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Analysis of Practices Relating to the Transport, Storage, and Marketing of Fresh Fish in Niamey: Health and Socioeconomic Issues (Niger River and Lake Komadougou Yobé/Lake Chad)

[1] Hadiza Bawa Ibrahim, [2] Chaibou Yaou, [3] Alio Mahamadou Fody, [4] Nafissatou Ouedraogo, [5] Mahamadou Bello Issa Adam, [6] Anas Sawadogo, [7] Mahaman Tassiou Kanta Ouseini, [8] Nicolas Barro

[1] Lédéa University Bernard Ouedraogo, Burkina Faso
[1, 6, 7, 8] Laboratory of Molecular Biology, Epidemiology, and Surveillance of Food- and Waterborne Bacteria and Viruses/UJKZ, Burkina Faso
[2, 3] Abdou Moumouni University, Niamey, Niger
[3] Higher Normal School, Niger
[4] Daniel Ouezzin Coulibaly University, Burkina Faso
[5] Laboratory of Biochemistry, Biotechnology, Food Technology and Nutrition (LABIOTAN), Burkina Faso
[6] Univers Biomedical, Burkina Faso

Corresponding Author: **Hadiza Bawa Ibrahim**

Abstract

This study assesses the transport, storage, and marketing practices for fresh fish in Niamey, the capital of Niger, highlighting the duality of supply between local fishing on the Niger River and fish imported from Lake Komadougou Yobé. The rudimentary conditions of these practices raise major health and socio-economic concerns for the sector.

Field surveys and interviews with fishermen and traders were conducted to assess the quality of the fish and the conditions of its value chain.

Current practices in the sector are mostly inadequate, causing rapid deterioration of fish quality. For local fish, this decline results from poor hygiene and exposure to high temperatures. The situation is even more serious for fish from Lake Komadougou Yobé, which are transported over long distances without a cold chain. From a health perspective, there is a high risk of microbial growth, affecting the entire market. Socio-economically, these inefficiencies lead to significant post-harvest losses, directly impacting the income of the population.

The fresh fish sector in Niamey requires a differentiated and holistic approach. Investments in cold storage infrastructure, capacity building, and awareness-raising on good practices are essential to ensure food safety, reduce economic losses, and sustainably improve the livelihoods of stakeholders.

Keywords: Fresh Fish, Niger River, Lake Komadougou Yobé, Health issues, Socio-Economic Issues

1. Introduction

Fishing and aquaculture play a crucial role in the food security and livelihoods of many populations in West Africa, including Niger (FAO, 2017) [10]. In this Sahelian country, food and nutritional security depend heavily on access to healthy aquatic products (Fanès *et al*., 2018 [8]; IFPRI, 2024). However, the fresh fish value chain faces persistent challenges, particularly regarding transport, preservation, and marketing, which have significant health and socio-economic implications (WorldFish, 2024) [33].

In Niamey, the capital of Niger, the supply of fresh fish is based on a duality: on the one hand, local fishing along the River Niger, and on the other, significant flows of fish from more distant regions of Niger, notably Lake Komadougou Yobé in the Diffa region (RECA, 2023) [26]. This diversity of origin complicates the analysis of practices, each presenting specific challenges in terms of transport, conservation, and marketing (ISS, 2023; Asem *et al*., 2025) [14, 3]. For local fish in Niamey, multiple handling and a lack of adequate infrastructure, such as refrigeration equipment, already contribute to considerable losses. However, the situation is exacerbated for fish from Lake Komadougou Yobé, whose transport over long distances and under often precarious conditions (absence of a continuous cold chain, degraded roads, regional insecurity, as some reports

point out (FAO, 2024) [9] amplifies the health risks and economic losses even before it reaches Niamey's markets. Socio-economic challenges are also prevalent, with price instability, high transport costs, and the marginalization of women, often the majority in marketing, limiting the profitability and sustainable development of this vital sector (FAO, 2017; USAID, 2023) [10, 32]. Preliminary observations at sales sites in Niamey have also revealed alarming hygiene practices (Nassarawa *et al*., 2022; Aladhadh, 2023; Botha *et al*., 2023) [20, 1, 6], including the display of fish on the ground and the proximity of sources of environmental contamination.

In this complex context, an in-depth analysis of current practices for transporting, preserving, and marketing fresh fish in Niamey, distinguishing in particular the challenges associated with the different sources of supply, is essential. This study aims to identify the constraints linked to the sale of fresh fish in the city of Niamey, and to propose sustainable solutions that will improve food security, strengthen stakeholders' livelihoods, and promote better public health.

