose</i>				
<i>Hydrocynus brevis</i>	+	+	+	+
<i>Hydrocynus forskahlii</i>	+	+	+	+
<i>Hydrocynus vittatus</i>	+	+	+	+
	+	+	+	+

Bagridae				
<i>Bagrus bajad</i>				
<i>Bagrus docmak</i>	+	+	+	+
	+	+	+	+
Clariidae				
<i>Heterobranchus bidorsalis</i>				
<i>Heterobranchus longifilus</i>				
<i>Clarias anguillaris</i>	+	+	+	+
<i>Clarias gariepinus</i>	+	+	+	+
	+	+	+	+
	+	+	+	+
Malapteruridae				
<i>Malepterurus electricus</i>	+	+	+	+
Mochokidae				
<i>Synodontis clarias</i>				
<i>Synodontis filamentosus</i>	+	+	+	+
<i>Synodontis gambiensis</i>	+	+	+	+
<i>Synodontis schall</i>	+	+	+	+
<i>Synodontis sorex</i>	+	+	+	+
<i>Synodontis violaceus</i>	+	+	+	+
	+	+	+	+
Claroteidae				
<i>Auchenoglanis biscutatus</i>	+	+	+	+
<i>Auchenoglanis occidentalis</i>	+	+	+	+
Schilbeidae				
<i>Schilbe mystus</i>				
<i>Siluranodon auritus</i>	+	+	+	+
	+	+	+	+
Latidae				
<i>Lates niloticus</i>	+	+	+	+
Cichlidae				
<i>Hemichromis fasciatus</i>				
<i>Hemichromis bimaculatus</i>				
<i>Oreochromis niloticus</i>	+	+	+	+
<i>Sarotherodon galilaeus</i>	+	+	+	+
	+	+	+	+
	+	+	+	+
Tetraodontidae				
<i>Tetraodon lineatus</i>	+	+	+	+
Protopteridae				
<i>Protopterus annactens</i>	+	+	+	+
Gymnarchidae				
<i>Gymnarchus niloticus</i>	+	+	+	+
Hepsetidae				
<i>Hepsetus Odoe</i>	+	+	+	+

The table above shows the names of the fish identified in the hands of fishermen and their distribution across the 4 fishery basins. These fish are the most commercialized in the value chain.

3.1 Percentage of fish species for rivers

The families of fish most caught and marketed, the Mochokidae family dominates with 6%, followed by the Cichlidae family with 5%, then the Alestidae, Clariidae and Mormyridae families with 4% each, and the Polypteridae family represents only 3%.

3.2 Functional analysis of the fish value chain

3.2.1 Description of stakeholders and their roles in the fish value chain

BBKN's fish value chain comprises two (2) main categories of stakeholders. Some are primary actors (fishermen, fishmongers, retailers, fishing input suppliers, restaurateurs and consumers) and others are secondary (government services).

3.3 Fishermen

The majority of fishermen are located in the Ndélé basin. These fishermen are mainly made up of the following ethnic groups: Rounga, Goula, Sara, Haoussa, Banda. The Bamingui, Bangoran and Koukourou basins are mainly made up of the Banda ethnic group. Some are permanent residents at the fishing sites, while others are temporary, depending on the fishing season. Fishermen say that they don't have the packaging needed to bring fish in good condition from the fishing basins to local markets, and that this is a disadvantage for them. To avoid transport losses, they sell the fish at low prices, which is profitable for fishmongers and retailers. From the point of view of WCS's management of the park's fishing zones, they feel that "invading the protected areas of the Bamingui-Bangoran and Manovo Gounda St Floris parks to fish is a right, because if the NGO WCS deprives us of this right, it should have found us alternative activities".

3.3.1 Angler age range

In terms of angler age, the figure 2 shows a dominance of anglers aged between 25 and 35. The youngest anglers are aged between 0 and 15.

