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Fish loss and waste across value chains in low- and lower middle-income countries: a review

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Abstract

Estimation and reduction of fish loss and waste (FLW) is essential for improving the contribution of fisheries and aquaculture to the achievement of national development objectives related to food security, income, employment, livelihoods and trade. Despite various FLW estimation and evaluation of interventions for loss reduction, a lack of consolidated data to support evidence-based investments and policy choices at national level still exist. The study aimed to evaluate FLW in low- and lower middle-income countries, identify gaps in assessment and examine causes and mitigation measures. A systematic review was performed using predefined criteria, and extracted quantitative data from eligible studies were used to calculate the average fish weight loss and the corresponding financial losses. The literature search was conducted without date restrictions. After applying the inclusion criteria and removing duplicates, 48 articles published between 1996–2024 were retained from an initial 247 for detailed analysis. Results indicate variation in estimated fish weight losses across various value chain stages. While small-scale FLW studies are more prevalent in Africa than in Asia or Latin America, data remains limited especially for distribution, marketing and consumption stages. In Africa, the greatest fish losses occur during processing (15%) and marketing (14.5%), while Asia fish loss is most pronounced during capture and distribution stages (12.6% and 10%, respectively). In Latin America, processing accounts for the largest share of losses (13%). Fish waste at the consumption stage is minimal (1.5%). Research focuses on small pelagic fish species, with most studies estimating physical losses. Assessment of quality, nutritional and financial losses are limited, and few studies incorporate gender disaggregated and responsive data. A multidimensional intervention approach is recommended to sustainably reduce losses, thereby ensuring food and nutrition security, while contributing to economic development.

1. Introduction

Fisheries and aquaculture constitute an important economic sector of the global food system, providing employment, livelihoods, trade opportunities and food and nutrition security to multitudes, particularly in low-income countries (FAO 2020). Global fish production comprises two main sectors namely capture fisheries, which harvest wild fish from natural waters, and aquaculture, the controlled farming of aquatic organisms. Nutritionally, fish are rich in high quality protein, as well as micronutrients such as vitamins, minerals and omega-3 fatty acids that are vital for human development and cognitive health (Béné *et al* 2015, Golden *et al* 2016). Over 3.3 billion people worldwide rely on aquatic foods as a key source of animal protein and essential micronutrients (FAO 2024). Globally, fish contributes around 17% of animal protein intake, with per capita consumption exceeding 20 kg annually (Golden *et al* 2016). Furthermore, fisheries and aquaculture support the livelihoods of about 600 million people worldwide, highlighting the sector's economic significance (FAO 2020, 2024).

As a cornerstone of employment in many low- and lower middle-income countries, the sector plays a critical role in sustaining both household economies and national economic development (FAO 2024). The primary and secondary industries of fisheries and aquaculture employ about 200 million people globally, most of whom work in low-income nations. Interestingly, women constitute a significant portion of the workforce in fisheries and aquaculture, accounting for 50% of the workers mostly in processing activities (Costello *et al* 2020). This highlights the integral role of women in fisheries and potential avenues for furthering their empowerment (WorldFish 2020, FAO 2022).

The economies of low and lower middle-income countries greatly benefit from fishing and aquaculture with Asia and Latin America dominating production in both capture fisheries and aquaculture. In 2020 alone, aquatic food production was estimated to be worth USD 424 billion with 44% global catch contribution from small-scale fisheries (Costello *et al* 2020). Small-scale fisheries are crucial for sustaining rural communities and promoting food security, as the majority of small-scale fishers live in low- and lower middle-income nations (FAO 2024).

In response to the growing demand, global fisheries and aquaculture have grown tremendously, with estimates indicating that they will reach over 200 million tons by 2030 (Golden *et al* 2016). The trade value of fisheries has increased by an astounding 200% since international trade rules were established in 1995. Sustainable fisheries and aquaculture industries will be essential to maintaining environmental sustainability and food security in the face of a growing global population that is predicted to reach 9.8 billion people by 2050.

Fish loss and waste (FLW) occurs in most, if not all, supply chains. Reducing this loss and waste has become increasingly more important as demand for fish as food increases (Wibowo *et al* 2017, Kruijssen *et al* 2020), and concerns over climate change rise (Tigchelaar *et al* 2021). Minimising FLW is critical for global food security, livelihood improvement, and sustainable economic growth. It improves nutritional outcomes, trade efficiency, and the sustainable use of aquatic resources, thereby advancing multiple sustainable development goals (SDGs). As highlighted by Erokhin *et al* (2021), enhancing trade and cooperation in fish and seafood sectors across regions like the Regional Comprehensive Economic Partnership provides a strategic pathway for realising these sustainability targets.

Despite the critical role of small-scale fisheries and aquaculture, fish are a highly perishable food item, so significant portions of fish are lost or wasted along the value chain from harvest through processing, storage, transport and consumption. This loss not only diminishes the availability and economic value of nutritious aquatic foods but also has far-reaching implications for the millions who depend on fisheries and aquaculture for their livelihoods and income, particularly in low and lower middle-income countries in Africa, Asia and Latin America. In addition to this, food loss contributes to global warming as food thrown into landfills is converted into greenhouse gas emissions (Levis and Barlaz 2011).

FLW is a major global issue, with substantial regional variations. There are mainly four categories of fish loss that occur at all stages of the value chain namely, physical, quality, nutritional, and market force loss. Despite criticisms of measurement methodologies (Delgado *et al* 2003), these categories remain widely used and relevant (Cheke and Ward 1998, Ward and Jeffries 2000, Kumolu-Joh and Ndimele 2011). These four categories lead to financial losses. Physical loss refers to the reduction of fish mass in the value chain caused by spoilage, consumption by insects and animals or discard of bycatch, measured by weight or monetary value. Distinguishing between physical loss from poor postharvest handling and normal moisture loss can be challenging (Affognon *et al* 2015). On the other hand, quality loss denotes the decrease in fish value resulting from spoilage or degradation, often quantified as the monetary difference between fish at optimal quality and after deterioration (Kruijssen *et al* 2020). Improper handling affects fish quality and increase the risk of contamination, making food safety concerns more likely. Nutritional loss involves reduction of nutrients such as proteins, lipids, vitamins and minerals in fish due to spoilage or processing methods e.g. cooking, smoking or removing nutrient-rich parts (e.g. head, bones, viscera). Nutritional loss overlaps with quality loss, particularly when meeting industry standards. Market force loss refers to the reduction in fish value due to market conditions or poor management, despite unchanged product quality. Typically market force loss occurs due to oversupply and is measured in monetary terms. Financial losses are caused by physical, quality and market force losses (Affognon *et al* 2015, Kruijssen *et al* 2020).

In Africa, approximately 32% of fish production is lost, primarily during postharvest stages due to inadequate handling infrastructure and poor handling (FAO 2017). Asia incur even higher losses at around 36%, spread across the entire value chain, attributed to inefficient fishing, quality control issues, and consumer waste (Wibowo et al 2017). Latin America experiences about 30% FLW, concentrated in post-harvest and processing, mirroring the infrastructure and handling challenges seen in Africa and Asia (Cederberg and Sonesson 2011).

Several methods are employed to assess fish losses across regions. In Africa and Asia, the Informal Fish Loss Assessment Method (IFLAM) is widely used to estimate physical and quality losses at landing and marketing stages (Akande and Diei-Ouadi 2010). Load tracking (LT) methods monitor volume changes throughout the entire value chain (Torell et al 2020), while questionnaire loss assessment methods (QLAM) are used to collect both qualitative and quantitative data, especially in small-scale fisheries (Bawa et al 2024).

Accurate measurement of FLW in Africa, Asia, and Latin America is vital for sustainable fisheries and food security. The current study focused on these 3 continents due to their high dependency on under resourced small-scale fisheries that experience significant post-harvest losses.

Significant gaps persist in understanding the extent, assessment approaches, drivers, and reduction strategies for FLW value chain stages and regions. Targeting these gaps enables more effective interventions.

Most studies focus on a single stage of the fish value chain or a limited area, limiting their broader applicability (Akande and Diei-Ouadi 2010, Noswad 2010, Wibowo et al 2017). Moreover, gender-related aspects of fish loss remain underexplored, especially the roles women play in processing and marketing. Although gender has been considered in some fisheries research, further studies are needed to design interventions that address fish losses while promoting gender equity (FAO 2020).

This study, based on a systematic literature review aimed to assess FLW in low- and lower middle-income countries, identify assessment gaps, analyse causes and mitigation strategies and highlight implications for future fish postharvest research. The findings may inform the formulation of data driven interventions for reducing FLW significantly contributing towards the achievement of SDG 1, 2 and 12 aiming to eliminate poverty, hunger and ensure responsible consumption and production.

2. Methodology

2.1. Study design

The study focused on low- and lower middle-income countries according to World Bank income groups, mainly targeting Africa, Asia and Latin America small-scale fisheries (World Bank 2024). A literature search was conducted to identify published research in low- and lower middle-income countries focusing on objectives of this review. This review explored mainly published articles (peer-reviewed journals and book chapters) and grey literature (institutional websites, technical papers and project reports).

Grey literature was included due to the applied and multidisciplinary nature of FLW research. Some of the evidence in this field is produced by international development organisations, fisheries institutions, and government agencies rather than in academic journals. Including grey literature helped to (1) capture unpublished or context-specific data not available in peer-reviewed outlets; (2) reduce publication bias, as practical or null findings are often documented only in project reports and (3) reflect policy, industry, and regional perspectives, especially in low- and lower middle-income countries contexts where primary data collection is limited.

To ensure reliability, grey literature was critically evaluated using a modified AACODS checklist, assessing Authority (recognized institutional sources such as FAO, WorldFish, UNEP, IFAD, and national fisheries departments), Accuracy (clearly described and referenced data and methods), Coverage (focus on post-harvest FLW), Objectivity (balanced interpretation without promotional or political bias), Date (no restriction applied), and Significance (contribution to understanding the magnitude, causes, or mitigation of FLW).

The review featured studies that reported on FLW in low- and lower middle-income countries (Africa, Asia and Latin America). The design of the review was carried out according to the 2018 Preferred Reporting Items for Systematic Review and Meta-Analysis Extension for Scoping Reviews (PRISMA-ScR) checklist which clarifies the purpose and comprehensiveness of the scoping process (Tricco et al 2018).

