

# Assessment of Fish Post-Harvest Handling Practices in Kambata Tembaro and Wolaita Zones, Southern Ethiopia

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## ABSTRACT

**Background:** Fish is highly vulnerable to post-harvest damage, manifesting as physical impairment or microbial spoilage due to inadequate handling and a lack of modern infrastructure. In Southern Ethiopia, these inefficiencies lead to rapid quality degradation and significant economic "forced sales," undermining regional food security.

**Objective:** This study aimed to evaluate the post-harvest value chain, stakeholder demographics, and operational constraints within the fisheries of the Wolaita and Kambata Tembaro zones to propose actionable interventions for loss mitigation.

**Methods:** A cross-sectional study design was employed using a multi-stage sampling technique to survey 270 respondents (fishermen, retailers, and consumers). Primary data were gathered through semi-structured questionnaires, direct field observations of infrastructure, and focus group discussions with fishery experts.

**Key Results:** Results indicated a 100% male dominance in fish harvesting, with educational attainment significantly higher in Wolaita (60% secondary or above) than in Kambata Tembaro (34%). Harvesting relied on traditional gillnets and hooks (42–52%) with limited boat access (4–16%). While 60–72% of respondents fished exclusively for sale, systemic inefficiencies were prevalent; poor road access (36–48%), inconsistent electricity, and inadequate storage (15–27%) were identified as primary constraints. Retailers primarily sold whole fish in Wolaita (45%), while fish soup dominated the Kambata Tembaro market (50%). Notably, raw fish consumption (4–10%) persists despite severe food safety risks linked to the absence of a cold chain.

**Conclusion:** The transition to a modernized fishery value chain in Southern Ethiopia is hindered by infrastructural bottlenecks. Urgent interventions, including the establishment of solar-powered cold-chain hubs and the provision of insulated transport materials, are required to mitigate losses and enhance the economic viability of the sector.

**Keywords:** Fisheries, Post-harvest loss, Value chain, Handling practices, Marketing, Food security.

## 1. Introduction

Fish is highly vulnerable to post-harvest damage, typically manifesting as fleshly impairment or microbial spoilage. Rough handling during capture and transport leads to physical damage, while poor hygiene and inadequate sanitation environments significantly expedite the spoilage process [9]. Research indicates that environmental factors such as high temperatures, alongside inappropriate processing, storage, and supply chain inefficiencies, are primary drivers making fish prone to physical and quality degradation [13]. This degradation is further accelerated by endogenous enzymatic autolysis, which creates an ideal substrate for microbial proliferation in the absence of a rigid cold chain [7].

Consequently, these losses do not only represent a financial deficit for fishers but also a significant reduction in the availability of high-quality animal protein for vulnerable populations [2].

These post-harvest losses are multi-dimensional, encompassing material losses due to spoilage, breakage, and the discarding of by catch, as well as operational losses [6]. Furthermore, these inefficiencies result in economic losses regarding monetary value, quality losses affecting consumer attractiveness, and nutritional losses, where the fish provides fewer dietary benefits than its fresh state [6]. Such losses stem from systemic flaws in handling, storage, distribution, and marketing techniques, which are further compounded by rapid microbial proliferation and enzymatic autolysis [2], [7]. As the study of losses must be conducted on a case-by-case basis to facilitate improvement, assessing these gaps is a critical first step toward increasing food availability and raising the income of fishing communities [3]. Consequently, the main objective of this study was to identify the specific types and stages of losses occurring in the target areas to propose actionable interventions for prevention.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The study was conducted in the Wolaita and Kambata Tembaro administrative zones of Southern Ethiopia. Within the Wolaita Zone, the research sites comprised Kindo Didaye, Kindo Koysha, and Boloso Bombe woredas. In the Kambata Tembaro Zone, the study focused on the Tembaro, Qacha Bira, and Hadaro Tuto Zuria woredas.

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These specific areas were purposively selected based on their high potential for fish production, the intensity of marketing activities, and their strategic importance to the regional fish supply chain.