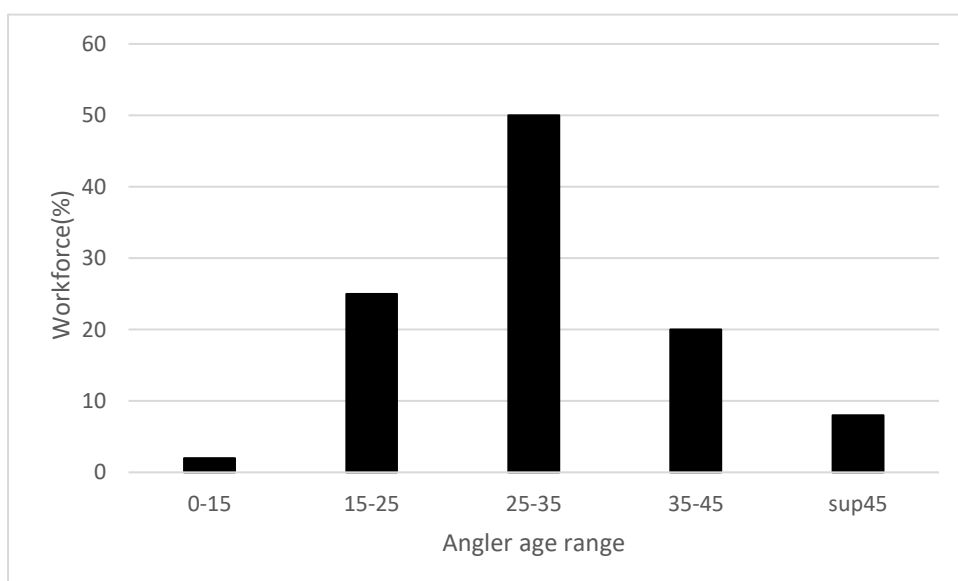


Figure 2 : Angler age range

	201
3.3.3 Fishmongers	202
Fishmongers play an important role in the fish value chain. They are responsible for distributing fish to local and national markets. Fish selling is primarily reserved for women, but some men also participate. Fishmongers have a very close relationship with fishermen. They can provide them with fishing equipment in exchange for a few baskets of fish. The fishmongers travel on motorcycles to help distribute the fish from Akoursoulbak and Ngarmba to Ndélé, then from Ndélé to Bamingui, Mbré or Bandoro. Despite their high incomes, fishmongers say they take a lot of losses through poor sales, due to the poor quality of the fish supplied by fishermen.	203 204 205 206 207 208 209 210
3.3.4 Retailers	211
Retail is carried out by wholesalers and retailers. They sell smoked fish in Ndélé, Bamingui, Bangoran and the capital, Bangui. Most resellers are Muslim women from the town of Ndélé. Sales of smoked fish are made in bulk in tubs, commonly called "n'gawi", or in cardboard boxes. Where preservation isn't possible, retailers engage more in the smoked fish trade than in fresh fish. Retailers say they have difficulty reselling smoked fish because of its small size and poor quality, due to the smoking technique. As a result, they lose money through poor sales. Others have no packaging to sell the fish on the market.	212 213 214 215 216 217 218 219
3.3.5 Restaurateurs	220
Fresh, smoked fish is a major source of savings for restaurateurs. Fish can be found in restaurants in Ndélé and Bamingui. Menus consists of both fresh and smoked fish. Fresh fish dishes are not available every day. Availability varies, depending on the fishing season and consumer demand. Restaurateurs report that fresh fish is expensive on local markets.	221 222 223 224 225
3.3.6 Consumers	226
Potential consumers are government officials, and travelers. According to the study, more than 37% of consumers like the taste of the fish but find the prices quite high but 63% find the fish less expensive, but their size is too small for good consumption.	227 228 229
3.3.7 Input suppliers	230
Suppliers of fishing inputs (reels, hooks, etc.) play a significant role throughout the value chain. Fishermen depend on them for the materials they need to make fishing nets.	231 232
3.3.8 Secondary players in the fish value chain	233
BBKN's fish value chain is neglected by secondary actors (water and forestry agents). Fish production statistics are unknown to the Ministry of Water and Forests.	234 235
3.4 Governance and participation of the Wildlife Conservation Society (WCS) in the fish value chain	236 237
The governance of the Bamingui-Bangoran and Manovo Gounda St Floris national parks and their fishing basins is ensured by the NGO WCS in partnership with the Central African government. WCS-CAR plays an extremely important role in the fish value chain of Bamingui, Bangoran, Koukourou and Ndélé. In the past, the fish value chain in BBKN was disorganized, but now, thanks to the ongoing work of WCS since 2018, there has been a lot of progress in the management of fisheries resources. Through the BC Chari project, which aims to support fishing communities through sustainable fishing, WCS currently supports 132 fishermen's groups recognized by local authorities. The trend is evolving to	238 239 240 241 242 243 244 245

