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Assessment of post-harvest fish losses at the fishers' level in Lake Tana, Ethiopia

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Abstract

Fish are essential for ensuring food and nutrition security; and economic growth. However, post-harvest loss poses a significant challenge in the value chain due to the perishable nature of fish. This study aimed to address the information gap on post-harvest fish losses at the fishers' level in Lake Tana. Data were collected through direct field observation, questionnaire-based loss assessment, and load-tracking methods. Assessment results revealed that fishers incur three types of losses, namely: physical, quality, and market forces, at different points in the value chain. The main causes of loss were identified as delays in net hauling, poor post-harvest handling, and the absence of a market for open sun-dried fish. An average of 1.45 ± 0.51 kg of raw fish loss was estimated per fishing trip. The physical loss of raw fish resulted in an annual loss of 5,121.85 Ethiopian Birr ($102.43) per fisher, representing a total percentage loss of 6.32%. The estimated annual mean financial losses due to both physical and quality-related factors in dried fish products were valued at 1,178.5 Ethiopian Birr ($23.57), representing 11.32% of their total income. To mitigate the extent of post-harvest losses, the fishers used different methods, like drying poor-quality fish rather than discarding it. The findings of this study revealed that post-harvest fish loss was not as severe as compared to other water bodies in Ethiopia. This is a good trend showing proper resource utilization to ensure food security, where other fishers from different parts of the country can learn from.

Keywords: Fish, Lake Tana, Loss reduction, Post-harvest loss, Value chain

Introduction

Aquatic foods, such as fish, are increasingly recognized for their significant role in addressing food security, nutrition, and economic growth (FAO, 2022). This aquatic food contributes approximately 17% of the world's animal protein and more than 50% in Africa, particularly in low-income countries. According to the FAO (2022) report, the global average consumption of aquatic food stands at 20.2 kg, 10.1 kg in Africa, and less than 1 kg in Ethiopia. However, this resource is challenged by post-harvest loss in the value chain due to inefficiencies in value chains (FAO, 2022), as well as due to the social and cultural

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dimensions of vulnerability (Diei-Ouadi et al., 2015; Wibowo et al., 2017). The most common types of post-harvest losses in fish include physical loss, loss of quality, loss of nutrients, and market force loss (Akande & Diei-Ouadi, 2010; Ward & Jeffries, 2000). Assessing these losses can be achieved using the FAO-recommended Informal Fish Loss Assessment Method (IFLAM), load tracking (LT), and Questionnaire Loss Assessment Method (QLAM) (Diei-Ouadi & Mgawe, 2011).

Global fish losses and waste are estimated to be 30% to 35% (FAO, 2011), and recent estimate shows 27 percent of landed fish is lost or wasted between landing and consumption (FAO, 2018). The losses are high in developing countries, with 20% to 75% of fish production lost in the value chain (FAO, 2014). In sub-Saharan Africa, losses reach approximately 30% (Akande & Diei-Ouadi, 2010; FAO, 2016), while Ethiopia experiences a loss of 33.3% (Teklu, 2015). Despite Ethiopia's abundance of fish-rich water bodies, with an annual fish production potential of 94,541 tons (Tesfaye & Wolff, 2014), the country faces numerous challenges in fish production. For example, poor handling, storage, and management practices contribute to post-harvest fish losses while fish demand grows at a rate of 3.7% annually (Gordon et al., 2007; Tesfay & Teferi, 2017). To meet the ever-increasing fish demand, it is crucial to optimize catches and minimize losses.

In Lake Tana, the catch per unit effort of commercial species has been declining over the past two decades due to increased fishing efforts (Aragaw, 2012; de Graaf et al., 2004; Dejen et al., 2017). However, in 2010, the production was reported at 6,561 tons, increasing to 9,980 tons in 2013. Furthermore, in 2012, 64 tons of dried fish were produced and exported to Sudan (Yalew, 2012). This production has significantly contributed to the regional economy from exports (Mengistu et al., 2017; Yalew, 2012). The estimated potential yield for the Lake Tana fishery is 18,620 (FAO, 2003) tons per year, and it contributed an average of 17% to the total annual fish catch in Ethiopia from 1999 to 2009 (Tesfaye & Wolff, 2014). The production potential is challenged by limited accessible landing sites, the distance to marketing sites (to Addis Ababa), the absence of local demand for dried fish products, a lack of cold storage and ice for transportation, illegal fishing, a lack of enforcement of fishery legislation and regulations, and water quality deterioration (Gordon et al., 2007; Mengistu et al., 2017; Yalew, 2012). Additionally, the existence of poor handling, storage, distribution, processing, and marketing systems for harvested fish has been reported (Asmare et al., 2015; Gordon et al., 2007; Misganaw & Getu, 2016; Mohammed, 2011; Yimer et al., 2017). However, there was limited information regarding the post-harvest fish loss experienced by fishers in this lake. As a result, this study was designed to address the gap by assessing the types, causes, and extent of post-harvest fish losses at the fishers' level in the Lake Tana Fishery.