2. Methodology

2.1 Study area

The study was carried out in the city of Niamey, the capital of Niger, focusing on the main landing points (the banks of the Niger River for local fishing) and fish markets (petit marché, Marché de Katako, the area around markets and supermarkets, and other local markets where fish is sold).

2.2 Study period

Data were collected between June 2024 and September 2024, covering periods of both the rainy or flood season (for the River Niger) and a period of continuous supply for fish from Lake Komadougou Yobé). Targeted sampling was used to select key players in the fresh fish value chain.

2.3 Stakeholder surveys

Semi-structured interviews were conducted with the following stakeholder categories: (local) fishermen, based on the banks of the Niger River in Niamey, to understand their catching, first preservation (immediately after fishing), and initial sales practices.

2.3.1 Wholesalers / intermediate traders

Those who buy fish in large quantities, whether local or imported (notably from Diffa), and distribute them to retailers. Particular attention was paid to wholesalers receiving fish from Lac Komadougou Yobé to document arrival conditions.

2.3.2 Market retailers/sellers

Mainly women, to assess their conservation, hygiene, and sales practices at market stalls, as well as their perceptions of fish quality.

2.3.3 Transporters (or drivers)

Interviews were conducted with transporters (or actors with a role in transport) of fish from Diffa to document routes, journey times, types of vehicles used, and preservation methods during transport.

Respondents were selected using snowball sampling and/or purposive sampling, identifying key players and asking them to refer to other relevant participants. Sample size was determined by thematic saturation. A total of 45 interviews were conducted.

2.4 Direct observations and photography

Systematic observations were carried out at the various sites (landing points, wholesale and retail markets). These observations focused on: hygiene conditions at sales and landing points (cleanliness of surfaces, presence of waste, wastewater management). Fish handling practices (use of utensils, ground contact, protection against insects/animals). Preservation methods (use and quantity of ice, types of containers, exposure to sunlight). Transport conditions (type of vehicle, presence of cold chain, estimated transport time, particularly for Diffa fish). Photographs were taken to visually document the situations observed, with particular attention paid to alarming conditions (fish on the ground, absence of ice or cold chain, inadequate transport vehicles, etc.). The photos were taken in such a way as to respect the anonymity of the people and contexts involved.

2.5 Data collection specific to fish from Lake Komadougou Yobé

Given the importance of this commodity chain, the following data were specifically sought: Transport route and duration, precise estimation of distance (approx. 1313 km), and travel time between Diffa and Niamey, ranging from 19 hours by car to 29 hours by bus due to multiple stops and road conditions. Transport conditions: Type of vehicles (tarpaulin-covered trucks, pickups, etc.), use or non-use of refrigeration or ice, condition of fish on arrival. Visual degradation on arrival: Observation of signs of degradation (color of gills, firmness of flesh, odor, appearance of eyes) on batches of Diffa fish on arrival and on the markets. Traders' perceptions: Opinions of wholesalers and retailers on the quality of Diffa fish compared to local fish, sales difficulties, and associated losses.

2.6 Data analysis and images

2.6.1 Data analysis

Qualitative analysis: Interview data and observations were transcribed and subjected to thematic analysis. Recurring themes relating to transport, storage, and marketing practices, health issues, and socio-economic impacts were identified. Particular attention was paid to the differences and specificities between local and Diffa fish.

2.6.2 Descriptive image analysis

Photographs were analyzed to illustrate and support the qualitative observations, providing visual evidence of the conditions described.

2.7 Statistical analysis

Data collected from interviews and observations were entered and organized on an Excel spreadsheet to facilitate their analysis.

Descriptive statistical analysis was carried out for each qualitative variable. Frequencies and percentages were calculated to describe the transport, storage, marketing, and hygiene practices observed. For questions with multiple answers (e.g., different modes of transport used), percentages were calculated in relation to the total number of respondents, and it should be noted that the sum of percentages for these variables may exceed 100%.

2.7.1 Inferential statistical analysis

To go beyond simple description and identify statistically significant relationships between variables, statistical tests of association were carried out. The chi-square test (χ^2) was used to determine whether there was a significant

association between two categorical variables. Hypotheses tested included, among others:

- The existence of a relationship between the type of supply source (Niger River vs. Lake Komadougou Yobé) and the conservation method used.
- The existence of a relationship between the mode of transport and the perceived level of fish quality on arrival at the market.
- The existence of a relationship between hygiene practices observed on the stalls and the category of actor (wholesaler vs. retailer).