## 2.2. Data Source and Collection Methods

A cross-sectional study design was employed to quantify fish handling practices and post-harvest losses, utilizing an integration of primary and secondary data sources. Primary data were gathered through a field-based approach involving the administration of semi-structured questionnaires to stakeholders, complemented by direct observations of physical handling practices and existing infrastructure at landing and market sites. To gain deeper technical and systemic insights, Key Informant Interviews (KII) and Focus Group Discussions (FGD) were conducted with zonal and woreda-level livestock and fishery experts. A multi-stage sampling technique was utilized to select 270 respondents, comprising fishermen, retailers, and consumers across the two study zones. This stratified approach ensured a representative assessment of the various stages within the fishery value chain, allowing for a comprehensive analysis of the factors contributing to quality and quantity degradation.

## 2.3. Data Analysis

Collected data were coded and analysed using one way ANOVA Table. Descriptive statistics were employed to summarize the socio-economic characteristics of the respondents and the magnitude of post-harvest losses.

**Table 1: Distribution and membership of fishery cooperatives in the study zones**

Zone	Woreda	Cooperative Name(s)	No. of Members (n)
Wolaita	Kindo Didaye	Egna Legna and Robota	20
	Kindo Koyisha	Nebar, Hidase, and Zetsat	24
	Boloso Bombe	Hidota, Lamiya, and Moluwa	25
Kambata Tembaro	Tembaro	Omo, Gayicha, and Belela Kebele	56
	Qacha Bira	Worerama	10
	Hadaro Tuto Zuria	Ajora and Mandoye	32
Total			167

Source: Survey data (2024)

## 3.2. Gender and Educational Profile of Harvesting Respondents

The demographic characteristics, specifically gender distribution and educational attainment of the harvesting respondents (N=100), are summarized in Table 2. Gender distribution was entirely uniform across both study areas, with males accounting for 100% of the active harvesters interviewed. This absolute male dominance is consistent with broader trends in Ethiopian inland fisheries, where harvesting is traditionally perceived as a male-exclusive physical activity, while women are predominantly relegated to post-harvest processing and retail marketing [5].

Regarding educational status, respondents in the Wolaita zone demonstrated a higher level of formal education compared to those in the Kambata Tembaro (K/T) zone. In Wolaita, 42% of respondents had completed secondary school and 18% held diplomas, whereas in the K/T zone, these figures were notably lower at 24% and 10%, respectively. Conversely, the K/T zone exhibited higher rates of primary education (50%) and illiteracy (16%) compared to Wolaita (10% illiteracy). These results indicate that fishers in the Wolaita zone possess a comparatively stronger educational foundation. Higher educational attainment is a critical determinant in the adoption of modern fishing technologies, improved hygiene protocols, and sustainable management practices, as literate fishers are more likely to access and implement technical manuals and national fishery development strategies (Akande and Diei-Ouadi 2010).

**Table 2: Gender and educational status of fish harvesting respondents (N=100).**

Demographic Variable	Wolaita (n=50)	%	Kambata Tembaro (n=50)	%
<b>Gender</b>				
Male	50	100	50	100
Female	0	0	0	0
<b>Education Level</b>				
Illiterate	5	10	8	16
Primary School	15	30	25	50
Secondary School	21	42	12	24
Diploma	9	18	5	10
<b>Total</b>	<b>50</b>	<b>100</b>	<b>50</b>	<b>100</b>

Source: Survey data (2024)

Continuous variables were expressed as mean  $\pm$  standard deviation (SD). Categorical variables, including education level and fish preservation methods, were summarized using frequencies and percentages.

## 3. Results

### 3.1. Fisher Cooperatives in the Study Areas

The distribution and membership density of fishery cooperatives within the surveyed administrative zones are presented in Table 1. In the Wolaita zone, eight cooperatives were identified across three woredas. Specifically, Kindo Didaye comprised the Egna Legna and Robota cooperatives (n=20 members), while Kindo Koyisha featured the Nebar, Hidase, and Zetsat cooperatives (n=24). Boloso Bombe contained the Hidota, Lamiya, and Moluwa cooperatives, totaling 25 members. In the Kambata Tembaro zone, the cooperative structure varied by woreda. Tembaro woreda hosted three cooperatives; Omo, Gayicha, and Belela (n=56) representing the largest membership concentration in the study area. In contrast, Qacha Bira woreda consisted of a single entity, the Worerama fisher cooperative (n=10). Finally, the Hadaro Tuto Zuria woreda included the Ajora and Mandoye cooperatives with a combined membership of 32 individuals. The variation in membership size across woredas suggests differing levels of communal organization and resource access within the regional fishery value chain.