Materials and Methods

Description of the study area

This study was conducted in Lake Tana from February 2022 to November 2022, the largest freshwater body in Ethiopia. It is situated at 12°N, 37°15'E coordination, at an elevation of 1,830 meters above sea level, and covers an area of 3,050 km^2 (Vijverberg et al., 2009). The lake is shallow, with an average depth of 8 meters, and its water column does not experience long-term thermal stratification (Dejen et al., 2004). The area experiences an annual rainfall of up to 2,000 mm, with a rainy season from May to October and a peak from July to September (Wondie et al., 2007). The average temperature of the Lake Tana basin is 20℃ (Abebe et al. 2017). A total of 28 fish species have been identified and classified into four families: Cyprinidae, Balitoridae, Clariidae, and Cichlidae (Getahun & Dejen, 2012; Habtesselassie, 2012). Many of these fish species are endemic to the lake, and commercially important species targeted for fishing are *Oreochromis niloticus* (Nile tilapia), *Labeobarbus* species, and *Clarias gariepinus* (catfish) (Wudneh, 1998).

Sampling method and data collection

The target population, which includes both legal and illegal fishers in Lake Tana, is estimated to be more than 5,000 individuals. From this, based on fish production potential and accessible landing sites, we purposefully selected six landing sites (Fig. 1), and the fishers in these landing sites were our study population (n = 2,428), where the study sample (n) was drawn using a formula. The total number of fishers at Bahir Dar, Kunzla, Nabega, Mitsrihaba, Gorgora, and Delgi landing sites was 650, 324, 433, 371, 350, and 300, respectively. A sample size of 344 fishers was calculated using the Yamane (1967) formula and distributed proportionally to the population size of each landing site, Bahir Dar (92), Kunzla (46), Nabega (60), Mitsrihaba (53), Gorgora (50), and Delgi (43). During the interview, fishers at each landing site were selected randomly.

$$n = \frac{N}{1 + N\left(e^2\right)} \tag{1}$$

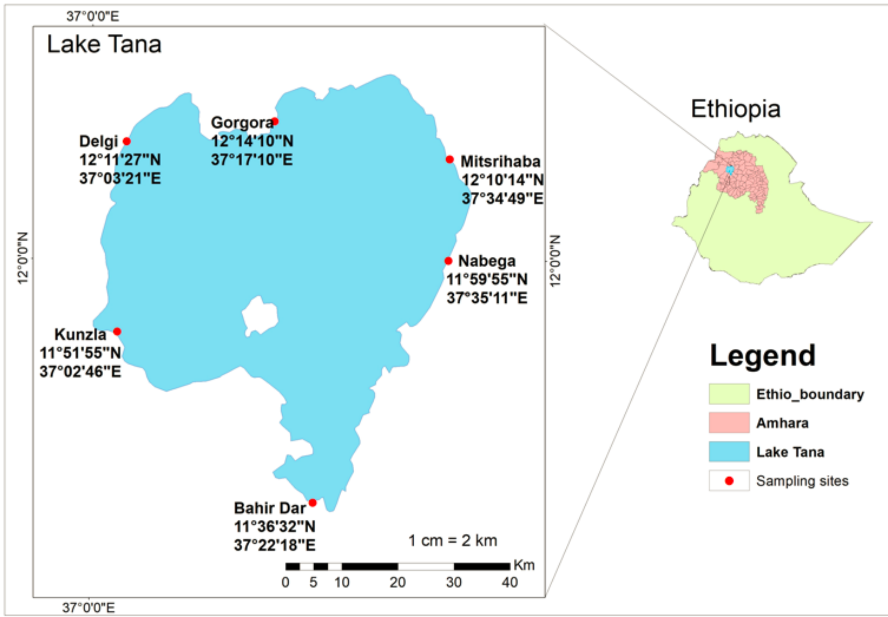

Fig. 1. Map of the study area and sampling sites.

where "n" represents the sample size, "N" is the population size, and "e" is the level of precision (0.05).