2.2. Literature search strategy

Original articles written in English and relevant to the review were obtained through online searches in the following databases: *Science Direct, PubMed, Web of Science, Google Scholar, Scopus and Google*. The following key words and their combinations were used for the searches:

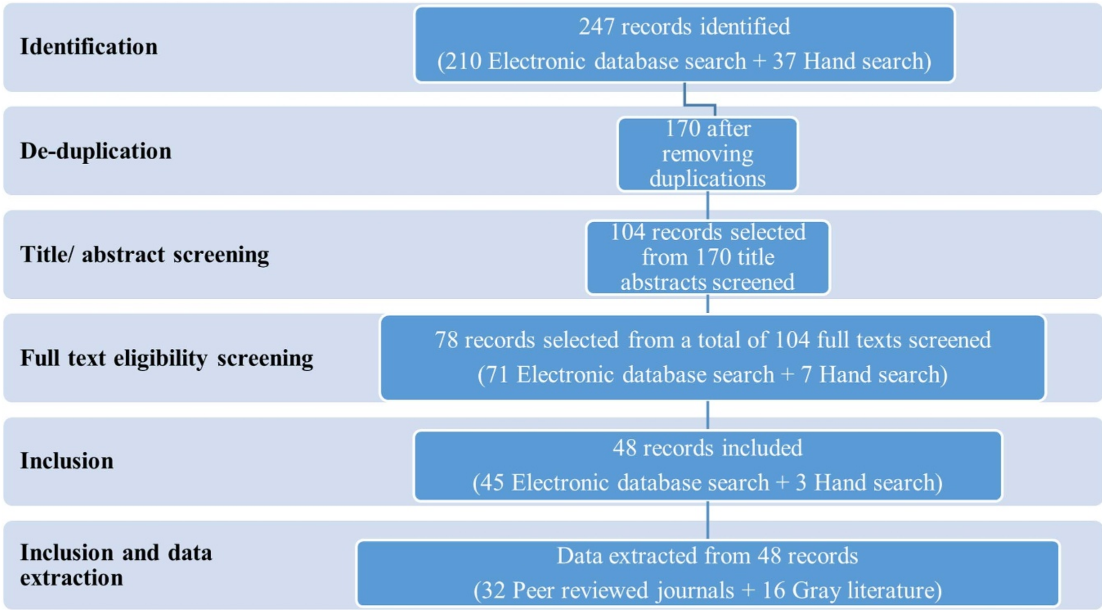

Figure 1. Flowchart of the literature selection process.

('*Scale and drivers of FLW*' AND '*Factors influencing/Determinants FLW patterns*' AND ('*Africa, Asia, and Latin America*') AND ('*Value chain** AND *Causes** AND *Regions/Location** AND *Scale of operation** AND *Economic implications** AND *Impact** AND *Interventions**')

The literature search had no date restrictions, to cover a wider period.

2.3. Data extraction

The data from selected articles were independently screened by two independent reviewers. Any discrepancies between reviewers were resolved through discussion, and when necessary, by consulting a third reviewer. During the search, the title and abstract of the retrieved papers were read to determine if the paper was relevant for the study or not. Relevant papers included data on FLW, its causes and mitigation strategies across Africa, Asia, and Latin America. After confirming the paper's relevance, the full text was analysed to extract key information. References included in the selected articles were also screened to identify studies that had not appeared in the search. The information extracted after reading the full paper in a peer-reviewed journal included the study year, study area or location, fish species, estimation of loss (key research findings and conclusions), method used, significant drivers, gender responsiveness, intervention and research gaps. The original research papers were included as well as literature review papers. Methodology in selecting the papers for the study is shown in figure 1. A total of 48 papers were used for the study.

2.4. Calculation of financial losses from physical losses

Data on physical fish weight loss percentage at each value chain stage from fishing and landing stage to consumption in Africa, Asia and Latin America was extracted from various sources included from the literature selection (tables 2(a)–(i)) and tabulated. The average fish weight loss percentage at each value chain was calculated as given in equation (1). The calculated averages are given in table 3. The average market price of fish for each continent was found in literature, Africa ($2.33 per kg), Asia ($1.88 per kg) and Latin America ($2.23 per kg) (Cederberg and Sonesson 2011, FAO 2024). The commonly harvested fish species where loss estimation was done, namely small pelagic, Nile perch, tilapia, sardines and mackerel were considered in determining the estimate average fish price. The financial loss was calculated using the mean fish loss ratio to the total capture fish landing (table 1) in each continent multiplied by the average market price per kg as shown in equation (2) (Adelaja *et al* 2018, Assefa *et al* 2018, Torell *et al* 2020). Our work was focused on capture fisheries which include marine and inland fisheries. Aquaculture was excluded from financial loss calculations to maintain focus on capture fisheries, where losses arise from natural harvest and postharvest conditions. Including aquaculture, with its controlled production and loss management systems, would introduce unrelated variability. This exclusion ensures

Table 1. Estimated production statistics of seafood in low- and lower middle-income countries in 2022.

Region	Year	Capture fisheries—Marine and Inland (Tons)	Aquaculture (Tons)	Total production (Tons)	Reference
Africa	2022	10.6 mil	1.9 mil	12.5 mil	(FAO 2022, 2024)
Asia	2022	70 mil	85.0 mil	155.0 mil	
Latin America	2022	9.8 mil	7.5 mil	17.9 mil	
TOTAL		90.4 mil	94.4 mil	185.4 mil	

consistent data interpretation and a clear assessment of economic losses specific to capture fisheries.

$$\text{Average fish weight loss} = \frac{\text{Sum of } \% \text{ fish loss at VC stage per each continent}}{\text{Number of values}} \tag{1}$$

$$\text{Financial loss} = (\text{Average loss proportion} \times \text{total fish capture}) \times \text{Average fish market price}\,. \tag{2}$$

The study focused on physical losses because it provides a practical and measurable approach to improving fish availability and fisher livelihoods. In contrast, nutritional and quality losses, though important, are less apparent and require advanced analytical capacity that is often lacking in these contexts. Thus, prioritizing physical loss reduction offers a feasible and impactful strategy that indirectly supports nutritional and quality improvements.

Discrepancies in physical loss estimates across studies were reconciled by ensuring methodological consistency, aligning definitions of loss and adjusting unit measures where necessary to enable comparability. Where studies used different criteria (e.g. loss by weight or volume), data were converted to a common basis typically percentage weight loss relative to the initial quantity.

2.5. Statistical analysis

Means and standard deviations of FLW at each value chain stage, grouped by continent, were calculated using Microsoft Excel (version 21) and summarised in a table.

3. Results

3.1. Profile of FLW studies

A notable number of the studies on FLW (48%) were published in the period 2021–2024, compared to less than 13% from 1996–2015, which indicates a growing interest in FLW research and development or simply improvement of the dissemination of fish loss results in the last decade (figure 2(a)). Most of the articles targeted processing and storage (33%), followed by capture and landing (25%) and trading and retail (20%), whereas little attention was given to other stages (figure 2(b)). Research on FLW estimation at the consumption stage is limited in low- and lower middle-income countries, with only 2% of the reviewed studies focusing on this phase. (figure 2(b)). A substantial portion of the studies (13%) assessed losses across the entire value chain rather than focusing on specific stages (figure 2(b)).

Approximately more than half of the articles (67%) reported on scales of FLW, methodologies for the loss assessment and causes of losses, while 33% of the studies reported on causes of loss only without quantifying the losses. The most dominant method of loss assessment was IFLAM, QLAM and LT combined (37%) followed by LT (23%). Field observations were employed in 17% of the studies, whereas simulation experiments were utilised in only a small fraction (3%) (figure 3).

Small pelagic fish (*Dagaa*) were the most frequently studied species, accounting for 25% of the studies, followed by Nile perch and tilapia, each representing 8% (figure 4). A significant proportion of the articles (23%) examined multi-species groups, each consisting of four or more different types (figure 4). Species such as catfish, mini trawl, shrimp, sprat, squid and lobster have not been thoroughly investigated in terms of the extent and causes of postharvest losses (figure 4).

Most studies focused on estimating physical losses, whereas only 31% assessed financial losses, and fewer than 5% addressed nutritional losses. Additionally, market force-related losses were estimated in just 10% of the articles.

Across all stages of the value chain, Africa has the highest number of published articles on FLW (over 60%), followed by Asia, with Latin America having the fewest (figure 5).

Table 2a. Production/Fishing losses of fish per country, method used, gender disaggregation, loss cause and species.

Value chain stage	Estimation loss (Weighted average) Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/causes of loss	References
Production	0–7.5	—	1.5–18.9 volume	3–5	—	Physical loss measurement and IFLAM	Silver cyprinid	Kenya (Africa)	Limited data on women's roles in production activities	Poor handling, theft, and lack of cooling infrastructure	(Akande and Diei-Ouadi 2010)
	1–5	—	0.3 volume	—	—	idem	Jarife (gillnet fisheries)	Kenya (Africa)	—	—	(Akande and Diei-Ouadi 2010)
	16–20	—	—	—	—	idem	Watsa (purse seine) fisheries	Ghana	—	—	(Akande and Diei-Ouadi 2010)
	1.50	USD 266 000/year	5–10	3–5	—	Physical and economic surveys (IFLAM)	Nile perch	Lake Victoria Tanzania	—	Inefficient catch handling and theft Selling fish for a reduced price to fish salters, mainly because it was of a quality that was unacceptable to fresh fish buyers and traders	(Ward 1996)
	2.30	24, 000 USD/yr	—	—	—	idem	Multi-species fisheries	Mafia Island, Tanzania	—	—	(Ward 1996)
	2.03	—	—	—	—	Questionnaire Loss Assessment Method (QLAM)	Multi-species fisheries	Barotse Floodplain, Zambia	Men dominate fishing, limited women's involvement	Spoilage due to long distances and lack of infrastructure	(Kefi *et al* 2017)

(Continued.)

Table 2a. (Continued.)