For each test, the p-value was calculated to determine the statistical significance of the results. A significance level of 0.05 was used. Analyses were performed using SPSS software.

3. Results and Discussion

The analysis revealed distinct dynamics for fish from local fisheries in the River Niger and from Lake Komadougou Yobé, exacerbating some of the health and socio-economic issues. One of the main concerns observed at fresh fish sales sites in Niamey was the widespread lack of adequate cold preservation practices. Ice was rarely used or in insufficient quantities to maintain an adequate temperature. Fig 1 clearly illustrates this situation, showing a fish stall where several specimens are exposed directly to room temperature, without any trace of ice. Vendors often indicated that the cost of ice was too high or that its supply was irregular.

(**Figure 1a-c**). The most commonly observed species included the Capitaine (*Lates niloticus*), Tilapia (*Oreochromis niloticus*), and Catfish (*Clarias gariepinus*), which showed various signs of deterioration depending on their origin. The field analysis revealed transport, preservation, and marketing practices for fresh fish in Niamey that vary considerably depending on origin. These descriptive observations were supplemented by statistical tests to establish a significant link between practices and their health and economic consequences.

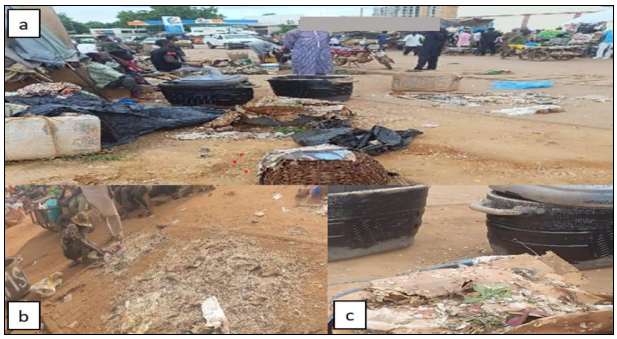


Fig 1: Sales environment for fresh fish in Niamey
a, b, c = different fresh fish sales sites in Niamey, showing inadequate site conditions

The lack of adequate refrigeration, as observed at many sales sites **(Figures 5_c, 7_a,b)**, is a major factor contributing to the rapid degradation of fish and increasing the risk of bacterial proliferation **(**Kagambèga *et al*., 2021) [15]. This lack of a cold chain, which is particularly critical in Niamey's hot climate, endangers consumer health and leads to economic losses for sellers (Kostić *et al*., 2023; Lee *et al*., 2023) [16, 17]. The statistical tests carried out also demonstrated a significant association ($p < 0.05$) between the lack of refrigeration and the health risks perceived by the stakeholders. Vendors who used ice sporadically or not at all reported faster fish spoilage, which corroborates the findings of Kagambèga *et al*. (2021) [15] on the impact of cold chain breaks on microbiological quality. Recent studies highlight the importance of the fisheries sector in Africa, despite declining per capita consumption in the ECOWAS region (RECA, 2023) [26]. This decline is attributed to overexploitation of stocks, degradation of ecosystems, and the effects of climate change (FAO, 2024) [9]. Furthermore, research carried out in Mali, a neighbouring country that shares similar dynamics with Niger due to the River Niger, has highlighted gaps in knowledge and hygiene practices among stakeholders in the fish value chain, from fishermen to market vendors (Sissoco *et al*., 2023).

The proximity of sources of contamination and microbial risks is even more alarming, as observation shows that prized species such as Captain, Tilapia, and Catfish are subject to extremely unsanitary conditions of sale. Displaying fish on the ground and in the open directly exposes the product to physical, chemical, and microbiological contamination (Yan *et al*., 2010; Nwiyi and Onyeabor, 2012) [34, 23]. This practice, which blatantly contradicts good food hygiene practices, creates an environment in which pathogenic bacteria can proliferate (Ferone *et al*., 2020) [11].