include fishmongers and fish traders. A sustainable fisheries management plan has been drawn up by WCS and its consultants, approved by a steering committee and validated by the fishermen at a general assembly. WCS-CAR continues to work to ensure that the Management Plan is respected by all stakeholders.

3.5 Features of fishing techniques

In the Bamingui-Bangoran, Koukourou and Ndele fishing basins, fishing is either active or passive, depending on the technique used. Fishing is both individual and collective. Fish are caught by hand. Applying to 108 fishermen, the equipment most used is gillnets (21%), followed by pirogues (17%) and longlines (14%).

3.6 Links of the fish Value chain

3.6.1 Production

During the dry season, Catch Per Unit Effort (CPUE) is 17 kg/day, or 510 kg/month. This compares with 4 kg/day, or 120 kg/month during the rainy season.

3.6.2 Processing

Caught fish undergo three types of processing: smoking, drying and frying. Drying is used less by processors, as consumers do not appreciate its quality. Frying is also used less frequently, due to the high cost of cooking oil. Smoking, on the other hand, is the method most used by processors, as it is easier to use and requires no financial resources.

3.6.3 Conservation

Traders (wholesalers or retailers) have no freezers to keep fresh fish in good condition for several weeks, nor packaging (coolers) to pack fish in hygienic conditions. Instead, fish are stored and packaged in cardboard boxes and/or baskets, which lead to enormous losses sometimes.

3.6.4 Fish marketing channels

There are two key players in the marketing circuit (figure 3): fishmongers and transporters. They operate in two commercial circuits: the local circuit, where the product is transported to local markets, and the external circuit, where the product is transported to urban markets.

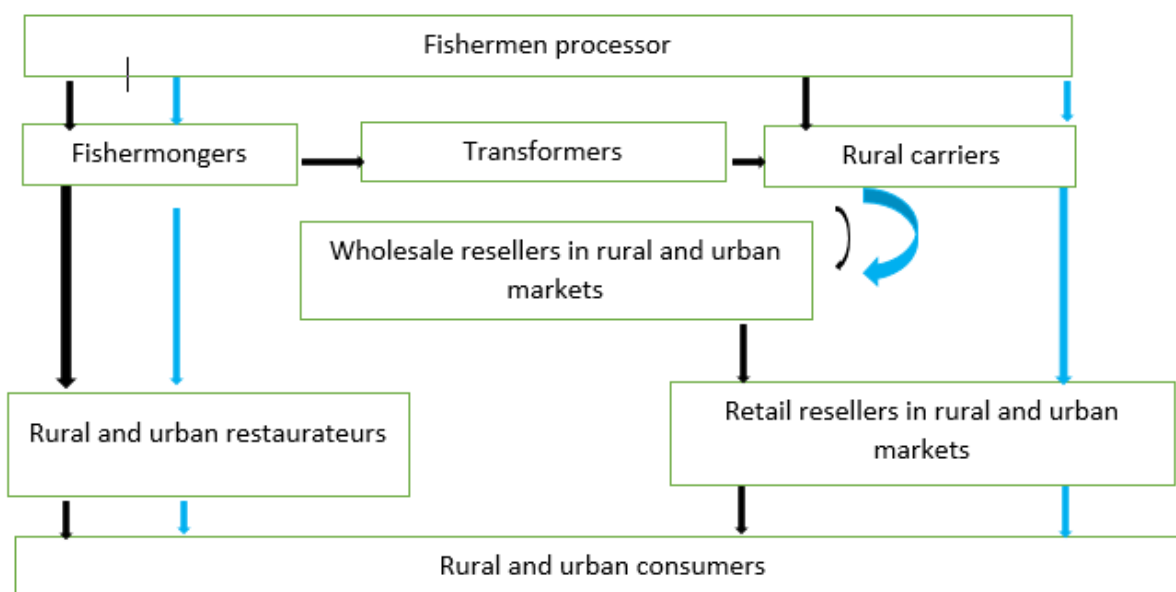


Figure 3. Market channels for fish value chain products in the Bamingui, Bangoran, Koukourou and N'Dele fishing basins in CAR (→ smoked fish, → fresh fish).