7.57	—	—	—	—	Load tracking	Shrimp	Ondo State, Nigeria	Small-scale fishing is dominated by males	Lengthy duration of fishing cycle, poor handling practices, lack of covering facilities, failure to use ice, lack of storage facilities and lack of good means of transportation	(Adelaja *et al* 2018)
7.76	—	—	—	—	idem	Catfish	Ondo State, Nigeria	—	—	(Adelaja *et al* 2018)
8.15	—	—	—	—	idem	Croaker	Ondo State, Nigeria	—	—	(Adelaja *et al* 2018)
16.67 (theft)	—	0.1 volume	—	—	IFLAM, QLAM	Gillnet fishery	Gunung Kidul, Indonesia	—	Bycatch, which has a potential environmental and biodiversity impact.	(Wibowo *et al* 2017)
—	—	0.2 volume	—	1–2 value	idem	Mini trawl	Gunung Kidul, Indonesia	—	—	(Wibowo *et al* 2017)
—	—	0.3 value	—	—	idem	Small pelagics	Tegal, Indonesia	—	—	(Wibowo *et al* 2017)
—	—	<0.1 volume	—	—	idem	Squid	Muara Angke, Indonesia	—	—	(Wibowo *et al* 2017)
4	—	18	—	—	Mixed method approach. EFLAM and QLAM	Multi species	Zambia	Greater proportion of women than men experienced physical losses	Inadequate technologies and mishandling	(Kaminski and Cole 2017)
22	1.4 M USD/yr	—	—	—	Surveys	Mud crab	Madagascar	—	—	(Kasprzyk *et al* 2015)

(Continued.)

Table 2a. (Continued.)

Value chain stage	Estimation loss (Weighted average): Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/causes of loss	References
Rod and Line Fishery	0 (Primary data); 1.5 (QLAM)	USD693	0.31	—	—	Questionnaire Loss Assessment (QLAM)	Oreochromis niloticus, mixed cichlids	Zimbabwe (Lake Kariba)	Dominated by females (42 years average age)	High temperatures, direct sunlight, predation by crocodiles, negligence, poor handling	(Mavuru *et al* 2022)
Gill-Net Fishery	1.9 (Primary data); 1.8 (QLAM)	USD355.20	96	—	—	Load Tracking (LT), QLAM	Oreochromis niloticus, mixed cichlids	Zimbabwe (Lake Kariba)	Male-dominated, (33 years average age)	Theft, state seizures, crocodile predation, high water temperatures, late net hauling	(Mavuru *et al* 2022)
Fishing/Beach	4.1	USD49.7 million nationwide	43	—	—	Load Tracking (LT), IFLAM	*Usipa* (Engraulicypris sardella), *Matemba* (Barbus spp.), Chambo (Oreochromis spp.)	Malawi (Lakes Malawi, Malombe, Chiuta, Chilwa)	—	High ambient temperatures, lack of ice on boats, contamination from boat environment	(Torell *et al* 2020)

(Continued.)

Table 2a. (Continued.)

Fishing	6	—	—	—	—	Observations	Sprat (Stolothrissa tanganicae), Sardine (Limnothrissa miodon), Perch (Lates stappersii)	Lake Tanganyika (Tanzania)	Primarily male-dominated, minimal female participation	Poor onboard handling, high ambient temperatures, lack of ice during fishing	(Sendall *et al* 2022)
Fishing	6	—	—	—	—	Macro approach	Fish and seaweed	Sub Saharan Africa	—	—	(Cederberg and Sonesson 2011)
	5	—	—	—	—	idem	Fish and seaweed	Latin America	—	—	(Cederberg and Sonesson 2011)
	9	—	—	—	—	idem	Fish and seaweed	South and Southeast Asia	—	—	(Cederberg and Sonesson 2011)
	6	—	—	—	—	Idem	Fish and seaweed	North Africa	—	Significant due to discard rates of between 6–8% of marine catches	(Cederberg and Sonesson 2011)
	8	—	—	—	—	Macro approach	Marine fish	World*	—	—	(Kelleher 2005)

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss. * Not included in the calculations of the weighted average loss.

Table 2b. Landing losses of fish per country, method used, gender disaggregation, loss cause and species.

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
Landing	Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)						
	2–6	10–50	8–12	5–7	—	Physical and financial loss surveys (QLAM)	Katsuwonan Pelamis	Sri Lanka (Asia)	Minimal gender representation in decision-making	Lack of immediate processing facilities	(Daluwatte and Sivakumar 2018)
	8–18	13-45	—	—	—	Physical and financial loss surveys (QLAM)	Decapterus russeli	Sri Lanka (Asia)	—	—	(Daluwatte and Sivakumar 2018)
	13–23	39-51	—	—	—	Physical and financial loss surveys (QLAM)	Auxis Thazard	Sri Lanka (Asia)	—	—	(Daluwatte and Sivakumar 2018)
	7.60	4 M USD/yr	10–15	5–8	—	Economic loss assessment (QLAM)	Kainji Lake fishery: tilapia, nile perch, moon fish	Nigeria (Africa)	No gender specific data	Delayed transport and lack of ice availability	(Eyo and Mdaihli 2005)
	Some form of loss: 29.3% of the consignment, Totally discarded: 6% of the consignment	—	—	—	—	Mixed method approach. EFLAM and QLAM	Multi-species fisheries	Barotse Floodplain, Zambia	—	—	(Kaminski and Cole 2017)
Post-catch	5	—	—	—	—	Macro approach	Fish and seaweed	Sub Saharan Africa	—	—	(Cederberg and Sonesson 2011)
	4	—	—	—	—	idem	Fish and seaweed	North Africa	—	—	(Cederberg and Sonesson 2011)
	5	—	—	—	—	idem	Fish and seaweed	Latin America	—	—	(Cederberg and Sonesson 2011)
	3	—	—	—	—	idem	Fish and seaweed	South and Southeast Asia	—	—	(Cederberg and Sonesson 2011)

(Continued.)

Table 2b. (Continued.)

Landing to wholesale After landing	5	6.4 M USD/yr	—	—	—	Load tracking	Silver cyprinid	Tanzania	—	—	(Mgawe 2008)
	0.1615	—	—	—	—	Questionnaire and personal communications	Multi-species fisheries	Port Sudan, Sudan	—	—	(Hamza *et al* 2017)
	1.04 kg day^{-1}	500 USD /yr	—	—	—	IFLAM, QLAM, Load tracking Monetary loss was estimated from quantity of losses multiplied by price of fish	Multi-species fisheries (including Bagrus documak, catfish, labeobarbus, tilapia)	Lake Hayd, Amhara region Ethiopia	No gender specific data	Long hours of setting gear before hauling Season—rainy season Distance from fishing ground	(Assefa *et al* 2018)
	15.55 ton year^{-1}	—	—	—	—	idem	Multi-species fisheries	Lake Tekere, Amhara region, Ethiopia	No gender specific data	—	(Assefa *et al* 2018)
	6.08 kg day^{-1}	3672 USD/yr	—	—	—	idem	Multi-species fisheries (including Bagrus documak, catfish, labeobarbus, tilapia)	Lake Tekere, Amhara region, Ethiopia	No gender specific data	—	(Assefa *et al* 2018)
	7.92 ton year^{-1}	—	—	—	—	idem	Multi-species fisheries	Lake Hayd, Amhara region, Ethiopia	No gender specific data	—	(Assefa *et al* 2018)

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss.

Table 2c. Processing losses of fish per country, method used, gender disaggregation, loss cause and species.

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)						
Processing	1.8 (IFLAM), 4.73 (load tracking)	—	15–20	10–12	—	Physical loss evaluation (Load Tracking)	Small pelagics	Tegal, Indonesia	No gender-specific data	Inadequate smoking and drying facilities Poor quality raw material for processing, with substandard quality product identified only after thawing in the case of frozen products, forms the bulk of the quality losses Poor hygiene practices and facilities Prolonged soaking time, i.e. 12 h Prolonged and poor on-board handling and storage	(Wibowo *et al* 2017)

(Continued.)

Table 2c. (Continued.)

2.7	1300 USD/yr	12–15	8–10	—	Quality and weight loss assessment (QLAM) Formal recall questionnaire survey designed and used to generate quantitative data Informal one based on the tools and techniques of Participatory and Rapid Appraisal	Multi-species fisheries	Mafia Island, Tanzania	No clear data on women's roles	Spoilage due to inadequate facilities	(Ward 1996)
3.8	75 000 USD/yr	—	—	—	Quality and weight loss assessment (QLAM)	Silver cyprinids	Lake Victoria	No clear data on women's roles	—	(Ward 1996)
Frying: 7.1	98 000 USD/yr	—	—	—	idem	Nile perch	Lake Victoria	—	Bird predation, theft, spoilage and colour change Seasonal variations -Losses of *Dagaa* are especially high during the rainy seasons	(Ward 1996)
Scorching: 6.5	—	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996)
Smoking: 2.5	—	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996)
Salting: 2.2	—	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996)

(Continued.)

Table 2c. (Continued.)

Value chain stage	Estimation loss (Weighted average) Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	3.1	—	—	—	—	idem	Nile perch	Mafia Island Tanzania	—	—	(Ward 1996)
	7.4	—	—	—	—	Questionnaire Loss Assessment Method (QLAM)	Multi-species fisheries	Barotse Floodplain, Zambia	Women face three times higher losses compared to men	Inadequate processing techniques (smoking, drying); pest infestation	(Kefi *et al* 2017)
	10	—	25	—	—	Mixed method approach. EFLAM and QLAM	Multi-species mostly Tilapiine Cichlids, Mormyridae, and Claridae	Barotse Floodplain, Zambia	Participation in the fishery value chain is gendered Female processors lost three times the mass of their fish consignments compared to male processors	Technical constraints (lack of processing technologies) and social constraints (norms and beliefs) create gender gaps in postharvest losses	(Kaminski *et al* 2020)
	Breakage: 61.5 of the consignment	—	—	—	—	idem	Multi-species fisheries	Barotse Floodplain, Zambia	—	—	(Kaminski and Cole 2017)
	Over-processing: 23.1 of the consignment	—	—	—	—	idem	Multi-species fisheries	Barotse Floodplain, Zambia	—	—	(Kaminski and Cole 2017, Kaminski *et al* 2020)
	42.9	—	—	—	—	idem	Multi-species fisheries	Barotse Floodplain, Zambia	—	—	(Kaminski and Cole 2017)
	10.8	—	—	—	—	Idem	Multi-species fisheries	Barotse Floodplain, Zambia	—	—	(Kaminski and Cole 2017)

(Continued.)

Table 2c. (Continued.)