Data on fish loss were collected using the informal fish loss assessment method (IFLAM), load track (LT), and the Questionnaire Loss Assessment Method (QLAM), adapted from FAO (Diei-Ouadi & Mgawe, 2011). The main site of losses in the value chain indicated by IFLAM was measured by LT. Selected fishers were interviewed using a pre-tested questionnaire, which was translated into the local language (Amharic). Field observation was also done using a checklist at selected landing sites. The total percentage loss and financial loss were calculated using a formula adapted from Adelaja et al. (2018). The best price and reduced price of fish was recorded in Ethiopian Birr (ETB).

$$\text{Financial loss} = \text{Weight of fish loss (kg)} \times \text{Best price of fish (ETB)} - \text{Weight of fish loss (kg)} \times \text{Reduced price of fish (ETB)} \quad (2)$$

$$\text{Expected income} = \text{Weight of fish captured (kg)} \times \text{Best price of fish (ETB)} \quad (3)$$

$$\text{Total percentage loss} = \frac{\text{Total financial loss (ETB)}}{\text{Total expected income (ETB)}} \times 100 \quad (4)$$

The annual monetary loss per fishers was calculated using a formula adapted from Assefa et al. (2018).

$$\text{Annual monetary loss per fisher} = \text{Amount of loss in kg incurred by fishers per fishing trip} \times \text{Average number of days fishers works in a week} \times \text{Price of fish per kg} \times \text{Number of allowed fishing weeks.} \quad (5)$$

Market force loss was calculated as the difference between the expected price and the actual price obtained, as indicated by Diei-Ouadi & Mgawe (2011). The causes of post-harvest fish loss were assessed through open-ended interview questionnaires. Additionally, a 5-point Likert scale (ranging from strongly disagree to strongly agree) was used to determine the primary factors influencing the loss across the distribution channel. For a better understanding of the possible causes, a weighted mean for the Likert scales was computed by giving a weight of 1 for strongly disagree, 2 for disagree, 3 for neither agree nor disagree, 4 for agree, and 5 for strongly agree. Here, the higher value is 5, the lower value is 1, the range is 4 (which is 5–1), and the interval is 0.8 (which is 4/5). The weighted mean for each possible cause was calculated, and the mean ranging from 1.00 to 1.79 is interpreted as very weak agreement; from 1.80 to 2.59 is implied to be low agreement; from 2.60 to 3.39 is average; from 3.40 to 4.19 is high agreement; and from 4.20 to 5 indicates very high agreement.

To assess the loss incurred during the filleting process, a sample of five fishers was randomly chosen, and the loss was

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quantified using load tracking. For the filleting process, the initial weight of the fisher catch was measured, followed by the measurement of the fillet and the discarded part (offal) after filleting (Fig. 2). Then, to determine the percentage of physical loss incurred during filleting, the weight of the discards (useful if processed further) was divided by the initial weight of the fish before filleting. In addition, in order to evaluate the raw fish quality, a sensory assessment (considering texture, appearance, and odor) was carried out on a randomly selected subset of raw fish at the fishing ground, landing site, and market site using a conventional organoleptic assessment adapted from Diei-Ouadi & Mgawe (2011) (Table 1). To ensure precision in the loss assessment, triplicate measurements were taken (5 fishers × 3 = 15 measurements). During the sensory evaluation, the initial weight of the fisher's catch was weighted, and then the weights of good, average, and poor-quality fish were separately mea-

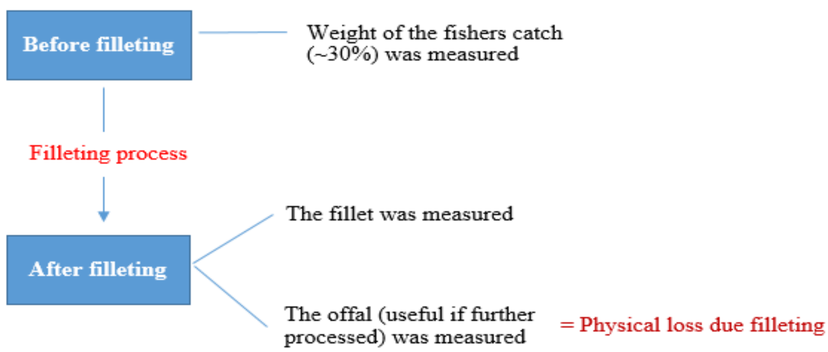

Fig. 2. A flow chart showing physical loss measurement before and after filleting process.