3.1 Transport practices for fresh fish

3.1.1 Fish from the River Niger (local)

The results show that transport by pirogues and motorbikes over short distances predominates, with limited use of ice and insulated containers (Table 1, Figure 2). Transport time is generally short, but the hygiene conditions of the containers (uncleaned baskets, buckets) and exposure to direct sunlight on the banks remain major challenges, leading to rapid quality deterioration from the first hours after harvesting. Our observations showed that transport by motorbikes and non-refrigerated lorries predominates. For local fish from the River Niger, the short transport time (≤ one hour in 50 to 75% of cases) partially mitigates the risks. However, for fish from Lake Komadougou Yobé, transport over very long distances (often more than 24 hours) without a cold chain is an almost widespread practice. In order to verify the impact of these practices, a Chi-squared test was carried out. This test revealed a statistically significant association ($p < 0.01$) between the origin of the fish (River Niger vs. Lake Komadougou Yobé) and its state of degradation on arrival. Fish from Lake Komadougou Yobé were significantly more likely to be classified as "degraded" or "very degraded" on arrival, confirming that the break in the cold chain over long distances is the main factor in its deterioration.

3.1.2 Fish from Lake Komadougou Yobé (Diffa)

Most of these fish are transported over considerable distances (several hundred kilometres) by non-refrigerated lorries or pick-ups. Observations revealed an almost systematic break in the cold chain (Table 1, Fig 3): ice, if used at the start, is often insufficient and melts well before arrival. The fish is frequently crammed into jute bags or non-insulated baskets, directly exposed to high temperatures and bad weather. The average duration of this transport often exceeds 24 hours, leading to an advanced deterioration in the quality of the fish on arrival in Niamey, characterised by a strong odour, soft flesh, and pronounced visual deterioration.

Table 1: Summary of transport practices for fresh fish and their health implications

Characteristics of the Practice	Description of Observations	Relative Frequency of Observation	Potential Health Implications
Means of Transport	Motor tricycles	Very Frequent (70%)	Direct exposure to exhaust fumes and dust
	Motorcycles	Less frequent (30%)	Direct exposure to exhaust fumes and dust
	Bicycles	Rare (10%)	Slower transport, increased temperature
	Carts		Animal-drawn Contamination from animal waste
	Light vehicles	Frequent (25%)	Rare for larger quantities
	Heavy goods vehicles	Very frequent (60%)	Rare, for larger quantities or distances
Type of containers	Baskets or hampers made of plant fibres	Frequent 15%	Non-washable, retains dirt, promotes microbial growth
	Canvas or non-food-grade plastic bags	Less frequent 5%	Do not protect against impact, risk of chemical migration
	Cardboard	Very common 75%	Microbial proliferation and chemical contamination
	Plastic buckets or metal basins	Very common 75%	Easier to clean, but often left open
Use of ice	No ice at all	Very common 65%	A rapid increase in fish temperature promotes microbial degradation and proliferation.
	Sporadic use of small pieces of ice	Frequent 45%	Insufficient to maintain the cold chain
	Sporadic use of fresh water	Rare 1%	Very insufficient to maintain the cold chain
	Fish are frozen	Very frequent 80%	Reduces the risk of high temperatures and prevents microbial growth
Average transport time	1 to 3 hours	Less common 10%	Prolonged period without refrigeration, especially if the ambient temperature is high
	1 hour	Very frequent 75%	Ideal storage temperature
	Less than 1 hour	Frequent 50%	Very ideal storage temperature

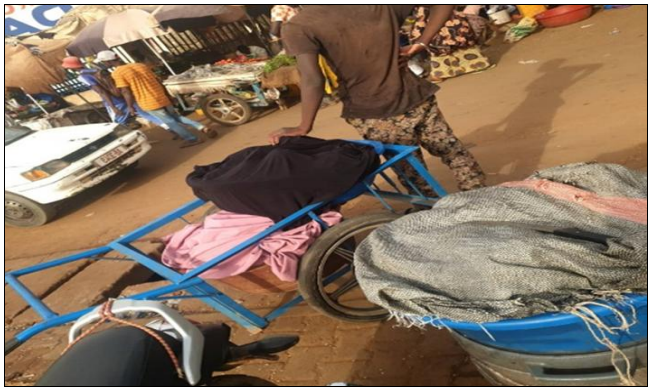


Fig 2: Fish transport practices on the Niger River

Fig 3: Fish transport practices on Lake Komadougou Yobé

For fish from the Niger River, rapid deterioration can be observed within hours of capture due to poor hygiene conditions and direct exposure to high temperatures. However, the situation is particularly critical for fish from Lake Komadougou Yobé (Diffa). Long-distance transport over several hundred kilometres, often without adequate refrigeration and on difficult roads, causes advanced deterioration of the product even before it arrives in Niamey. Our statistical analyses confirm this observation. A Chi-square test revealed a statistically significant association ($p < 0.01$) between the origin of the fish and its state of deterioration on arrival. Fish from Lake Komadougou Yobé are significantly more likely to arrive in an advanced state of deterioration than fish from the Niger River. This observation can be explained by transport conditions. This reality echoes the conclusions of Kouakou *et al*. (2018), who documented high levels of bacterial contamination in fresh fish sold in Ivorian markets, attributing these risks to