3.7 Economic analysis

The average price of a cardboard carton of smoked fish in the Ndele basin is around 89\$ for the fisherman, i.e. 3\$/kg, 112\$ for the fishmonger, 123\$ for the wholesaler, 134\$ for the retailer and 200\$ to 223\$, i.e. 4\$/kg for the consumer. Considering the same situation in the Bamingui, Bangoran and Koukourou basins, smoked fish is sold in baskets with an average price of at least 45\$, i.e. 3.17\$/kg for the fisherman, 56\$ for the fishmonger, 67\$ for the wholesaler, 78\$ for the retailer and 89\$ to 112\$, i.e. 6,3\$ to 8\$/kg for the consumer. For fresh fish, we considered the same average price for 1kg of fish across all the BBKN fishing basins, which is at least 1\$ for the fisherman, 1.7\$ for the fishmonger, 2.3\$ for the wholesaler, 2.7\$ for the retailer and 4.5\$ for the consumer. The results relating to investments in required fishing equipment per fisherman indicate that it lasts about one year. The annual depreciation of investments per fisherman amounts to 428\$, and their net operating income to 7795\$.

Table 3. Operating costs of fishermen in the fishing basins of NE CAR.

The operating costs of fishermen in the BBKN fishing basins includes revenues and costs, such as the purchase of dugout canoes, nets, etc., and costs involving depreciation.

Indicators	Period (months)	Quantity (kg/unit/month)	Unit price (\$/unit)	Annual total (\$)
Production				
Catch per year for fresh fish	12	226	1\$	3000
Annual catch of processed smoked and dried fish	12	630	0.89	6720
Production value				9734
Wooden canoe without motor		1	234	234
Beach seine				0
Gillnets		3	49	147
Pots and traps		530	1.8	943

Machetes/knives		4	12	45
Transport				0
Fishing permits				0
Water rights				0
Food	12	1	89	89
Health		1	55	55
Fishing helper wages				0
Total costs				1512
Depreciation				
Wooden canoe without motor	60	1	3.9	234
Pots and traps	12	530	1.8	22
Beach seine				0
Gillnets	3	3	45	134
Machetes/knives	36	3	1.2	40
Total depreciation				428
Net operating income				7795

The economic profitability of the various players in the fish value chain in Bamingui, Bangoran, Koukourou and Ndele (figure 4) is as follows: retailers have a net monthly income of 1334\$, wholesalers 1112\$, fishmongers 889\$, restaurateurs 667\$, transporters 445\$ and fishing units 223\$. The low net monthly income of fishermen is explained by their dependence on fishmongers and suppliers of fishing inputs, but it also depends on the quality of the fish caught, which are most often bought by fishmongers at low prices. In fact, most fishermen are in debt because they receive their fishing inputs from suppliers and fishmongers.