Table 1. A conventional organoleptic assessment evaluation form

Observable aspect	Score
General appearance (5 marks)	
Eye, skin, slime, gills, belly flaps, blood, muscle along the backbone	
- Eyes perfectly fresh, convex black pupil, bright red gills, no bacterial slime, no bleaching	5
- Eyes slightly sunken, grey pupil, some discoloration of gills and some mucus, outer slime opaque and somewhat milky	3
- Eyes sunken, milky white pupil, thick knotted outer slime with some bacterial discoloration	2
- Eyes with a completely sunken pupils; gills showing bleaching or complete discoloration and covered with thick mucus	0
Odors (5 marks)	
Gills, guts, body cavity, muscle	
- Fresh sea weedy odors	5
- Loss of fresh sea weed odors, shellfish odors	4
- Slight musty odors	3
- Strong ammoniacal and sulphide odors	2
- Indole, fecal, nauseating, putrid odors	0
Texture (5 marks)	
Rigor mortis, fingerprints, muscle, belly flaps	
- Firm, elastic to the finger touch	5
- Softening of the flesh, some grittiness	3
- Softer flesh, definite grittiness and scale easily rubbed off the skin	2
- Very soft and flabby, retains the finger indentations, grittiness quite marked	1
Total score	

Adapted from Diei-Ouadi & Mgawe (2011) with CC-BY-NC.

sured based on texture, appearance, and odor attribute scoring (Fig. 3). Based on Diei-Ouadi & Mgawe (2011) scoring guide, fish with a total score within the range of 12–15 were classified as of good quality, those with a score of 6–11 were considered average, and fish with a score below 6 were poor quality.

Data analysis

The collected data were analyzed using descriptive statistics such as percentages, figures, and tables to visualize the information on the cause and extent of the fish loss. Furthermore, the results were expressed as means ± SD using statistical analysis software like SPSS (version 20, IBM, Chicago, IL, USA).

Results and Discussion

Demographic characteristics of respondents

A total of 344 fisher were interviewed around Lake Tana at six landing sites. The demographic characteristics of respondents show that most of them were married (98.83%) and Orthodox Christian followers (82.55%) (Table 2). The average age and fishing experience of interviewed fishers were 30.05 ± 4.83 and 9.79 ± 3.13 years, respectively. Due to the labor-intensive nature of fishing activities in Ethiopia, there were only male respondents in this survey.

Post-harvest fish losses

The findings from the QLAM and IFLAM assessments revealed that fishers in Lake Tana experience fish losses at multiple points, mainly at the fishing grounds, landing sites, and market sites. All the interviewed fishers (100%) experienced post-harvest fish losses at the fishing grounds, with 9.6% of them reporting losses at the landing sites and 4.3% of them at the local marketing sites. This suggests that the loss leads to a decrease in revenue for fishers and also might have an effect on the economy at large. According to the respondents, the fishing grounds were the primary source of fish loss compared to the landing and market sites. Similarly, Tesfay & Teferi (2017) found that 89.4% of fishers in Tekeze Dam and Lake Hashenge experienced physical fish loss in the value chain. This might be due to the traditional fishing, preservation, and processing methods employed by Ethiopian fishers. Studies from different low and

Table 2. The frequency of respondents' sex, marital status, religion and educational level

Demographic characteristics	Frequency	Percent (%)
Sex		
Male	344	100
Female	0	0
Marital status		
Single	4	1.16
Married	340	98.84
Religion		
Orthodox Christian	284	82.56
Muslim	60	17.44
Educational level		
Not educated	188	54.65
Educated	156	45.35