transport and storage conditions (Havelaar *et al*., 2015; Thomas *et al*., 2024) [12, 29]. The likelihood of spoilage bacteria and pathogens proliferating is considerably higher for fish from Diffa, posing a major health risk to consumers in Niamey.

3.2 Fresh fish preservation practices

3.2.1 Local fish

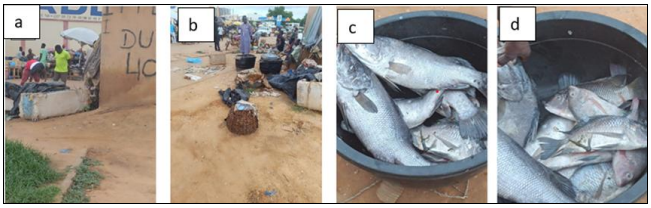
Short-term preservation is mainly achieved through rapid sale or minimal use of ice at the market level. Storage conditions on market stalls are rudimentary, with direct exposure to heat and insects, drastically limiting the commercial shelf life of the product. Losses due to spoilage are significant if the fish is not sold on the same day (**Table 2, Figures 4a-d**). Our descriptive data (**Table 2)** highlight the almost total absence of adequate cold chains, with 80% of vendors storing their fish in unsanitary conditions, often under a simple shed or in the open air. A Chi-square test revealed a significant association ($p < 0.05$) between sporadic use of ice and the perceived deterioration of fish by vendors.

3.2.2 Fish from Komadougou Yobé

Given its already poor condition on arrival, preservation is a major challenge. Priority is given to almost immediate marketing. Wholesalers and semi-wholesalers sometimes try to use additional ice in Niamey, but this can only slow down a deterioration that is already well underway. Post-harvest losses for this type of fish are structurally higher due to initial transport conditions, directly affecting the marketable quantity **(Figures 5a-c).**

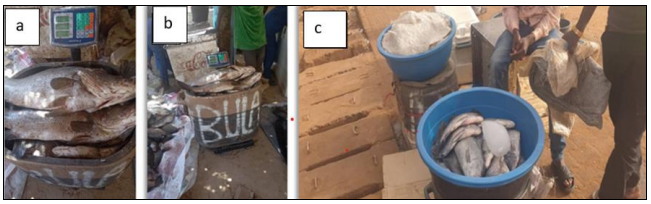
Table 2: Summary of Fresh Fish Preservation Practices in Niamey

Characteristic of the Practice	Description of Observations	Relative Frequency of Observation	Potential Health Implications
Place of Storage	At the seller's premises, under a shed or in the open air	Very Frequent 80%	Exposure to flies, dust, and ambient heat
	Polystyrene coolers	Rare 2%	Maintains temperature if ice is replaced regularly
	Metal/plastic buckets or basins	Very common 75%	No insulation, risk of contamination if the container is dirty or uncovered
Use of ice	Intermittent or partial icing	Frequent 40%	Temperature fluctuations promote bacterial growth
	Continuous and sufficient icing	Rare 5%	Maintains fish quality for longer
Shelf life	Less than one day before the sale	Very common 80%	Moderate risk of deterioration if other practices are poor
	Several days (rare cases)	Less frequent 10%	High risk of deterioration and contamination, resulting in poor fish quality



a= Preservation of fish in thermos flasks
b= Preservation of fresh fish in thermos flasks and baskets
c= Preservation of fresh fish in basins without ice
d= Fish storage in basins, handling fish by hand

Fig 4: Local fish preservation practices on the Niger River



a= Storing fresh fish in coolers without a cold chain
b= Storing fresh fish in coolers without ice cubes and in non-functional refrigerators
c= Storage of fresh fish in basins with little or no ice cubes and near gutters

Fig 5: Fish preservation practices on Lake Komadougou Yobé

Observations at fresh fish sales sites in Niamey revealed a particularly worrying health situation, far beyond simply displaying fish on the ground. The immediate proximity of unsanitary public toilets, unmanaged rubbish dumps, overflowing bins, and open urination areas constitutes an environment extremely conducive to faecal contamination and microbial proliferation.