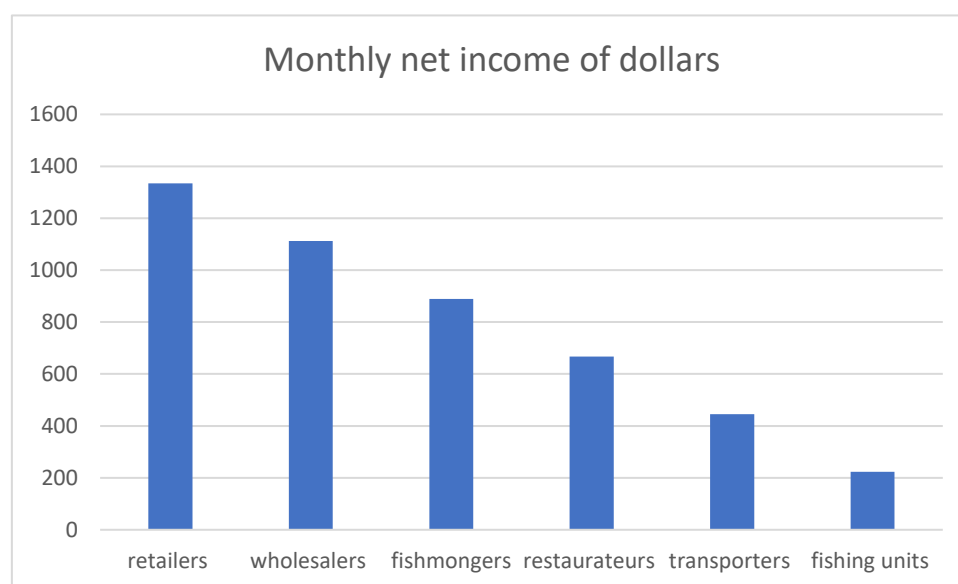


Figure 4. Economic profitability of the various actors in the BBKN fish value chain.

3.8 Social analysis of the fish value chain

In order to verify that the value chain is socially sustainable, various aspects were examined:

3.8.1 Working conditions

Working conditions in the fish value chain in the BBKN fishing basins in northern CAR do not appear to be very good for all stakeholders, and do not comply with the national labor code, since 85% of stakeholders claim to have worked in precarious conditions. However, they are at risk from drowning, attacks by hippopotamus and crocodiles, snake bites, injuries caused by oyster shells or the spines of certain fish (*Synodontis*), bee stings and attacks by magnan ants. Women and children working in this value chain are subjected to difficult tasks such as fishing, processing and transporting fish, for very low wages.

3.8.2 Water and land rights

Customary rights over the use of fishery resources do not exist, and value chain actors pay no fees to local authorities. Access to fishing sites is not based on the issuance of a fishing permit, nor does it comply with CAR's fishing code. The only actor involved in the governance of fishery resources in the Bamingui, Bangoran, Koukourou and Ndélé basins is the NGO WCS. This is why fishing is forbidden to fishermen in the protected areas of the Bamingui, Bangoran and Manovo parks, in accordance with the wildlife code, pending the development of a new fisheries management plan by the NGO WCS. To this end, fishermen are only allowed access to fishing in village hunting zones (ZCV).

3.8.3 Gender equality

Access to fishing sites is open to both men and women, regardless of gender. At the organizational level and throughout the value chain, women are heavily involved in marketing, but have lower incomes when it comes to profit-sharing. Only 30% of women are involved in collective fishing. The fishing technique most used by women is creel fishing, which accounts for 55%, and scoop fishing for 45%. Fishing products are intended solely for family consumption. In general, during the fishing season, 75% of women travel with the male fishermen just to help them collect the faggots for smoking the fish, smoke the fish and cook the meals. At the end of their fishing activities, they transport the smoked fish to market. From this point onwards, they become simultaneously traders, entrepreneurs and managers. The woman's role becomes more important than when she is involved in the men's activities. Unfortunately, they have little income at the end of these activities, according to 60% of the women who have already taken part.

3.8.4 Food and nutritional conditions

In the Bamingui, Bangoran and Ndele basins, value chain products (smoked and fresh fish) are an important source of animal protein for the population. Fish are available almost year-round.

3.8.5 Social capital

We found that social capital is weak all along the value chain. Actors never receive subsidies or credits.

3.8.6 Household living conditions

The activities of the various links in the value chain do not contribute to improving living conditions. Stakeholders invest little in access to health, education, training, housing, water and sanitation infrastructures and services. In other words, fishermen and their organizations lack the financial means to access all these essential goods.

3.9 Environmental analysis

In the BBKN fish basins, we noted habitat destruction (aquatic plants, riparian shrubs, spawning grounds). At fishing sites, fishing is destructive, resulting in the capture of small fish with very small-mesh nets (figure 5). In addition, bush fires are frequent, destroying riparian zones often used as spawning grounds or shelter for fry (nurseries).