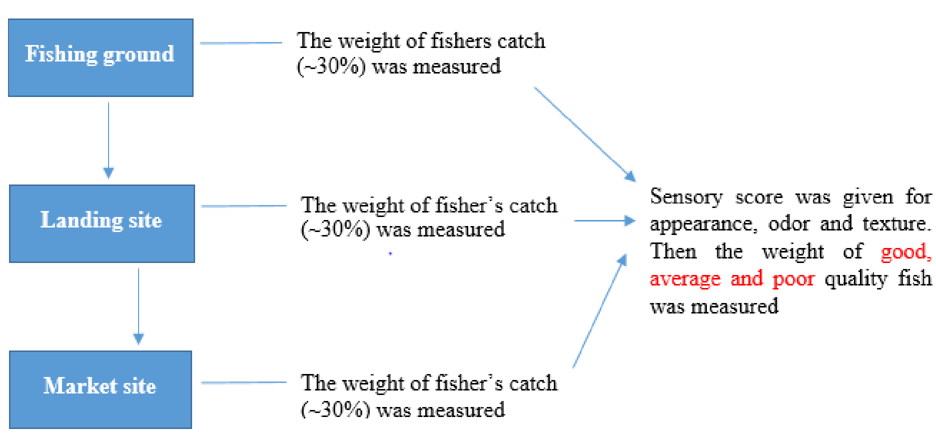

Fig. 3. A flow chart showing sensory evaluation of raw fish at the fishing ground, landing site, and market site.

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middle-income countries also reported similar post-harvest fish loss nodes (Akande & Diei-Ouadi, 2010; Eyo & Mdaihli, 2005; Kefi et al., 2017; Wibowo et al., 2017).

Type of post-harvest fish losses

In the raw fish value chain of Lake Tana, all respondents (100%) experienced physical and market force losses, while 25.3% reported quality losses. Most respondents abstained from selling deteriorated fish in the study area, which resulted in a lower percentage of respondents for quality loss than expected. Rather, 39.9% of respondents reported using salting and open sun-drying techniques for raw poor-quality fish instead of discarding or selling them at a reduced price. Using such a cost-effective way of preserving fish is a good trend to reduce the amount of fish wasted. At the Kunzla & Mitsrihaba sites, we observed that there is an obvious trend of sorting open sun-dried fish into categories of good-quality and poor-quality based on factors such as color, insect infestation, and dryness level. Poor quality dried fish were sold at a reduced price (50 Ethiopian Birr), suggesting a clear recognition of quality loss associated with open sun-drying compared to good quality fish (90 Ethiopian Birr).

In addition to facing physical and quality losses, fishers in Lake Tana encounter market force losses of considerable magnitude. Specifically, they experienced market force losses of up to 55.5% (equivalent to 20 Ethiopian Birr/kg) for Nile tilapia, 50% (15 Ethiopian Birr/kg) for *Labeobarbus* spp., and 33.3% (10 Ethiopian Birr/kg) for catfish during periods of high production season. This financial loss due to imbalances in supply and demand, with supply exceeding demand during high production, might affect small-scale fishers who rely on daily catch for their livelihood. Findings from this study revealed that physical, quality, and market force losses were the three main types of losses faced by fishers in Lake Tana. Physical loss of fish in other water bodies of Ethiopia was also reported from previous studies (Asmamaw et al., 2021; Assefa et al., 2018; Teklu, 2015; Tesfay & Teferi, 2017; Tigabu, 2012). In Zimbabwe, Mavuru et al. (2022) also reported similar loss types, and such losses are particularly prevalent in small-scale fisheries (Akande & Diei-Ouadi, 2010; Ward & Jeffries, 2000). In line with our findings, a considerable market force loss was reported in Togo, Ghana, and Burkina Faso (Diei-Ouadi et al., 2015).

Causes of post-harvest fish loss

Fishers mentioned many causes for post-harvest fish losses, mainly delays in net hauling, insect infestation, absence of markets, too much storage time, and others (Table 3). In contrast,

Table 3. Causes of post-harvest fish losses around Lake Tana based on the Likert scale weighted mean

Items	Weighted mean	Description
Delays in net hauling	4.68	Very high
Delay in transportation of harvested fish	2.74	Average
Catch of small size fishes	2.65	Average
Gill net type used for fishing	2.38	Low
Poor post-harvest handling	3.75	High
Insect infestation for open sun-dried fishes	3.43	High
Absence of market for open sun-dried fishes	3.8	High
Direct sunlight exposure during transportation	2.97	Average
Animal predation	3.15	Average
Physical damage	1.97	Low
Too much storage time for open sun-dried fishes	3.94	High

Tigabu et al. (2006) reported that fish size discrimination is the primary cause of physical loss in other water bodies in Ethiopia. Researchers from different countries have also reported similar causes in small-scale fisheries, with the main cause varying (Adelaja et al., 2018; Mavuru et al., 2022; Torell et al., 2020).