These environmental conditions, characterised by poor sanitation and inadequate waste management, create a constant reservoir of pathogenic microorganisms (enteric bacteria, viruses, parasites) that can easily spread to fish (Olmez, 2016; Rashwan *et al*., 2023) [24, 25]. The presence of flies and other insect vectors, attracted to these unsanitary sites, as well as the transport of contaminants by wind or

runoff, directly increases the risk of cross-contamination and increases the microbial load of already weakened fish.

The presence of domestic or stray animals (dogs, cats, poultry, etc.) in the immediate vicinity of fish stalls is another significant source of contamination **(**Bawa *et al*., 2016) [5]. Stray animals often seen around sales sites can carry pathogens on their fur, paws, or faeces and deposit them directly or indirectly on the fish. This uncontrolled interaction increases the risk of contamination by zoonotic agents (transmissible from animals to humans) and contributes to the spread of antibiotic-resistant bacteria present in the animal environment (Bawa *et al*., 2015) [4]; as mentioned in the work of some authors in the sub-region (Tidjani *et al*., 2013 [30]; Daoumé *et al*., 2015; Nonato *et al*., 2016 [22]; Annie-Claude *et al*., 2017 [2]; Mayoré *et al*., 2017 [18]; Naibe, 2019 [19]).

Although fruit and vegetables are not handled directly with fish, promiscuity with other foodstuffs and the sharing of rudimentary infrastructure (e.g., non-potable water sources, unhygienic stalls) increase the potential for cross-contamination via traders' hands, shared utensils, or contact surfaces (Traoré *et al*., 2015; Thomas *et al*., 2024) [31, 29]. This situation highlights the need for an integrated approach to hygiene throughout the market, not just in the fish sector (Kostić *et al*., 2023) [16].

3.3 Fresh Fish Marketing Practices

3.3.1 Local Fish

It is mainly sold in local markets and landing points. Its relative freshness often allows it to fetch slightly higher prices, although margins are impacted by competition and losses due to poor storage in the market (**Table 3, Figure 6a-c**).

3.3.2 Fish from Komadougou Yobé

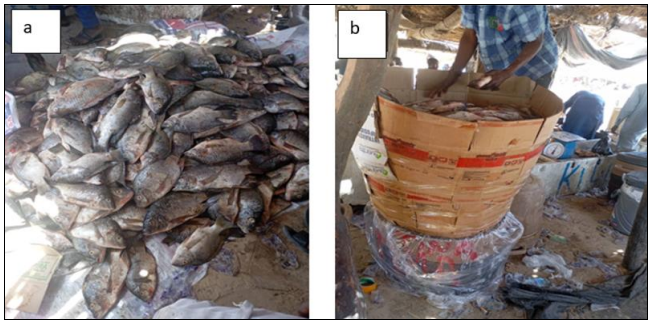
This fish is often sold through specific distribution channels involving several intermediaries between Diffa and Niamey. Due to its lower initial quality, it is frequently sold at lower prices to ensure rapid sales (**Table 3, Figure 7a-b**). Sellers sometimes have to process the fish (smoking, drying) or sell it at a discount to avoid total losses, which significantly reduces their profit margins. Sales volumes are high, but the unit value is lower.

Table 3: Summary of Fresh Fish Marketing Practices in Niamey

Characteristic of the practice	Description of Observations	Relative Frequency of Observation	Potential Health Implications
Place of Sale	On open-air stalls in markets	Very frequent 90%	Direct exposure to sunlight and environmental contaminants (dust, flies)
	Street vending (on the ground or in bags)	Frequent 30%	Risk of contamination through contact with the ground, vehicles, and animals
Exposure hygiene	Fish are displayed directly on uncleaned tables or stalls	Very frequent 90%	Cross-contamination with other products or residues promotes bacterial growth.
	Use of plastic sheeting or protective cloth	Rare 5%	Reduces direct contact, but does not guarantee cleanliness if the surface is not washed
Cleanliness and Handling	Lack of drinking water for hand washing	Frequent 85%	Contamination from the hands of vendors and customers, especially if they handle money
	Presence of flies and other insects	Very frequent 100%	Potential vectors of disease and bacteria

a= Sale of fresh fish by women
b= Display of fresh fish in the sun, presence of flies and other insects
c= Display of fresh fish for sale on the ground