Deforestation through the cutting of wood for smoking fish and the construction of dug-out canoes is recurrent at fishing sites. The slash-and-burn agriculture practiced by some fishermen leads to the degradation of forest ecosystems. The use of natural or artificial chemicals by fishermen not only kills all fish, including larvae and fry, but also their main food source, aquatic macro-invertebrates. Finally, the smoking technique has an impact on the environment and on human health, notably through the production of Polycyclic Aromatic Hydrocarbons (PAHc).

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Figure 5. Some types of environmental impact of fishing: (a) Poor fishing technique, (b) Ecosystem degradation (burning), (c) Ulcerated fish, (d) Juvenile fish.

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3.10 SWOT analysis of the fish value chain in BBKN fisheries basins

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Links	Actors	Constraints	Opportunities
Production	Fishermen	Work accident and illness ; Lack of credit ; Inexistence of work contracts;	Availability of fish for consumption; Possibility of selling fish on local and national markets; Creation of fishermen's groups ;
Intermediaries	Mareyeurs	Lack of credit ; Lack of equipment : Lack of technical support ;	Existence of fish markets ; Existence of groups ;

		Weak relations between stakeholders ;	
Marketing Retailers, wholesalers	Retailers, Wholesalers	Lack of credit ; Lack of materials ; Lack of technical support ; Weak relationships between players; Lack of product packaging ; Lack of energy to preserve fresh fish;	Existence of outlets ; Existence of groups ;
	Consumers	High cost of fish ; Poor quality of smoked fish for Consumption ;	Availability of fresh and smoked fish;

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3 Discussion

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The specific richness of the Bamingui, Bangoran, Koukourou and Ndélé fishing basins known through this study is 18 fish families that are marketed by fishermen in this Value Chain. In the BBKN fishing basins, we identified a wide variety of fishing techniques, depending mainly on the gear used. The fishing gears identified and most widely used by fishermen are: gillnets (21%), followed by pirogues (17%) and longlines (14%), the results of this study corroborate those of Luhusu (2013) and Mwanandeke (2022). However the variety of fishing techniques are practised according to local knowledge, but not always judiciously or appropriately. On the fishing sites of the Bamingui, Bangoran, Koukourou and Ndele fishing basins, overfishing, the growing number of fishermen and the use of prohibited fishing gear are leading to a decline in fish stocks.

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Working conditions in the fish value chain in the BBKN fishing basins in northern CAR do not appear to be very good for all stakeholders, and do not comply with the national labor code, since 85% of stakeholders claim to have worked in precarious conditions, and 95% of actors claim to have worked without work contracts, in insecurity and without adequate equipment. This translates into precarious working conditions. This result is similar to that obtained by Akwada (2024).

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There is a gender imbalance, with only 15% of women having access to fishing sites. At the organizational level, and throughout the fish value chain, 95% of women claim that they are not allowed to speak at meetings with men. What's more, they are the ones who invest in the marketing of fish products more than men, but for lower incomes. These results are similar to those obtained by Harper et al (2020) and Frangoudes (2019). Overall, only 35% of women are involved in the marketing of fresh and smoked fish in BBKN's fish value chain. Apart from these value chain activities, they have other heavy tasks such as farming and housework, since 95% of women claim to have farmed after the fish marketing periods. What's more, women and children working in this value chain represent only 35% of men.

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However, to preserve fish, only 12% of fishermen use the fish salting technique, because its quality is not appreciated by consumers, this result is close to that of Masirika et al. (2020). In fact, wholesalers and retailers display their fresh fish without ice. It's obvious that fish spoils quickly. Wholesalers and retailers want freezers and a source of energy. The region's climate, waters and vegetation are conducive to fish production.

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However, 90% of farmers practice slash-and-burn agriculture on the riverbanks of the catchment areas. This poses a threat to spawning grounds and fry nurseries and 95% of fishermen cut firewood for smoking fish and building pirogues, causing enormous damage to biodiversity.