### 3.3. Purpose of Fishing

The primary motivations for engaging in fishing activities across the study areas are detailed in Table 3. The data indicate a strong commercial orientation in both zones, though the degree of market reliance varies significantly. In the Kembata Tembaro (K/T) zone, a substantial majority of respondents (72%) fished exclusively for sale, compared to 60% in the Wolaita zone. This high commercial focus (above 60% in both areas) aligns with the evolving role of cooperatives in transitioning artisanal fisheries from subsistence levels to market-linked livelihoods [5]. Conversely, subsistence-oriented fishing was more pronounced in Wolaita. While 34% of Wolaita respondents reported fishing for both consumption and sale, and 6% fished solely for home consumption, the corresponding figures for K/T were 28% and 0%, respectively. These findings suggest that while fishing is primarily an income-generating activity in both regions, the Wolaita zone exhibits a higher level of household fish consumption. Such disparities may be attributed to differences in local dietary habits, varying levels of market access, or the proximity of landing sites to urban centres [2].

Table 3: The primary purpose of fishing in the study areas (N=100)

Purpose of Fishing	Wolaita (n=50)	%	Kembata Tembaro (n=50)	%
Only for Sale	30	60	36	72
Only for Consumption	3	6	0	0
Consumption and Sale	17	34	14	28
Total	50	100	50	100

Source: Survey data (2024)

### 3.4. Fishing Gear and Equipment Utilization

The technical characteristics of fish harvesting are summarized in Table 4. The findings reveal a reliance on traditional and semi-modern gears, with the combination of **gillnets and hooks** emerging as the most prevalent method, utilized by 52% of respondents in the Kembata Tembaro (K/T) zone and 42% in the Wolaita zone. Standalone gillnet usage was the second most frequent approach (32% in Wolaita; 26% in K/T). Notably, the utilization of more integrated equipment comprising gillnets, hooks, and boats was significantly higher in the Wolaita zone (16%) compared to the K/T zone (4%), suggesting greater capitalization or better access to watercraft within Wolaita cooperatives. Conversely, the use of hooks alone was more frequent in the K/T zone (18%) than in Wolaita (10%).

Table 4: Distribution of fishing equipment used by respondents (N=100)

Fishing Equipment	Wolaita (n=50)	%	Kembata Tembaro (n=50)	%
Gillnet	16	32	13	26
Hook	5	10	9	18
Gillnet & Hook	21	42	26	52
Gillnet, Hook & Boat	8	16	2	4
Total	50	100	50	100

Source: Survey data (2024)

### 3.5. Constraints and Challenges in Fish Harvesting

The operational challenges identified by respondents are categorized in Table 5. Poor infrastructure and road access emerged as the primary constraint, cited by 48% of respondents in the Kembata Tembaro (K/T) zone and 36% in the Wolaita zone. This lack of reliable transportation networks directly exacerbates post-harvest losses by extending the time between capture and market delivery (Akande and Diei-Ouadi 2010). Illegal fishing activities were a secondary major concern, particularly in the Wolaita zone (32%), compared to the K/T zone (18%). Furthermore, equipment shortages were reported by 26% of K/T and 20% of Wolaita fishers, while dangerous aquatic animals (e.g., crocodiles and hippopotami) posed risks to 12% and 8% of fishers, respectively.

Table 5: Major constraints and problems identified by respondents (N=100)

Problem Category	Wolaita (n=50)	%	Kembata Tembaro (n=50)	%
Poor Infrastructure / Road	18	36	24	48
Illegal Fisherman	16	32	9	18
Shortage of Equipment	10	20	13	26
Dangerous Animals	6	12	4	8
Total	50	100	50	100

Source: Survey data (2024)

### 3.6. Retailer Perspectives and Income Sources from Fish Products

The revenue streams for fish retailers, categorized by product type (N=70), are presented in Table 6. In the Wolaita zone, whole fish sales were the primary income source (45%), whereas retailers in the Kembata Tembaro (K/T) zone derived their highest revenue from fish soup (50%). The sale of filleted fish was less prevalent, accounting for only 15% in Wolaita and 10% in K/T. Integrated sales of both soup and fillets represented the smallest market share (6.7–10%), suggesting limited product diversification among local vendors.