10	—	—	—	—	Structured and semi-structured questionnaires	Multi-species fisheries	Siavonga district, Zambia	—	Lack of cold storage facilities and fluctuating weather conditions	(Maulu *et al* 2020)
21.55	—	—	—	—	Load tracking	Mixed (molluscs and small pelagics)	Zanzibar Tanzania	Women involved in processing but underrepresented in managerial roles	Lack of cold chain infrastructure; poor smoking and drying facilities	(Akande and Diei-Ouadi 2010, FAO 2020, World Economic Forum 2024)
25–30	—	—	—	—	Load tracking	Small pelagics, Mollusks	Mbour region, Senegal	Women heavily involved in processing but face resource constraints	Poor smoking techniques and beetle infestations	(Diei-Ouadi and Mgawe 2011)
20–25	—	—	—	—	Field observations	Mollusks, small pelagics	Dorobaga and Maiduguri Fish Markets, Nigeria	Women dominate processing but lack access to resources	Lack of cold chains, improper drying facilities	(Diei-Ouadi and Mgawe 2011)
15–20	—	—	—	—	Surveys	Small pelagics	Albert Bosomtwi-Sam fishing harbour, Western Region, Ghana	No mention	Inadequate drying and pest infestations	(Gyan *et al* 2020)

(Continued.)

Table 2c. (Continued.)

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)						
	20–30	—	25-30	—	—	Surveys	Smoked and sun-dried fish	Nigeria (Kebbi State)	Women dominate processing, lack access to modern facilities	Poor smoking and drying techniques, pest infestations	(Bawa *et al* 2024)
	0.8	Economic gain of $12 million. Poor-quality fish are processed for resale, despite quality losses (54%)	54	—	—	QLAM, IFLAM	Small fish *(Usipa, Matemba, Chambo)*	Malawi (Lakes Malawi, Malombe, Chiuta, Chilwa)	—	Poor drying during rainy season, insect infestation, over-drying or over-smoking Pricing not sensitive to quality	(Torell *et al* 2020)
	10	Not estimated	Moderate	—	—	Field observations	Sprat, Sardine, Perch	Lake Tanganyika (Tanzania)	Limited involvement of women in decision-making roles	Lack of refrigerated storage, suboptimal packaging solutions	(Sendall *et al* 2022)
	Solar Tent: 0.7 Raised Racks: 15.6 Bare Sand: 25.6	—	High (bare sand and raised racks)	—	—	Load Tracking (LT) Simple random sampling of *Dagga* from boats, key informant interviews and desk review of secondary data.	Small fish (*Dagaa)*	Mwanza, Tanzania	Female-dominated, limited access to modern technology	Poor drying practices, pest infestation, contamination by sand and dust Consumption by birds and dogs during drying process For sand dried *Dagaa*, attributed to leftovers during collection after drying	(Mhanga and Mwandya 2022)

(Continued.)

Table 2c. (Continued.)

	8	—	—	—	—	Macro approach	Fish and seaweed	Sub Saharan Africa	—	Financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions	(Cederberg and Sonesson 2011)
	9	—	—	—	—	idem	Fish and seaweed	Latin America	—	—	(Cederberg and Sonesson 2011)
	6	—	—	—	—	idem	Fish and seaweed	South and Southeast Asia	—	—	(Cederberg and Sonesson 2011)
	9	—	—	—	—	idem	Fish and seaweed	North Africa	—	—	(Cederberg and Sonesson 2011)
Processing and transport	3.9-10	—	—	—	—	Economic loss assessment (QLAM)	Processed fish	Nigeria	—	—	(Eyo and Mdaihli 2005)

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss. * Not included in the calculations of the weighted average loss.

Table 2d. Storage losses of fish per country, method used, gender disaggregation, loss cause and species.

	Estimation loss (Weighted average)										
Value chain stage	Physical loss (%)	Value loss (USD or %)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
Storage	15–25	—	18–22	—	—	Structured Questionnaire	Mixed fish species	Nigeria (Kebbi State)	Limited cold storage access for both men and women	Reliance on ambient storage conditions, lack of refrigeration facilities	(Bawa *et al* 2024)
	—	—	—	—	Protein 4.5 Iron 0.18 Fat 0.8	Simulation storage experiment for 10 weeks	Silver cyprinid (*Rastrineobola argentea*)	Uganda	No mention	Long storage duration at ambient temperature. Permeability of packaging material to oxygen and moisture.	(Namwanje *et al* 2021)

Table 2e. Transportation and distribution losses of fish per country, method used, gender disaggregation, loss cause and species.

	Estimation loss (Weighted average)										
Value chain stage	Weight loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
Transport	0	0	—	—	—	Quality and weight loss assessment (QLAM) Formal recall questionnaire survey Informal one based on the tools and techniques of Participatory and Rapid Appraisal	Multi-species fisheries	Mafia Island, Tanzania	—	—	(Ward 1996)
	0.30	USD725/yr	—	—	—	idem	Silver cyprinids	Lake Victoria	—	—	(Ward 1996)
	Fresh:1	USD9200/yr	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996)
	Salted: 0.1	—	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996)
	Smoked: 0	—	—	—	—	Idem	Nile perch	Lake Victoria	—	—	(Ward 1996)
	6.01	—	—	—	—	Physical loss evaluation (Load Tracking)	Mini trawl fishery	Tegal, Indonesia	—	—	(Wibowo *et al* 2017)

(Continued.)

Table 2e. (Continued.)

	Estimation loss (Weighted average)										
Value chain stage	Weight loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
Distribution	8	Not estimated	Moderate	Not estimated	Not estimated	Surveys, Observations	Sprat, Sardine, Perch	Lake Tanganyika (Tanzania)	Minimal representation of women in logistics and transportation	Poor road infrastructure, lack of insulated transport	(Sendall *et al* 2022)
	11	—	—	—	—	Macro approach	Fish and seaweed	Sub Saharan Africa	—	In appropriate transport and distribution facilities	(Cederberg and Sonesson 2011)
	8	—	—	—	—	idem	Fish and seaweed	North Africa	—	—	(Cederberg and Sonesson 2011)
	8	—	—	—	—	idem	Fish and seaweed	Latin America	—	—	(Cederberg and Sonesson 2011)
	10	—	—	—	—	Idem	Fish and seaweed	South and Southeast Asia	—	—	(Cederberg and Sonesson 2011)

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss.

Table 2f. Trading and marketing losses of fish per country, method used, gender disaggregation, loss cause and species.

	Estimation loss (Weighted average)										
Value chain stage	Physical loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
Trading	Minimal	—	—	—	—	Physical loss measurement and IFLAM, LT and QLAM	Tilapia	Uganda	—	—	(Akande and Diei-Ouadi, 2010)
	2.90	—	—	—	—	idem	Multi-species fisheries	Barotse Floodplain, Zambia	Women primarily involved in trading but lack market control	Poor handling during transport; over-reliance on traditional trading methods	(Kefi *et al* 2017)
	10	—	—	—	—	idem	Lobster	Gunung Kidul, Indonesia	—	—	(Wibowo *et al* 2017)
	4 (QLAM)	$119.17 (Primary buyers), $328.90 (Secondary buyers)	Drip loss: 4.2	—	—	Load Tracking (LT), QLAM	Mixed species	Zimbabwe (Lake Kariba)	Predominantly male traders	Weight loss due to drip, state seizures, lack of adequate refrigeration	(Mavuru *et al* 2022)
Marketing	Minimal	—	—	—	—	Physical loss measurement and IFLAM, LT and QLAM	Tilapia	Kenya	—	Weather, in terms of sun drying of fish and access to markets, especially during the rainy season because of the poor conditions of roads. Mishandling during auctioning. Intentional delay by customers until seller is desperate to lower prices.	(Akande and Diei-Ouadi, 2010)

(Continued.)

Table 2f. (Continued.)

	Estimation loss (Weighted average)										
Value chain stage	Physical loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	6.40	—	—	—	—	Economic loss assessment (QLAM)	Kainji Lake fishery: tilapia, Nile perch, moon fish e.a	Nigeria	—	Poor handling and inadequate infrastructure such to establish a cold chain.	(Eyo and Mdaihli 2005)
	3.3	USD4 million/yr nationwide	69	—	—	Load tracking	Small fish (*Usipa*, *Matemba*)	Malawi (urban and rural markets)	Mixed gender roles; women prevalent in rural markets	Breakage, discoloration, blending of poor-quality fish to offset losses. Theft.	(Torell *et al* 2020)
	10	USD25,420/yr	—	—	—	Surveys and observation	Multi-species fisheries	Tekeze Dam and Lake Hashenge, Ethiopia	Minimal women's involvement	Poor storage infrastructure, lack of refrigeration facilities, and geographic challenges	(Tesfay and Teferi 2017)
	6	—	25	—	—	Mixed method approach. EFLAM and QLAM.	Multi-species	Barotse Floodplain Fishery Zambia	Women encounter more physical losses than men	Inadequate storing and fish handling facilities	(Kaminski *et al* 2020)

Table 2g. Retail losses of fish per country, method used, gender disaggregation, loss causes and species.

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	Weight loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)						
Retail	0.1	USD450/yr	5–10	4–6	—	Micro loss tracking (QLAM)	Multi-species fisheries	Mafia Island, Tanzania	Minimal representation of women in market analysis	Price fluctuations and spoilage	(Ward 1996)
	0.8	USD9000/yr	5–10	4–6	—	Economic assessment (QLAM)	Silver cyprinid	Lake Victoria	Some women involved in small-scale retail	Market gluts and low consumer demand	(Ward 1996)
	Fresh: 1.5	USD23,000/yr	—	—	—	IFLAM	Nile perch	Lake Victoria	Minimal gender consideration	Spoilage due to expiration; inefficient stock rotation	(Ward 1996, World Economic Forum 2024)
	Smoked: 0.8	—	—	—	—	idem	Nile perch	Lake Victoria	—	—	(Ward 1996, World Economic Forum 2024)
	Salted: 0.1	—	—	—	—	Idem	Nile perch	Lake Victoria	—	—	(Ward 1996, World Economic Forum 2024)
	57.1	—	—	—	—	IFLAM, QLAM, Load tracking	Catfish	Amhara region, Ethiopia	—	—	(Assefa *et al* 2018)

(Continued.)

Table 2g. (Continued.)