4 Conclusion and Suggestion

The Bamingui, Bangoran, Koukourou and Ndele basins are full of diverse ichthyological fauna. This ichthyological fauna was identified in this work thanks to the Blache and Stiasny databases. In fact, this ichthyological fauna risks disappearing due to fishing activities. Indeed, these fishing activities take place without any control by the competent administrations. This is why we thought that the approach through the creation of fishermen's groups will allow the competent organization to train and raise awareness among fishermen to adopt the code of conduct for responsible fishing. The fish value chain of Bamingui, Bangoran, Koukourou and Ndele is not sustainable because the players in this value chain are poorly structured overall. Indeed, fishing is destructive with the use of prohibited gear leading to the capture of small fish. In addition, fish are poorly processed leading to cases of poor sales and loss of profits. Finally, poorly smoked fish have harmful consequences on the health of consumers. This is why we propose to train processors on good fish processing techniques and to fishermen, we propose to the competent administration to enforce the law on good fisheries management. It therefore seems necessary for the future to:

1. Provide fishing communities with adequate fishing equipment to ensure sustainable fishing;
2. Reinforce fishermen's knowledge of good fishing practices;
3. Reinforce processors' knowledge of good practices for smoking fish in the Chorkor oven;
4. Review the delimitation of fishing zones;
5. Delimit spawning areas and set up defenses with the support of fishermen;
6. Set up a fishing statistics program (CPUE);
7. Support organizations of fishmongers, retailers and input traders to improve collaboration;
8. Encourage fishermen to adopt sustainable fishing practices through the Code of Conduct for Responsible Fishing, etc;
9. Ensure that the laws governing fisheries management in the Central African Republic are revised and enforced.

In view of the many challenges facing the BBKN fish value chain, the following model is proposed for its improvement:

1. Structuring of VC players (fishermen, fishmongers and traders);
2. Creation of agro-piscicultural sites to enhance the value of the most commercialized fish species, not only to increase the income of stakeholders, but also to limit their access to prohibited areas to maintain fish stocks;
3. Improved living conditions for stakeholders (medical care, access to education, drinking water, etc.) through subsidies (micro-credits);
4. Capacity-building for fishermen, with the adoption of chorkor ovens to improve fish smoking techniques;
5. Raising fishermen's awareness of proper fishing techniques to supply mature fish to all players in the value chain to improve their incomes;
6. Implement a co-management approach to fisheries resources between WCS and stakeholders.

Acknowledgments: First of all, the authors would like to thank our main partners and financial backers, namely AGRINATURA and the European Union, for bearing the costs of our training for a Professional Master's degree in Protected Area Management at ERAIFT during the years 2021 to 2023. We would also like to thank UNESCO, the University of Liège and Gembloux (Belgium) and the University of Namur (Belgium), in particular Professor Jean-Claude MICHA, for their teaching and technical assistance in our training course. We would also like to thank the academic authorities at ERAIFT, notably Director Baudouin MICHEL and Academic and Research Secretary Jean-Pierre MATE MWERU, at the Ecole de Faune in Garoua, the members of the WCS-RCA project, notably Country Director M. TWAGUIRASHYAKA Felin, the BC-Chari Landscape Manager, Mr. ONDOUA ONDOUA Gervais, Jenica Betsch, the actors of the Fish Value Chain of the Bamingui, Bangoran, Koukourou and Ndélé Basins for their good will and support in the realization of this study.

Authors' contributions: Contributed by: The article is written by Gbagalama.

Data acquisition: Field data acquisition is done by Gbagalama (1st author).

Data analysis and interpretation: Data analysis and interpretation by Gbagalama.

Correction and revision of the article: The correction and revision of the article were carried out by Professor Micha, teacher-researcher Samba and cross-border expert Ndakobo.

Validation of the article: the final version of the article was approved and validated by Professor Micha. All the authors contributed equally to this work.

Project management: The Nature Conservancy Society (WCS-CAR) is responsible for project management.

Acquisition of funds: The field mission costs were allocated by the WCS-CAR project and the internship costs were borne by ERAIFT/UNESCO from Kinshasa.

Resources: Field materials and equipment were provided by WCS-CAR.

Conflicts of interest: The authors declare no conflict of interest.

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