As per fishers' responses, delays in net hauling were the main cause of physical and quality loss of fish, and almost all fishers strongly agreed on. In the study area, most fishers (54.8%) have other occupations in addition to fishing, which might be a contributing factor to the delay. Furthermore, about 6.8% of fishers leave the nets unchecked for up to 36 hours due to social emergencies, adverse weather conditions, crop farming, a lack of motorized boats, and other commitments, which might increase further spoilage of fish. This suggests that, the longer the nets remain in the water, the higher the chances of fish loss, which leads to a decrease in profits for fishers, processors, and traders. The average duration for setting and hauling nets was recorded as 20.74 ± 6.15 h. Such a delay in net hauling might provide an opportunity for microbial degradation of fish since fish spoil within 12 hours of harvest in tropical environments (Akintola & Fakoya, 2017). However, our findings contradict the reports of Assefa et al. (2018) and Mavuru et al. (2022), where the average setting gear time was reported as less than 6 hours. The difference might be related to the fishing system, where in Lake Tana, most of the time, fishers leave the net in the water for a longer time to increase their chances of catching more fish. In addition, our finding also differs from that of the Tesfay & Teferi (2017) report in Tekeze dam, where such extended delayed net hauling was not mentioned in the report.

Insect infestation of open sun-dried fish was one of the main causes of loss in the study area. This might not only lead to financial losses for fishers but also might poses a health risk to consumers. The reports of Yalew (2012) and Yimer et al. (2017) from the same lake further support the findings of this study regarding poor post-harvest handling and storage practices of fish products. One of the main causes of insect infestation in dried fish is poor drying methods. As a result, the demand for open sun-dried fish has decreased, leading to a lack of market for producers. Around Lake Tana, we have observed that fish were dried in open spaces for several days with little or no protection from insects. In addition, field observation at the landing sites using a checklist adapted from Diei-Ouadi & Mgawe (2011) also highlights potential causes that can contribute to the loss of fish (Table 4).

Estimated physical and quality losses of raw fishes

Using the QLAM method, the estimated mean catches of commercially important fish species were 21.48 ± 10.98 kg per fishing trip, with an average working day of 4.53 ± 1.18 per week during the legal fishing season. According to the interview response, fishers encountered an average physical loss of 1.45 ± 0.51 kg (6.74% of catch) per fishing trip for raw fish, which resulted in an estimated annual economic loss of 5,121.85 ETB ($102.43) per fisher, representing a total percentage loss of 6.32%. The current finding indicates that the reported loss is lower than the figures presented by the previous studies, which were a loss of 30% in Lake Tana (Mohammed, 2011), a loss of 50% in the Amhara region (Kruijssen et al., 2020), and a loss of 33.3% in Ethiopia (Teklu, 2015). According to our findings, the post-harvest loss in Lake Tana is also relatively small compared to other Ethiopian water bodies (Table 5). The reason for such variation among Ethiopian water bodies might be due to the differences in fish handling, processing, and preservation practices in general. Specifically, infrastructure problems, high temperature, and lack of market in Tekeze dam (Assefa et al., 2018; Tesfay & Teferi, 2017); absence of marketing, harvesting immature fish, distant fishing grounds, predators, long hours of setting gear, and flooding in Lake Hayq (Assefa et al., 2018), and high temperature, shortage of storage facilities, and low price of fish in Alwero reservoir (Asmamaw, 2021) were the specific reasons mentioned behind the higher fish losses. The lower extent of fish losses in Lake Tana could be attributed to the implementation of value-added approaches in the value chain, such as market connectivity, the increasing demand for fish consumption, including catfish, and the implementation of loss avoidance strategies such as drying methods for low-quality fish and covering the fish to protect them from direct sunlight during transportation. Another crucial factor contributing to the lower post-harvest loss might be the reduction in catch over time. Additionally, most fishers could be able to reach the landing site within 2.09 ± 0.8 hours, either using motorized boats or by having access to selling fish in nearby markets. In line with our findings, Akande & Diei-Ouadi (2010), Diei-Ouadi et al. (2015), Eyo & Mdaihli (2005), Kruijssen et al. (2020), and Torell et al. (2020) reported a physical loss of less than 10% in low and middle-income countries. Such lower post-harvest loss of fish might have