Value chain stage	Estimation loss (Weighted average) Weight loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)	Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	38.5	—	—	—	—	idem	Bagrus documak	Amhara region, Ethiopia	—	—	(Assefa *et al* 2018)
	42.3	—	—	—	—	idem	Labeobarbus	Amhara region, Ethiopia	—	—	(Assefa *et al* 2018)
	71	—	—	—	—	Idem	Tilapia	Amhara region, Ethiopia	—	—	(Assefa *et al* 2018)
	12.03	—	—	—	—	Market Surveys	Mixed	Dhaka (Bangladesh)	Minimal gender consideration	Spoilage due to expiration; inefficient stock rotation	(Wibowo *et al* 2017)
Food service	4.65	—	—	—	—	Field study	Small pelagics	Mombasa (Kenya), Colombo (Sri Lanka)	—	Handling errors; overstocking during service hours	(World Economic Forum 2024)
	7	—	—	—	—	Field study	Mixed	Peru	—	Inappropriate handling	(World Economic Forum 2024)

Table 2h. Consumption losses of fish per country, method used, gender disaggregation, loss cause and species.

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/Causes of loss	References
	Physical loss (%)	Value loss (USD)	Quality (%)	Market Force (%)	Nutritional (%)						
Household consumption	8.58	—	—	—	—	Survey	Mixed	Higher-income regions Oslo (Norway), London (UK)	—	Misunderstanding of expiration labels; disposal of edible food.	(World Economic Forum 2024)
	1	—	—	—	—	Macro approach	Fish and seaweed	Sub Saharan Africa	—	Cultural habits driving waste behaviour	(Cederberg and Sonesson 2011)
	2	—	—	—	—	idem	Fish and seaweed	North Africa	—	—	(Cederberg and Sonesson 2011)
	2	—	—	—	—	idem	Fish and seaweed	Latin America	—	—	(Cederberg and Sonesson 2011)
	1	—	—	—	—	Idem	Fish and seaweed	South and Southeast Asia	—	—	(Cederberg and Sonesson 2011)

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss.

Table 2i. Entire value chain losses of fish per country, method used, gender disaggregation, loss cause and species.

Value chain stage	Estimation loss (Weighted average)					Method used	Species	Location	Gender responsiveness	Drivers/causes of loss	References
	Weight loss (%)	Value loss (USD or %)	Quality	Market Force	Nutritional						
Entire chain	Negligible	Not available	20–25	15–20	—	Load tracking and economic surveys	Squid	Muara Angke, Indonesia (Asia)	Limited gender-specific analysis	Market inefficiencies and poor infrastructure	(Diei-Ouadi *et al* 2015)
	1-3	Negligible	1–2	0.5–1	—	Volume tracking (Load Tracking)	Smoked clarias	Mali	—	Inefficient market practices	(Diei-Ouadi *et al* 2015)
	2	Not Available	25–30	20–25	—	Macro and micro approach combined (Macro-Micro Approach)	Tilapia (caught)	Togo	Insufficient gender disaggregation	Sun-drying inefficiencies, poor transport systems	(Akande and Diei-Ouadi 2010)
	2-3	—	—	—	—	idem	Fresh fish	Mali	—	Inadequate infrastructure such as ice makers and cooler boxes for cold chain establishment.	(Akande and Diei-Ouadi 2010)
	3-17	—	—	—	—	idem	Smoked fish	Ghana	—	Poor handling practices	(Akande and Diei-Ouadi 2010)
	4	—	—	—	—	idem	Multiple species	Ghana	—	—	(Akande and Diei-Ouadi 2010)
	6	—	—	—	—	idem	Tilapia (caught)	Burkina Faso	—	—	(Akande and Diei-Ouadi 2010)
	12.32	USD 6 M yr^{-1}	—	—	—	idem	Multiple-species fisheries	Barotse Floodplain, Zambia	Limited access to improved processing technology for women	Poor infrastructure and gendered labour divisions throughout the chain	(Kefi *et al* 2017)
	20-40	—	—	—	—	idem	Silver cyprinid	Tanzania	—	—	(Akande and Diei-Ouadi 2010)
	26-40	—	—	—	—	idem	Silver cyprinid	Uganda	—	—	(Akande and Diei-Ouadi 2010)

(Continued.)

Table 2i. (Continued.)

	32	—	—	—	—	Surveys	Sardinella maderensis (*Madeiran sardinella*) and *S. aurita* (Sardines)	Albert Bosomtwi-Sam fishing harbour, Western Region, Ghana	Limited access to improved processing technology for women	Poor processing techniques, gear related injuries, extended stay at the harbour and inadequate ice	(Gyan *et al* 2020)
Artisanal Fisheries	10	—	—	—	—	Surveys	Tilapia, Kapenta (*Limnothrissa miodon*)	Siavonga District, Zambia	Women minimally involved in fishing activities	Lack of cold storage facilities, long distances to markets, unfavourable weather conditions	(Maulu *et al* 2020)
	25 (total losses reported	USD 591/year per processor	—	—	—	Combined Assessment	Sprat, Sardine, Perch	Lake Tanganyika (Tanzania)	Women involved heavily in processing but limited in decision-making	Lack of cold chain, poor handling practices, and limited market access	(Sendall *et al* 2022)
	27.3	32–50	—	—	—	Literature review (secondary data)	Multi-species	Africa	—	Discoloration, bad weather, damage during handling and transportation, insect infestation, and spoilage	(Affognon *et al* 2015)
	—	—	4.4–13.5	—	—	Surveys	Nile perch	Ghana	—	—	(Cheke and Ward, 1998)

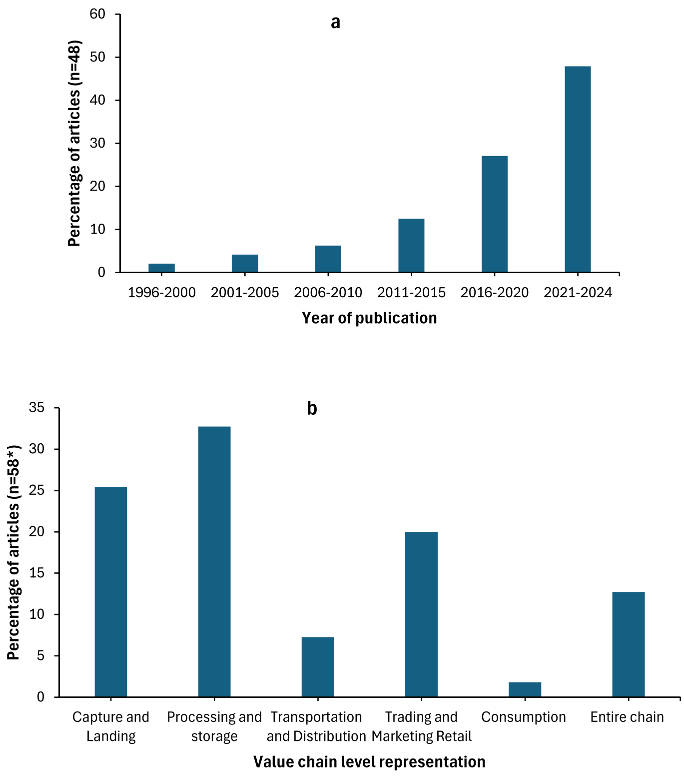

Figure 2. (a) Distribution of reviewed articles from 1996 to 2014 (b) Value chain level representation of the articles. *Some articles reported losses and causes at more than one level of the value chain.

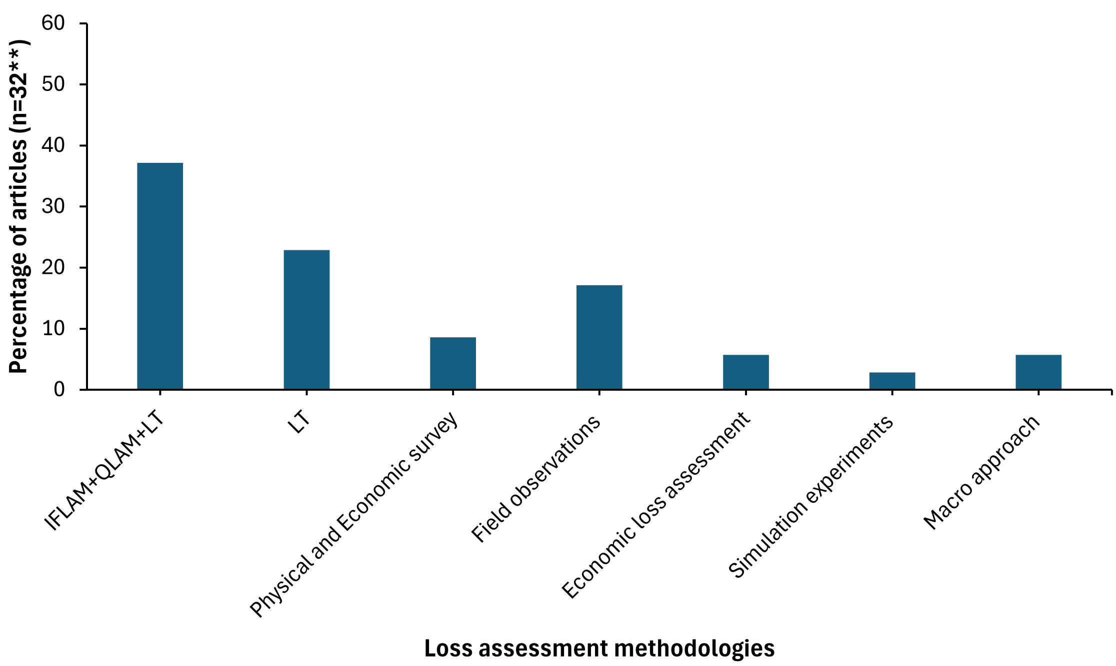

Figure 3. Distribution of methods of loss assessment in the articles. **Some articles did not assess losses.

A majority of FLW studies (62%) did not incorporate gender responsiveness in quantifying losses or identifying their causes, whereas only 38% included gender dimensions (figure 6). Gender-disaggregated data on FLW in Latin America remains scarce.