Table 6: Distribution of income sources among fish retailers by product type (N=70)

Product Type for Sale	Wolaita (n=40)	%	Kembata Tembaro (n=30)	%
Whole Fish Alone	18	45.0	10	33.3
Fish Soup Alone	12	30.0	15	50.0
Filleted Fish Alone	6	15.0	3	10.0
Soup & Filleted	4	10.0	2	6.7
Total	40	100	30	100

Source: Survey data (2024)

### 3.7. Post-Harvest Handling: Transport and Storage Materials

The materials utilized for the handling and transport of fish products are presented in Table 7. Across both study areas, plastic materials (crates and buckets) were the primary equipment, employed by 77.5% of respondents in the Wolaita zone and 66.7% in the Kembata Tembaro (K/T) zone. A significant portion of retailers, particularly in K/T (26.7%), utilized sacks or plastic bags ('pestals') for transport. Metallic materials were the least common, utilized by only 7.5% and 6.7% of respondents in Wolaita and K/T, respectively.

Table 7: Transport and storage materials used by fish retailers (N=70)

Equipment Type	Wolaita (n=40)	%	Kembata Tembaro (n=30)	%
Plastic Materials	31	77.5	20	66.7
Sack / 'Pestal'	6	15.0	8	26.7
Metallic Materials	3	7.5	2	6.7
Total	40	100.0	30	100.0

Source: Survey data (2024)



Figure 1: post-harvest practices and equipment in the Kindo Koyisha and Boloso Bombe



Figure 2: Improved storage and preservation methods for fish meat at a retail center in Kindo Koyisha

### 3.8. Constraints in Fish Product Marketing

The principal challenges facing fish marketing in the study areas are summarized in Table 8. Low supply emerged as the most critical bottleneck, cited by 53.3% of retailers in the Kembata Tembaro (K/T) zone and 45% in the Wolaita zone. This consistent supply deficit is intrinsically linked to the seasonal nature of artisanal catches and the technical limitations of local cooperatives [5].

Infrastructural and preservation deficits also present significant barriers to market efficiency. Inadequate storage equipment was a primary concern for 27.5% and 20% of respondents in Wolaita and K/T, respectively. Furthermore, a lack of consistent electricity essential for maintaining the cold chain—was reported by 26.7% of retailers in K/T and 15% in Wolaita. These findings suggest that addressing supply-chain infrastructure and energy access is vital for the economic viability of fish retailing in these regions.

Table 8: Principal marketing constraints identified by fish retailers (N=70)

Marketing Problem	Wolaita (n=40)	%	Kembata Tembaro (n=30)	%
Low Supply	18	45.0	16	53.3
Inadequate Storage Equipment	11	27.5	6	20.0
Lack of Electricity	6	15.0	8	26.7
Increase in Price	5	12.5	0	0.0
Total	40	100.0	30	100.0

Source: Survey data (2024)

### 3.9. Consumer Preferences and Common Fish-Based Dishes

The distribution of common fish-based dishes and preparation methods among consumers (N=100) is summarized in Table 9. Fish soup emerged as the most prevalent dish in both zones, consumed by 60% of respondents in the Kembata Tembaro (K/T) zone and 54% in the Wolaita zone. Roasted fish was the second most popular preparation method in Wolaita (20%), while a combination of soup and roasted fish was more frequent in the K/T zone (22%). Notably, the consumption of raw fish meat was documented in both areas, with a higher prevalence in Wolaita (10%) compared to K/T (4%).