Table 4. Field observation for the landing and processing site status

Observation	Response
Are there animals wandering freely where fish are processed?	Yes
Is the personal hygiene of fishers adequate?	No
Is the personal hygiene of handlers adequate?	No
Is the personal hygiene of processors adequate?	No
Are the harvested fish protected from the sun?	Yes (with traditional means)
Are fish iced before landing?	No
Is potable water used to wash fish or equipment?	No
Are fish being processed adequately?	No
Are fish being dried on the ground or on raised racks?	Both on the ground and rack
Are there blowflies where fish are processed?	Yes
Is fish packaging done hygienically with care?	No
Are fish storage facilities adequate?	No

Table 5. The annual estimate of physical and monetary loss of raw fish per individual fisher

Water body	Fish loss (kg) per year per individual fisher	Estimated monetary loss per year per fisher	Major causes	Reference
Lake Hayq	116.48	13,978 ETB ($499)	High temperature	Assefa et al. (2018)
Tekeze Dam	1,142.4	102,816 ETB ($3,672)	Distant fishing grounds	Assefa et al. (2018)
Alwero Dam	972	220,109 ETB ($7,861)	High temperature	Asmamaw et al. (2021)
Lake Tana	236.46	5,121.85 ETB ($102.43)	Delay in net hauling	Own (2022)

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economic benefits for fishers and also for the entire value chain actors.

Since the habit of sorting raw fish into good and poor quality is not common for most fishers around Lake Tana, load track measurement using sensory evaluation along the value chain was conducted. The sensory result revealed that only 3.79 ± 2.29%, 5.85 ± 2.66%, and 9.52 ± 4.90% of the catch were of poor quality at the fishing, landing, and market sites respectively (Table 6). However, the percentage of fishers who did not haul the catch on time at the fishing ground reached up to 26.53% (Fig. 4). About 5.45% of the caught fish had blood around the gill, which was attributed to improper disentangling from the net. In line with our findings, small quality losses were reported by Nowsad et al. (2015) and Wibowo et al. (2017) from low and middle-income countries. In contrast, higher quality losses up to 43%–79.4% were reported by Mavuru et al. (2022) and Torell et al. (2020). According to the Akande & Diei-Ouadi (2010) report, up to 80% of fish is sold at reduced prices due to quality loss in most African countries.

Estimated physical and quality losses of dried fishes

Fish drying is commonly practiced by most fishers (81.9%) around Lake Tana in a traditional way (Figs. 5 and 6), with an average annual physical loss of 9.59 ± 5.13 kg per fisher during storage and marketing. About 8.53% of their annual production is being sold at a reduced price (Table 7). Blowfly infestation and inadequate drying were the main causes of the quality deterioration and physical loss. The estimated annual mean financial losses due to both physical and quality-related factors in dried products were valued at 1,178.5 ETB ($23.57), representing 11.32% of their total income. This is higher than the percentage of quality loss for smoked and salted fish reported by Akande & Diei-Ouadi (2010) and Kruijssen et al. (2020) in low and middle-income countries.

Table 6. Poor, average and good quality status of evaluated fish in the value chain

Sites	% of good quality	% of average quality	% of poor quality
Fishing ground	87.44 ± 4.58	8.75 ± 2.52	3.79 ± 2.29
Landing site	67.45 ± 2.42	26..69 ± 4.90	5.85 ± 2.66
Market site	53.77 ± 5.27	40.03 ± 3.94	9.52 ± 4.90

Loss due to filleting process

Due to the traditional filleting process method in the study area, a considerable portion of Nile tilapia, about 59.61% was discarded, with 53.20% (excluding the gut content) considered valuable and advantageous if further processed for both human and animal consumption. One-fifth (20.74%) of valuable resources were also discarded due to the catfish filleting process (Table 8). Notably, the paired t-test reveals a significant difference in weight between the initial weight of the whole fish and the final weight of the fillet after the filleting process (p < 0.05). Yalew (2012) had previously highlighted the wastage of valuable resources resulting from the filleting practice, indicating that no improvements have been made in enhancing the filleting method or utilizing the offal. Furthermore, a similar drawback of the filleting process was reported at Lake Hayq and Tekeze Dam by Assefa et al. (2018).