Gender-inclusive research on FLW highlights that women are heavily involved in processing and trading stages of the fish value chain but often face resource limitations and limited participation in

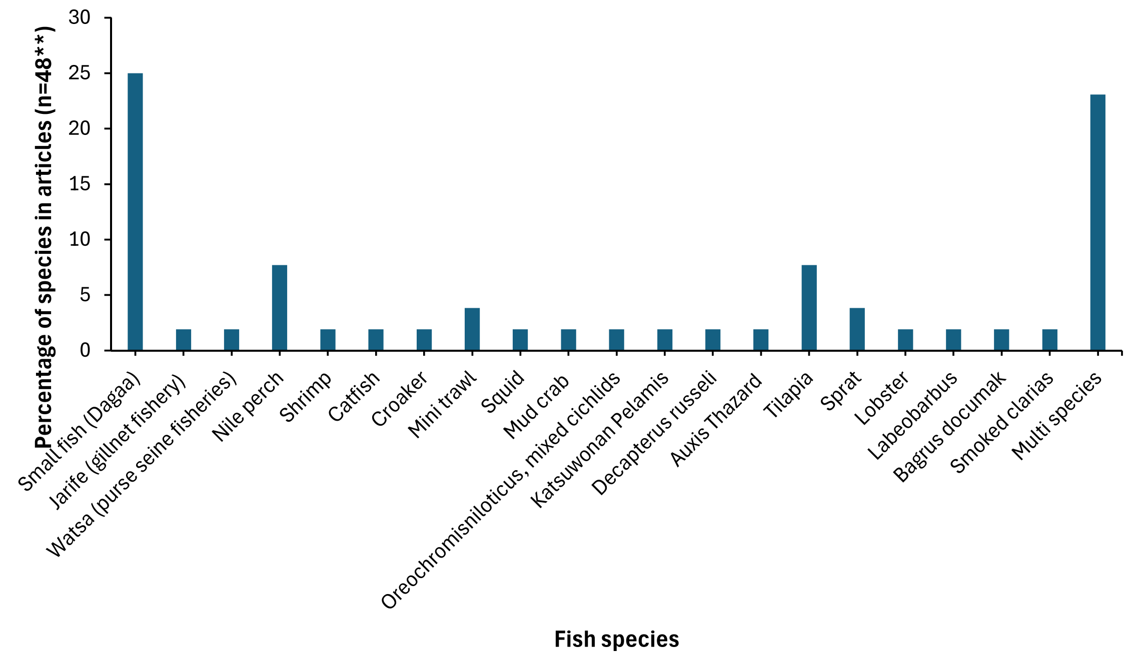

Figure 4. Distribution of fish species in the articles. *Some articles reported different species at more than one level of value chain.

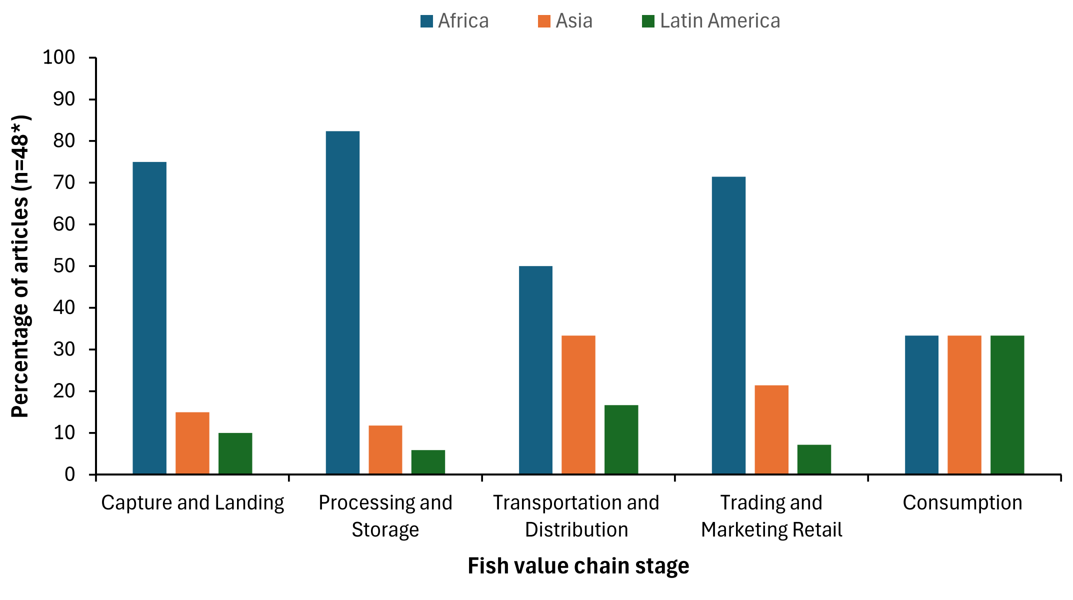

Figure 5. Value chain stage representation of FLW scale per continent. * Some articles reported losses and causes at more than one level of the value chain.

decision-making. In contrast, men typically dominate production, transport, and retail activities. Both genders have limited access to cold storage; however, women experience up to three times higher physical losses compared to men (figure 6) (tables 2(a)–(i)).

Some data were reported at the continental level (e.g. sub-Saharan Africa, North Africa and Latin America). These values were incorporated into the calculation of the weighted average loss.

3.2. Magnitude of FLW

Tables 2(a)–(i) present detailed estimates of losses, the methods used for their assessment, the fish species involved, and the underlying causes across various value chain stages in the low- and middle-income countries examined in the study. Among the reviewed articles, 66% estimated various types of FLW. All

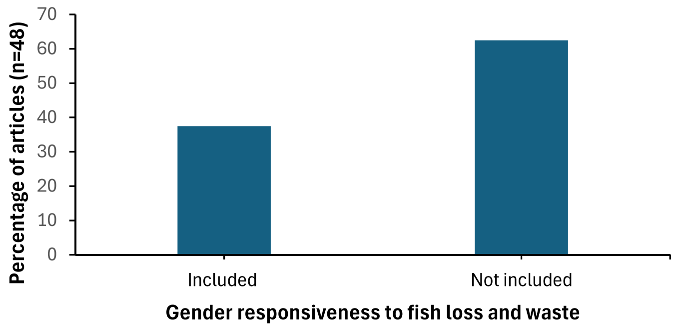

Figure 6. Inclusion of gender disaggregated data in FLW articles.

Table 3. Average fish weight loss percentage at each value chain in Africa, Asia and Latin America.

		Continent/ % fish weight loss ±SEM		
	VC Stage	Africa	Asia	Latin America
1	Capture and landing	4.4 ± 3.51	12.6 ± 5.61	5.8 ± 1.18
2	Processing and storage	15.1 ± 13.93	4.18 ± 1.76	13.0 ± 4.00
3	Transportation and distribution	3.8 ± 4.15	10.0 ± 0.00	8.0 ± 0.10
4	Trading and marketing retail	14.5 ± 11.97	8.9 ± 3.11	7.0 ± 0.00
5	Consumption	1.5 ± 0.50	1.5 ± 0.00	2.0 ± 0.00
6	Entire chain			30.0 ± 4.54

these assessed quantity losses, while only 28% and 31% evaluated quality and financial losses, respectively. Market force-related losses were estimated in 13% of the studies (tables 2(a)–(i)).

Significant variation in estimates of fish quantity loss in different stages of the value chain existed (table 3) (tables 2(a)–(i)). Table 3 presents the average fish weight loss percentage at each value chain in the regions studied. Higher average fish weight loss is experienced at the processing and storage (15.1 ± 13.93%) as well as trading and marketing value chain (14.5 ± 11.97%) as compared to other value chain stages in Africa (table 2(c)), while in Asia the key loss point is at capture and landing (12.6 ± 5.61%) (table 3) (table 2(c)). Furthermore, in Asia, substantial losses occur during transport and distribution, averaging 10%, while trading and marketing stages account for 8.9 ± 3.11%. In Latin America, the critical loss point is during processing and storage stage, with losses averaging 13.0 ± 4.00%. The estimated losses exhibited considerable variability, as indicated by the high standard deviations presented in table 3. The average fish waste at the consumption stage of the value chain was relatively low, recorded at 1.5% in both Africa and Asia, and 2% in Latin America (table 3). Studies on estimation of fish waste in Africa, Asia and Latin America are generally scarce.

Figure 7 presents the financial losses derived from average physical weight losses. Asia incurs the most substantial losses, with approximately USD 16 billion lost annually during capture and landing, and another USD 13 billion during transportation and distribution. Africa incurs substantial losses in its fisheries sector, estimated at USD 9 billion annually, with the majority occurring during processing (USD 3.5 billion) and trading (USD 3.4 billion) stages. In Latin America, losses from processing and storage account for approximately USD 2.8 billion annually, contributing to a total yearly loss of about USD 7.8 billion across the region (figure 7).

3.3. Drivers of FLW and proposed recommendations in low- and lower middle-income countries

FLW in low and middle-income countries occur throughout the value chain, driven by stage-specific factors. At the production stage, losses stem from limited cooling infrastructure, delayed landings and discard of by-catch. In the processing and storage stages, inadequate equipment (e.g. dryers, blanchers, refrigerators), animal predation and weather variability contribute significantly. Distribution losses are linked to poor road networks, unsuitable transport, border delays, and mixing of low- and high-quality fish. At the retail stage, price volatility, market oversupply and inefficient stock rotation are key issues. Finally, consumer behaviour contributes to food waste at the consumption stage.

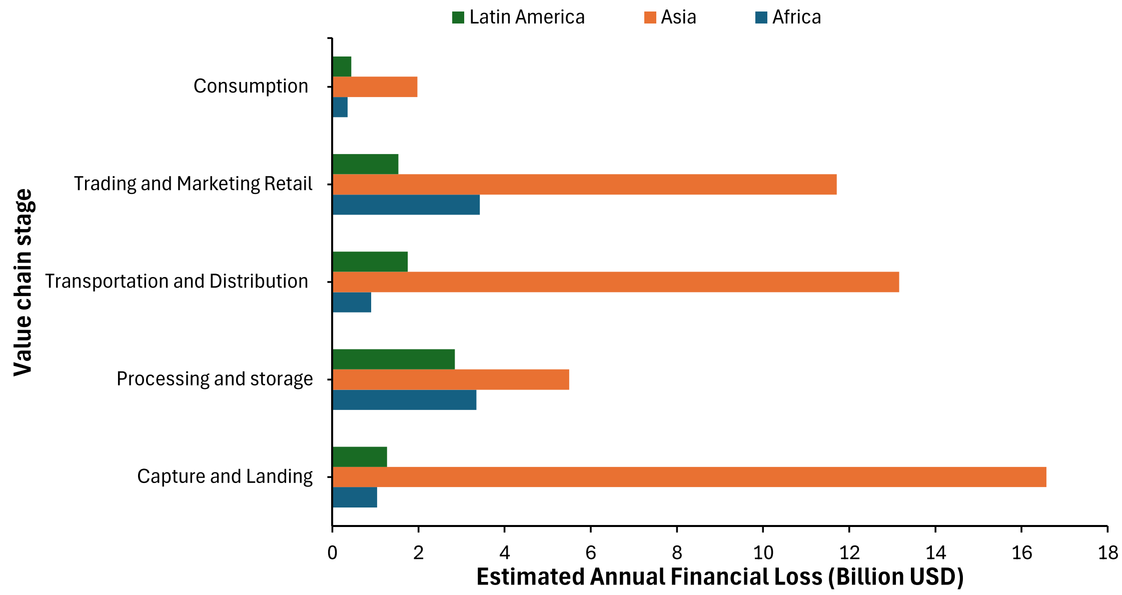

Figure 7. Summary annual financial losses calculated from physical losses per continent and VC stage.