Table 9: Common fish dishes and preparation methods among consumers (N=100)

Dish/Preparation Type	Wolaita (n=40)	%	Kembata Tembaro (n=30)	%
Fish Soup	27	54.0	30	60.0
Roasted Fish	10	20.0	7	14.0
Soup & Roasted	8	16.0	11	22.0
Raw Meat	5	10.0	2	4.0
Total	50	100.0	50	100.0

Source: Survey data (2024)



1. Fish Soap

2. Raw fish meat

## 4. Discussions

### 4.1. Socio-Economic and Institutional Dynamics

The identification of 16 fishery cooperatives across the study areas provides a foundation for communal management, yet membership fragmentation, particularly in Qacha Bira (n=10) and Kindo Didaye (n=20)—limits economies of scale. Larger clusters in Tembaro (n=54) align with [5], who noted that high-yield water bodies necessitate communal marketing for survival. Conversely, under-capitalized, smaller groups often fail

to implement standardized hygiene protocols, resulting in rapid microbial spoilage [2]. This organizational disparity necessitates site-specific interventions to mitigate the high operational costs that force fishers into "forced sales" and subsequent economic deficits [3], [6].

### 4.2. Gender and Educational Influence on Modernization

The 100% male participation in harvesting reinforces a rigid division of labor where women dominate downstream segments like processing and retail [5]. Consequently, interventions for capture-based damage should target men, while sanitation training must be gender-inclusive. Educational disparities further define the sector's modernization potential; higher literacy in Wolaita (60% secondary and above) favors the adoption of complex food safety standards and handling technologies [12]. Conversely, the high rate of primary-level education in Kembata Tembaro (66% combined) suggests that extension materials must rely on visual and demonstration-based training to effectively reduce post-harvest losses.

### 4.3. Commercial Orientation and Food Security

The 72% "sale-only" motivation in Kembata Tembaro underscores a deep economic dependency on fishery resources, necessitating an efficient Value Chain to prevent quality degradation. In contrast, the 40% retention for home consumption in Wolaita highlights the sector's dual role in Food Security and Poverty Alleviation. However, higher consumption in Wolaita may also indicate market barriers; poor transport infrastructure often compels fishers to consume the catch locally to avoid total physical loss [13]. Interventions must therefore balance market linkage improvements with the preservation of local dietary protein sources.

### 4.4. Technical Gear Utilization and Infrastructure

The ubiquitous reliance on gillnets and hooks reflects the low-capital nature of Ethiopian artisanal fisheries, targeting species such as *Oreochromis niloticus* and *Clarias gariepinus* [5]. However, the high utilization rate of gillnets (>70%) presents substantial quality risks; extended soak times in tropical temperatures trigger enzymatic autolysis and microbial proliferation before landing [7]. Furthermore, the structural deficit in boat ownership, particularly in K/T (4%), compels fishers to engage in shore-based harvesting, extending the period fish remain in unrefrigerated conditions during terrestrial transport. Integrating watercraft is therefore essential to expand fishing ranges and facilitate rapid delivery to landing sites to mitigate initial-stage spoilage [2].

### 4.5. Harvesting Constraints and Operational Hazards

Infrastructure deficits (36–48%) remain the primary driver of quality degradation, as the lack of all-weather roads in the rift valley forces the use of suboptimal transport, leading to prolonged "temperature abuse"[11]. Additionally, the high prevalence of illegal fishing in Wolaita (32%) undermines Community-Based Fisheries Management, as unauthorized small-mesh nets increase the breakage and discarding of juvenile stocks [6], [10]. Operational hazards, specifically dangerous aquatic animals (8–12%), further compromise post-harvest efficiency; as fishers prioritize rapid departure from hazardous zones, they often neglect critical on-board sorting and handling protocols, predisposing the catch to physical impairment [4].

#### 4.6. Retailer Dynamics and Value Addition

Retailer revenue streams reveal distinct regional consumer behaviors and value-addition strategies. The dominance of whole-fish sales in Wolaita suggests a market limited by processing infrastructure, which heightens the risk of microbial spoilage in ambient temperatures [2]. Conversely, the high prevalence of fish soup in K/T (50%) serves as a "salvage mechanism" to monetize smaller or slightly damaged fish that would otherwise be discarded as material loss [4]. While filleting (10–15%) offers potential for reduced transport waste, its expansion is contingent upon rigorous hygiene protocols to prevent secondary contamination during processing [7].