Loss reduction strategies implemented by fishers

Reducing post-harvest losses requires the wise use of resources through different management strategies. In the case of Lake

Fig. 4. Poor quality raw fish with cloudy eyes, foul odor, discolored appearance, soft and mushy texture and excessive sliminess at Mitsirhaba landing site during sensory evaluation.

Fig. 5. Traditional open sun-drying process practiced by fishers.

Fig. 6. Poorly dried fish product that are simply discarded with no market values.

Table 7. The annual estimate of financial loss due to physical discard and poor quality of dried fish products

Variables	Estimated values
Mean production/year/fisher (kg)	148.63 ± 54.74
Mean weight of physical loss (kg)	9.59 ± 5.13
Mean weight of poor quality (kg)	12.68 ± 4.29
Price of poor-quality fish (ETB)	50
Price of good quality fish (ETB)	90
Financial loss due to physical and quality	1,178.5 ($23.57)
% losses	11.32%

Table 8. Measurement results of the load track before and after the filleting process

Species	Initial weight (kg)	Weight of fillet (kg)	Weight of discards (kg)	
		Useful	Useful	Non useful
Nile tilapia	10.30 ± 0.15	3.61 ± 0.35	5.48 ± 0.41	0.66 ± 0.16
Catfish	10.41 ± 0.36	4.63 ± 0.43	2.16 ± 0.22	3.06 ± 0.24

Tana, fishers employed sacks and nets to cover their catch (52.7%) and soak the fish in the water (47.3%) during transportation to protect it from direct sunlight as a means of post-harvest loss reduction strategy, which is in line with Mavuru et al. (2022). In addition, the good market connectivity enabled fishers to reach nearby landing sites and sell their catch either at the landing site or, in some cases, directly at the fishing ground. According to Yalew (2012), much of the production (90%) is marketed in Addis Ababa through coordinated marketing channels. Furthermore, salting and drying were additional strategies employed by fishers to address poor quality and unsold fish. In most cases, the poor-quality fish were gutted and dried with traditional means. In the worst case, the fishers threw highly spoiled fish at the fishing grounds and landing sites. This is in line with Asmare et al. (2015), Deng (2020), and Tut et al. (2019) report, where the traditional preservation methods employed by most fishers in Ethiopia are salting and smoke drying.

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Conclusion and recommendation

Fish postharvest losses are a major problem, impacting food security, economic viability, and environmental sustainability. Despite the challenges, collective action of stakeholders through infrastructure improvement, strengthening market connectivity, and exploring value-added processing could address losses in the fisheries sector. The findings of this study indicated that physical post-harvest fish losses in Lake Tana at fishers' level were lower than those of other water bodies in Ethiopia. This could be a good trend for ensuring food security, less financial loss, and sustainable resource use. However, attention still needs to be given to the traditional handling, processing, and storage methods employed in the Lake Tana fishery. Specifically for fishers, avoiding delays in net hauling, proper/hygienic handling of the fish during transportation, processing, drying, and storing is highly recommended. It is also important for fishers to implement a system of quality grading for fish products where fish of better quality can be distinguished and given a higher price, which will serve as an incentive for fishers to produce quality products. Loss reduction strategies used by fishers in the study area were traditional, and further strategies of practicing value added processing like smoking and solar tent drying for producing high-quality dried fish products should be implemented. One positive practice observed in the study area was the salting and drying of poor-quality fish rather than selling them at reduced price or discarding. Therefore, using solar tent dryers made from locally available materials is crucial for enhancing overall quality and creating local demand. Post-harvest assessment is time-consuming and expensive, and addressing all issues is not possible in this study. To address other post-harvest loss issues like its association with environmental, economic and social conditions, establishing long-term monitoring systems and collecting data from multiple fishery actors is recommended for future research. This might allow fishers to make effective fish loss reduction measures.

Competing interests

No potential conflict of interest relevant to this article was reported.

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Availability of data and materials

Upon reasonable request, the datasets of this study can be available from the corresponding author.

Ethics approval and consent to participate

We have used fish caught by fishers for sensory evaluation, and we certify that this study followed all the applicable guidelines for the care and use of fish.

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