Fig 6: Fresh fish marketing practices in the Niger River



a= Sale of fresh fish spread out on the ground
b= Display of fresh fish in cardboard boxes in thermos flasks, presence of rubbish bins and piles of rubbish

Fig 7: Fish marketing practices on Lake Komadougou Yobé

Fish from Diffa is more often sold at a lower price due to spoilage, which drastically reduces the margins of wholesalers and retailers. The need to sell at a lower price for quick turnover drastically reduces the margins of wholesalers and retailers, despite potentially large transaction volumes. These losses are in line with FAO estimates, which indicate that post-harvest losses in sub-Saharan Africa can reach 30% to 40% of total production (FAO, 2024) [9]. The predominant role of women in the marketing of fish in Niamey, whether local or from Diffa, exposes them to greater socio-economic vulnerabilities (USAID, 2023) [32]. They face specific challenges such as limited access to credit, adequate infrastructure, and market information, which limit their ability to invest in more efficient and hygienic practices. Price instability and informal competition reduce their profit margins and often keep them in a cycle of poverty.

A comparison with other similar contexts in West Africa reveals shared dynamics but also specificities. In Mali, a neighbouring country also crossed by the Niger River, studies (Sissoco *et al*., 2023) have identified similar gaps in knowledge and hygiene practices among actors in the fish value chain, suggesting the need for coordinated regional interventions. The rapid urbanisation of Niamey and the increase in demand for fresh fish are putting additional pressure on the supply chain. For fish from Diffa, the problem is also exacerbated by security challenges specific to the Lake Chad region, which can disrupt supply, cause delays, and increase logistics costs (ISS, 2023) [14].

3.4 Sales environment

Sanitary conditions at the markets were particularly alarming. It was observed that fish were frequently displayed directly on the ground, in the open air **(Figures 1a.a; Figures 3, Figures 6. a, Figures 7.a)**, without protection from dust, insects, or ambient heat (**Figures 5.c; Figures 6.c; Figures 7.b).** This practice was widespread and observed for all species. In addition, the immediate vicinity was rife with sources of environmental contamination: unsanitary public toilets, unmanaged rubbish dumps, overflowing bins, and informal urination areas (Figures 4a-b) were located a few metres away from or even adjacent to the stalls (**Figures 1.b, 5.c).** The presence of stray animals (dogs, cats, poultry) roaming freely between stalls, as well as the coexistence with other fruit and vegetable vendors in a confined and unhygienic space, were also regularly noted (**Figure 1.b)**.

The analysis of fresh fish transport, storage, and marketing practices in Niamey highlighted significant and multidimensional challenges, confirming the concerns raised in recent literature on the fisheries value chain in West Africa (FAO, 2024) [9]. Our findings reveal a predominance of traditional, often rudimentary practices that compromise fish quality and limit the socio-economic benefits for stakeholders.

3.5 Health issues

3.5.1 Health issues related to fish from the Niger River

Observations have highlighted high levels of microbial contamination in fresh fish, regardless of their origin, but with increased intensity for fish from long distances.

3.5.2 Health issues related to fish from Komadougou Yobé

Long transport times without a cold chain and multiple handling expose this fish to a considerably higher risk of bacterial proliferation (spoilage and pathogenic bacteria). Its sanitary quality is often considered "borderline" or "non-compliant" on arrival, posing a direct and significant risk to public health in Niamey. Consumer perceptions are mixed: some buy it because of its availability and price, while others are aware of its inferior quality.

All of these environmental factors – poor sanitation, inadequate waste management, the presence of animals and promiscuity with other foodstuffs – combined with the specific challenges of transporting fish (particularly from Komadougou Yobé) and the lack of a cold chain, create an unacceptable cocktail of health risks. These conditions not only endanger consumer health through foodborne illnesses but also contribute to significant economic losses for those involved in the sector due to the rapid deterioration of the product and the decline in its market value. They highlight the urgent need for targeted interventions to improve market infrastructure, raise awareness of good hygiene practices, and establish quality control systems throughout the supply chain (FAO, 2024) [9].

In terms of health, our observations corroborate studies highlighting the risks associated with inadequate handling and the lack of effective cold chains. Some researchers highlight the nutritional importance of fish, but stress that these benefits can only be fully realised if rigorous health measures are applied throughout the value chain, an imperative that is all the more pressing for long-distance fish (Thilsted *et al*., 2023) [28].