The underlying causes are categorised into economic, environmental, social, cultural, and policy and governance domains (table 4). Key economic drivers of fish loss include limited market access, consumer behaviour, and insufficient financial resources to invest in improved supply chain infrastructure such as ice machines, cooler boxes, dryers and proper storage facilities (tables 2(a)–(i)) (table 4). Additionally, environmental factors such as rising temperatures and humidity, worsened by climate change and predators contribute significantly to losses (table 4). Enhanced collaboration and infrastructure development were recommended to minimise losses. Illegal fishing, unequal access to fish handling services and over-exploitation of marine resources are important social and cultural fish loss causative factors. Resolving these issues requires stricter regulation enforcement of fishery laws, promotion of climate and environmentally friendly aquaculture and equitable distribution of resources (table 4).

Inadequate governance in small-scale fisheries, particularly in Africa, contributes to significant FLW. Establishing and enforcing standards for fish handling, processing, and marketing across the value chain was recommended to reduce these losses (table 4).

4. Discussion

4.1. Profiling of fish losses and waste studies in low and lower middle-income countries

Overall, most of the published studies on FLW estimation were conducted in Africa as compared to Asia and Latin America. Africa's fisheries are often studied within the context of poverty reduction, climate change, sustainability and food security, attracting global attention and funding (FAO 2024). Furthermore, they are commonly assessed through collaborations between local institutions and international organisations e.g. FAO, WorldFish and USAID, leading to more documented and published research (Kruijssen *et al* 2020). Many governments and NGOs prioritise studies on fisheries due to the socio-economic importance of the sector (FAO 2017). Due to limited infrastructure, technology and value chain development, many African countries experience fish loss rates exceeding 30% (Diei-Ouadi and Mgawe 2011), making the fisheries sector a priority for research and intervention.

While FLW are also significant in Asia and Latin America, research from these regions might be published in local languages or journals, making them less visible in global databases. Additionally, research in these regions often focuses on aquaculture productivity, technological advancements, market dynamics, industrial fisheries and sustainability rather than post-harvest losses (Little and Edwards 2003, FAO 2024). Further research on the quantification of small-scale FLW and the development of mitigation strategies in these regions could improve fishers' earnings and contribute to national economic growth.

Data on fish loss across transport, distribution, marketing, and consumption stages is scarce for small-scale fisheries in Asia, Africa and Latin America. Accurate loss assessment during transportation and marketing is complex due to the informal nature of small-scale fisheries and the lack of systematic data collection. The dispersed and unregulated nature of these activities (complexity and variability of

Table 4. Drivers of fish losses and waste in low- and lower middle-income countries.

Category of fish loss driver	Value chain stage	Drivers of fish losses	Recommendation	Fish species	Case studies (Country/loss assessment method/reference)
Economic factors	Marketing	a. Lack of markets - Poor buyer turnout cause delays in sales which create a time phase critical in deterioration of fish especially when there are no proper handling and storage facilities such as ice. b. Consumer habits - Preference of some fish species over others result in in loss of market for unpreferred species (FAO 2024). c. Date marking - Failure to properly package and indicate the shelf life of fish results in rejection of the product (FAO 2024).	Strengthen collaboration between Asian countries through shared access to market intelligence and technology transfer is essential. Also offer government subsidy and financial incentives in acquiring fish postharvest technologies and services to improve fish value chains (Emam *et al* 2021).	• Catfish *Arius heudeloti*, • Croaker *Pseudotolithus elongatus*, • *Nematopalaemon hastatus*	i. **Malawi**. QLAM, IFLAM. (Torell *et al* 2020). ii. **Nigeria**. QLAM. (Adelaja *et al* 2018). iii. **Tanzania, Mali, Uganda, Kenya, Ghana.** QLAM & IFLAM. (Akande and Diei-Ouadi, 2010). iv. **India**. LR. Keerthana *et al* (2022). v. **Ethiopia**. QLAM. (Tesfay and Teferi 2017) vi. **Ethiopia**. LT, QLAM, IFLAM. (Assefa *et al* 2018) vii. **China**. LR. (Emam *et al* 2021)

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Table 4. (Continued.)

Landing stage for capture fisheries	a. Fish size and species discrimination- Indiscriminate harvesting results in small fish or undesired species being thrown away at landing resulting in loss. b. Discarded parts of fish e.g. fish heads-Fish heads, skin and bones are sometimes discarded and this is common among Asian and African fish consumers (Ling Wen Xia *et al* 2024). Less skilled workers can also waste fish when separating flesh and bones resulting in losses (Smithrithee and Chamsai 2023).	Not mentioned		i. **Tanzania, Mali, Uganda, Kenya, Ghana**. QLAM & IFLAM (Akande and Diei-Ouadi, 2010). ii. **Ethiopia**. LT, QLAM, IFLAM. (Assefa *et al* 2018) iii. **Ethiopia.** Lake Chamo. LT, QLAM, IFLAM. (Tigabu and Tadesse 2020). iv. **Ethiopia.** Lake Tana. LR, QLAM, IFLAM (Tigabu and Tefera 2014). v. **Malaysia.** LR (Ling Wen Xia *et al* 2024). vi. **vi. Southeast Asia**. LR. (Smithrithee and Chamsai 2023).
Marketing	a. Demand versus supply - During peak supply periods, fish is overproduced beyond market demand, resulting in a significant portion of the catch spoiling before it can be sold.	Improve fish handling facilities deployment such as cold rooms, cooler boxes and establishment of processing initiatives such as drying and canning.	• *Arius heudeloti*, • Croaker *Pseudotolithus elongatus*, • *Nematopalaemon hastatus*,	i. **Nigeria**. QLAM. (Adelaja *et al* 2018). ii. **India**. LR. (Keerthana *et al* 2022). iii. **Malawi**. IFLAM, QLAM, LT (Torell *et al* 2020). iv. **iSoutheast Asia**. LR (Smithrithee and Chamsai 2023).

(Continued.)

Table 4. (Continued.)

Category of fish loss driver	Value chain stage	Drivers of fish losses	Recommendation	Fish species	Case studies (Country/loss assessment method/reference)
Environmental factors	Landing, transportation, marketing	a. High temperatures - Elevated temperatures, combined with the long distances travelled to landing sites, cause fish to spoil rapidly. High temperatures speed up the enzymatic degradation of fish leading to reduced texture and rancidity (Getu *et al* 2015). Physical losses are also high during rod and line fishing with prolonged delay in postharvest handling leading to early deterioration of the catch (Mavuru *et al* 2022). Restrictions on landing times resulting in extended exposure of the catch to high temperatures, as fishers avoid day landings to evade taxes.	Infrastructure and postharvest handling technology development such as cold chain development to reduce long exposure to high temperature. Change in policy—Fishers to be allowed to land the fish even at night to reduce the keeping time of catch. Tax fee can be collected at any time.	• *Arius heudeloti*, • Croaker *Pseudotolithus elongatus*, • *Nematopalaemon hastatus*, • *Oreochromis niloticus*	i. **Nigeria**. QLAM. (Adelaja *et al* 2018). ii. **Ethiopia**. QLAM. (Tesfay and Teferi 2017) iii. **Ethiopia**. LT, QLAM, IFLAM. (Assefa *et al* 2018). iv. **Zimbabwe**. QLAM, LT (Mavuru *et al* 2022).

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Table 4. (Continued.)

	Production stage in both capture fisheries and aquaculture	a. Climate change - Changes in environmental temperatures and precipitation impact fish production directly and indirectly. First, fresh water is irreplaceable and scarcity results in cessation of water flow in rivers and natural bodies affecting fish production directly (Dudgeon 2011). Second, increased temperatures impact on the water temperatures, thus affecting the ability of fish ecosystems to adapt to changes for sustainable production. Increased water temperatures cause changes in fish physiology altering timing of spawning and also causing fish migration (Dudgeon 2011, Anteneh *et al* 2023, Macusi *et al* 2011).		• Not specifically mentioned	i. **Ethiopia**. LR. (Anteneh *et al* 2023)
	Production stage	a. Flooding and water quality - The quality of water in the water body is directly related to fish quality. During flooding, it has been observed that fish spoil faster during flooding compared to when the water is clean (Zhao *et al* 2018).		• *Opsariichthys bidens* • *Carassius auratus,* • *Oreochromis niloticus* • *Bagrus documac* • *Catfish species* • *Labeobarbus species*	i. **China**. LT. (Zhao *et al* 2018). ii. **Ethiopia**. LT, QLAM, IFLAM. (Assefa *et al* 2018)

(Continued.)

Table 4. (Continued.)

Category of fish loss driver	Value chain stage	Drivers of fish losses	Recommendation	Fish species	Case studies (Country/loss assessment method/reference)
	Landing, postharvest processing stages in capture fisheries	a. Predators - Crocodiles and alligators as well as small animals e.g. rodents, dogs, cats and birds feed on harvested fish if left unguarded.		• *Arius heudeloti*, • *Pseudotolithus elongatus*, • *Nematopalaemon hastatus*, • *Oreochromis niloticus* • *Bagrus documac* • *Catfish species* • *Labeobarbus species*	i. **Nigeria**. QLAM. (Adelaja *et al* 2018). ii. **Ethiopia**. LT, QLAM, IFLAM. (Assefa *et al* 2018). iii. **Ethiopia**. LT, QLAM, IFLAM. (Tigabu and Tefera 2014, Tigabu and Tadesse 2020).
	Production stage in capture fisheries	a. Presence of water hyacinth - The weed affects water quality in lakes, reducing the ecological conditions for fish production leading to reduced fish production.			i. **Ethiopia**. QLAM. (Anteneh *et al* 2023).