#### 4.7. Post-Harvest Handling and Storage Materials

The prevalent use of plastic containers (66.7–77.5%) facilitates improved sanitation; however, the absence of insulated or refrigerated equipment remains a critical vulnerability. Non-insulated plastic buckets in tropical environments lead to rapid internal temperature spikes, accelerating enzymatic autolysis and microbial proliferation [7]. The continued reliance on sacks and plastic bags (up to 26.7% in K/T) is particularly deleterious, providing negligible thermal protection and poor structural support. Such mechanical damage creates entry points for bacterial contamination, significantly degrading the market value and shelf-life of the catch [2]. Without localized cold-chain infrastructure, even non-porous materials fail to prevent nutritional losses linked to lipid oxidation [8].

#### 4.8. Marketing Constraints and Supply Chain Vulnerability

Critical supply shortages (45–53.3%) reflect national trends where production meets only a fraction of potential due to technical limitations [11]. Infrastructural gaps, specifically the lack of reliable electricity for ice production, force retailers into "forced sales" to avoid total physical loss—a phenomenon that directly mirrors the economic and quality deficits described by [1], [6]. The high dependency on a "fresh-chain" system makes the regional fishery exceptionally vulnerable to transport delays. Consequently, the integration of solar-powered cooling solutions is recommended as a high-impact intervention to stabilize supply and maintain the nutritional integrity of the fish [2].

#### 4.9. Consumer Behaviour and Public Health Implications

The high preference for fish soup (54–60%) serves as a traditional "salvage mechanism" to monetize smaller or slightly damaged biomass [4]. However, the documented consumption of raw fish (4–10%), known as *Leb-leb* or *Kurt*, presents a critical food safety gap. In the absence of verified refrigeration and ambient temperatures exceeding 25°C, raw consumption increases susceptibility to rapid microbial proliferation and zoonotic parasites [8]. While preparation methods like roasting (14–20%) improve biological safety through heat treatment, they do not mitigate the nutritional losses incurred during prior improper storage [2]. These results underscore the urgent need for targeted consumer education on safe handling in resource-constrained environments.

### 5. Conclusions and Recommendations

#### 5.1. Conclusions

This study evaluated the post-harvest value chain, stakeholder demographics, and operational constraints within the fisheries of the Wolaita and Kembata Tembaro zones of Southern Ethiopia.

The findings reveal a fishery sector characterized by strong commercial orientation but hindered by significant systemic inefficiencies. The 100% male participation in harvesting and the dominance of traditional gears (gillnets and hooks) confirm that the regional fishery remains largely artisanal and gender-segregated. While educational attainment in the Wolaita zone was comparatively higher, the overall lack of specialized equipment and boat access across both zones limits the technical capacity of cooperatives to minimize physical and quality degradation.

Post-harvest losses in the study areas are driven by a critical lack of cold-chain infrastructure, specifically inadequate storage and inconsistent electricity, which affects up to 26.7% of retailers. These gaps lead to rapid microbial spoilage and forced sales, undermining the economic viability of the sector. Furthermore, while the high preference for fish soup suggests an effective local strategy for biomass utilization, the documented practice of raw fish consumption (up to 10%) poses a significant public health risk given the identified sanitation and temperature-control deficits. In summary, the transition from subsistence-based fishing to a modern, market-linked value chain is currently stalled by infrastructural bottlenecks and a lack of institutional support for cooperative modernization.

#### 5.2. Recommendations

Based on the empirical evidence gathered, the following interventions are recommended to mitigate post-harvest losses and enhance food security:

- **Infrastructural Development:** The regional government and development partners should prioritize the establishment of solar-powered cold-chain hubs at major landing sites to provide ice and refrigerated storage, bypassing the limitations of the unreliable national grid.
- **Cooperative Empowerment:** Financial institutions should provide low-interest credit to fisher cooperatives to facilitate the procurement of motorized boats and insulated plastic crates, which are essential for reducing transport time and mechanical damage to the catch.
- **Capacity Building and Extension:** Targeted training programs on Standard Operating Procedures (SOPs) for hygiene should be implemented. Given the educational disparities, these programs must utilize visual and demonstration-based methods, particularly in the Kembata Tembaro zone.
- **Public Health and Food Safety:** Consumer awareness campaigns are urgently needed to highlight the zoonotic risks associated with raw fish consumption, especially in areas lacking verified refrigeration.
- **Policy Integration:** Fisheries management should be integrated into broader regional agricultural strategies to improve road connectivity between landing sites and high-value urban markets, thereby reducing the "forced sale" phenomenon and increasing fisher income.

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