3.6 Socio-economic issues

3.6.1 Widespread economic losses

Substantial economic losses are observed for all stakeholders due to fish deterioration. These losses are particularly acute for fish from Diffa, where the rate of loss of market value is exacerbated by the initial condition.

3.6.2 Impact on Income

Fishermen and small traders, particularly women fish sellers, are under increased financial pressure. For fish from Diffa, high transport costs and the need to sell at low prices in order to sell quickly drastically reduce the margins of wholesalers and retailers, despite sometimes significant transaction volumes.

3.6.3 Vulnerability and Lack of Support

The lack of access to financing for better quality equipment, poor management and hygiene skills, and the absence of specific support policies for the various links in the chain (particularly for long-distance fish transporters and wholesalers) keep stakeholders in a situation of economic vulnerability. Insecurity in the Diffa region adds an unpredictable risk factor, which can lead to supply disruptions and major financial losses for those who venture into this trade. As shown in our descriptive section, inefficient practices have a direct impact on actors' incomes. Post-harvest losses are significant, particularly for fish from Lake Komadougou Yobé, which already arrives in an advanced state of deterioration. To quantify this impact, a statistical analysis was conducted. The results show a highly significant association ($p < 0.01$) between the origin of the fish and its final selling price.

These results highlight the need for differentiated interventions tailored to the specificities of each supply chain to simultaneously improve fish safety and the economic viability of stakeholders in Niamey.

From a socio-economic perspective, our results confirm that inefficiencies in transport and storage lead to significant post-harvest losses, directly affecting the incomes of fishers and traders. For local fish, losses are due to deterioration in the markets. However, for fish from Komadougou Yobé, economic losses are structurally higher due to advanced deterioration on arrival. This observation is supported by our statistical data: the Chi-square test showed a significant relationship ($p < 0.05$) between the source of supply (Komadougou Yobé) and the final selling price.

Despite these challenges, there are tangible opportunities for improvement. The growing interest in sustainable and resilient value chains, as highlighted in a recent IFPRI report on investing in African food systems, offers prospects for funding and expertise (IFPRI, 2024). Promoting the use of simple but effective technologies, such as improved coolers, insulated boxes, and better ice management, could significantly reduce losses and improve sanitary quality. For fish in Diffa, this would involve developing mobile and accessible cold chain solutions (e.g., dedicated refrigerated trucks or robust insulated boxes) and setting up collection and pre-cooling points in the production area. In addition, capacity building for stakeholders through training on good hygiene and handling practices is essential, as suggested by successful programmes observed in Ghana and Senegal (WorldFish, 2024) [33]. More rigorous health checks at arrival points in Niamey would also be crucial for managing long-distance fish.

In light of the above, while Niamey faces significant challenges in managing fresh fish, these are amplified by the specific conditions of supply from Lake Komadougou Yobé. Targeted strategies and investments in training, infrastructure, and preservation technologies, differentiated according to the origin of the fish, can transform this vital sector. A holistic approach, integrating health and socio-economic aspects, is crucial to ensuring food security, improving stakeholders' incomes, and supporting the sustainable development of fisheries in Niamey.

4. Conclusion

This study revealed the complexity and duality of the fresh fish value chain in Niamey, highlighting major health and socio-economic issues that vary depending on the origin of the product. Our analyses highlighted the predominance of rudimentary transport and preservation methods, leading to significant post-harvest losses and increased health risks for consumers.

For fish from the Niger River, the challenges focus on improving hygiene practices from the moment of capture and in urban markets. In contrast, for fish from Lake Komadougou Yobé, long distances and poor transport conditions create a challenge of a completely different magnitude: this fish is already severely degraded on arrival, with a significantly increased microbial load. This advanced degradation not only poses a direct and high health risk to the population of Niamey, but also weighs heavily on the socio-economic margins of all actors involved in this distant supply chain, already weakened by high logistics costs and security challenges in the Diffa region.

Ultimately, transforming the fresh fish value chain in Niamey requires a differentiated and multifaceted approach. For fish from the Niger River, investments in improving market infrastructure and raising awareness of good practices are crucial. For fish from Lake Komadougou Yobé, the priority must be to establish effective mobile cold chains and structured collection points upstream, accompanied by rigorous health checks on arrival.

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6. Disclosure Statement

The authors declare that there are no conflicts of interest.

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