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Table 4. (Continued.)

Social and cultural factors	Production stage Marketing stage in capture fisheries	a. Overexploitation through illegal fishers -Unlicensed/poachers overexploit capture fisheries and sell fish at discounted prices undermining the sales of licensed fishers, leading to spoilage of their unsold catch. (Tesfay and Teferi 2017). b. Overexploitation of marine fish - As a common good there is overexploitation by illegal fishers due to lack of regulation or enforcement of fishery laws.	Strict enforcement of fishery laws and promotion of climate and environmentally friendly aquaculture (Emam *et al* 2021).		i. **Ethiopia**. QLAM. (Tesfay and Teferi 2017). ii. **iChina**. LR. (Emam *et al* 2021).
	Production/harvesting stage in capture fisheries	a. Use of harmful fishing methods - Fish bombing e.g. The use of dynamite and chemical agents to kill fish is highly destructive, leading to rapid deterioration in fish quality (Akande and Diei-Ouadi 2010).	Strict enforcement of fishing methods used by fisherman	Not mentioned	i. **Tanzania, Mali, Uganda, Kenya, Ghana**. QLAM & IFLAM (Akande and Diei-Ouadi 2010)

(Continued.)

Table 4. (Continued.)

Category of fish loss driver	Value chain stage	Drivers of fish losses	Recommendation	Fish species	Case studies (Country/loss assessment method/reference)
	Landing, transportation stages for both aquaculture and capture fisheries	a. Lack and/or unbalanced access to fish handling services -Infrastructure e.g. refrigeration, power supply, transport are necessary to keep/transport fish and maintain a cold chain. Lack of such infrastructure by artisanal fishers exposes their harvest to microbial contamination. Exposure to high temperatures results in biological degradation of fish. b. Gender and wealth bias - Influence access to both markets and technologies to maintain cold chain in fish (FAO 2024).		Varied, general.	i. **Ethiopia.** Lake Chamo. LT, QLAM, IFLAM. (Tigabu and Tadesse 2020). ii. **Ethiopia.** Lake Tana. LR, QLAM, IFLAM. (Tigabu and Tefera 2014). iii. **Ethiopia**. LT, QLAM, IFLAM. (Tigabu and Tefera 2014, Tigabu and Tadesse 2020) iv. **Low to medium income countries**. QLAM, IFLAM. (Kruijssen *et al* 2020).
	Landing, transportation and postharvest processing stages	a. Poor handling, preservation and storage conditions - Handling and storage practices such as mixing new and old stock result in transfer of pathogens to new stock (Tesfay and Teferi 2017). Some fish are contaminated by insects and flies (and maggots) during drying leading to rejection on the market (Getu *et al* 2015). Poor handling at various stages causes breakages resulting in rejected fish (Kefi *et al* 2017).	Training and capacity building on fish handling and storage.	• *Arius heudeloti*, • *Pseudotolithus elongatus*, • *Nematopalaemon hastatus*, • *Sardinella maderensis* • *S. aurita* (Sardines)	i. **Nigeria**. QLAM. (Adelaja *et al* 2018). ii. **Zambia**. QLAM, EFLAM (Kefi *et al* 2017). iii. **Ethiopia**. QLAM. (Tesfay and Teferi 2017) iv. **Global**. IFLAM (Ahmed 2008) v. **Ethiopia**. IFLAM. (Getu *et al* 2015). vi. **Ghana**. QLAM, IFLAM. (Gyan *et al* 2020).

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Table 4. (Continued.)

	Production stage in capture fisheries	a. Riverbank cultivation - This farming practice leads to soil erosion and sedimentation in rivers leading to reducing the water capacity of rivers thus affecting fish ecosystems. Further, nitrogen and phosphorus are deposited into water bodies leading to algal growth due to nutrient availability subsequently depleting oxygen, affecting fish production due to eutrophication.		General	i. **Ethiopia**. QLAM. (Anteneh *et al* 2023). ii. **iChina**. LT. (Wen *et al* 2020).
Policy and Governance factors	Production, marketing and postharvest processing stages for both capture fisheries and aquaculture	a. Lack of effective governance of fish production - The role of national governments should be well defined in providing market information, certification and extension systems to small scale fish producers (Delgado *et al* 2003).	The government should set fish handling, processing and marketing standards in fishing value chains to ensure loss reduction.		i. **Global**. IFLAM. (Delgado *et al* 2003).
	Production/harvesting, postharvest processing and marketing stages for both capture fisheries and aquaculture.	b. Lack of food safety systems - National governments' role should also extend to enforcing food safety standards and prevent use of harmful chemicals in the fish value chains.	The government should set safety standards in fishing value chains.	General	i. **Global.** IFLAM. (Delgado *et al* 2003).

Key: LT (Load tracking), LR (Literature review), QLAM (Qualitative Loss Assessment Method), IFLAM (Informal Fish Loss Assessment Method).

value chains) makes it difficult to gather reliable data (Kruijssen *et al* 2020). Small-scale fisheries often operate with limited infrastructure, making it challenging to monitor and evaluate losses beyond the initial stages of the value chain (FAO 2008, Ward and Peñarubia 2025). Funding and policy initiatives have historically prioritised increasing production and reducing immediate postharvest losses to enhance food security (Gordon *et al* 2011). Consequently, less attention has been given to downstream stages like distribution and consumption although critical.

Most FLW data in Africa, Asia, and Latin America have been gathered through surveys employing FAO IFLAM and QLAM methods. These rely largely on respondents' perceptions and observations of loss indicators such as changes in colour, odour, eye and gill condition, and fragmentation which can sometimes introduce bias. The sensory assessment method cannot detect early-stage microbiological contamination and nutritional loss, as the product may appear intact despite nutrient degradation (Noswad 2010). Studies on direct measurement of fish loss through microbiological and nutritional analysis using LT are scarce due to high costs, logistical challenges and limited infrastructure in small-scale fisheries (Tesfay and Teferi 2017). The complexity of real-time monitoring, combined with technological and data integration difficulties, makes implementation difficult. Additionally, variability in spoilage factors across species and environments complicates standardisation (Tesfay and Teferi 2017, Kruijssen *et al* 2020, FAO 2022). Many studies rely on indirect assessments due to the accessibility and cost-effectiveness of qualitative methods. Limited research funding further prioritises broader economic and policy issues over scientific tracking (FAO 2022, Ward and Peñarubia 2025). To bridge these gaps, increased investment in infrastructure, technology, and collaborative research is essential.

Small pelagic fish were the most studied species, followed by Nile perch and tilapia. Nearly a quarter (23%) of the studies focused on multi-species groups with four or more types. However, species like catfish, mini trawl catches, shrimp, sprat, squid, and lobster remain largely under-researched regarding postharvest loss extent and causes. Estimating fish loss for individual species is essential due to the unique biological characteristics, economic values, and processing requirements of each species. Different species exhibit varying rates of spoilage and degradation, necessitating tailored handling and preservation strategies to minimise losses (Anggara and Rudin 2020). Additionally, species-specific loss data informs targeted conservation efforts and sustainable management practices, ensuring the long-term viability of diverse fish populations (FAO 2022, 2024). Targeting individual species allows for tailored interventions that mitigate specific weaknesses, improving the efficiency and sustainability of fisheries (Noswad 2010).

Small pelagic fish species and mollusks suffer substantial processing losses, averaging 23%, which vary depending on the methods used (Mgawe 2008). Small fish dried in solar tents experienced minimal loss (∼0.8%), compared to significantly higher losses on raised racks (15.6%) and sand (25.6%) (Beveridge and Phillips 1997, Mavuru *et al* 2022). Women predominantly handle processing of small pelagic fish, whereas men mainly engage in fishing and landing. Processing losses increase during the rainy season in Africa, as drying depends on sunlight, making small pelagic fish more vulnerable to spoilage (Diei-Ouadi and Mgawe 2011). Fish species influence loss patterns due to their unique handling and preservation requirements. In Africa, small pelagic fish, Nile perch, tilapia, catfish and mud crab are highly susceptible to losses during fishing and processing stages (Torell *et al* 2020, Mhanga and Mwandya 2022) mainly due to inadequate infrastructure and poor handling. Small pelagics and shrimp dominate in Asia, with significant losses occurring during handling and transportation (Ikbal and Bhattacharya 2023).

Most studies on FLW lacked gender responsiveness, either in the quantification of losses or in the identification of their underlying causes. Incorporating gender responsiveness in tackling FLW is vital for equity, effectiveness, and long-term impact. Across studies incorporating gender dimensions, evidence from Africa and Asia indicates that women frequently incur greater postharvest losses during processing and marketing than men. These disparities are primarily attributed to women's constrained access to resources such as credit and technologies, as well as their limited participation in critical decision-making processes (Kaminski *et al* 2020). Gender inequalities result in the fish value chains underperforming when women are unequally represented especially in postharvest processing stages (Kruijssen *et al* 2018). Tailored interventions that consider these disparities enhance the adoption and sustainability of solutions by ensuring that those most affected particularly women benefit from relevant policies, technologies, and capacity-building efforts (Cole *et al* 2018, Heyl and Totobesola 2025). There is a scarcity of FLW gender-disaggregated data for Latin America, underscoring the need for additional research. Gender-disaggregated data on FLW in Latin America is scarce possibly because the national fisheries data systems have traditionally focused on capture and formal production, with limited attention to postharvest and value chain activities where women are most active. As a result, processing, marketing and informal-sector work are often not recorded, leading to a lack of gender-disaggregated data on FLW.

This production-focused and gender-biased framing has obscured women's significant contributions to fisheries economies (Harper *et al* 2025).

The commonly used loss assessment approach was a combination of IFLAM, QLAM, and LT methods, which involves re-evaluating the value chain prior to measurement to minimise bias, making it more reliable than alternative methods (Mgawe 2008).

4.2. Scales of FLW at different value chain stages

High fish losses during processing and storage in Africa (15%) are largely attributed to inadequate infrastructure, poor handling practices, the absence of cold chain systems, and challenging environmental conditions (Abelti and Teka 2024, Ejeta *et al* 2024). Small-scale fisheries often depend on traditional preservation methods like sun-drying and smoking, which are prone to spoilage (Ejeta *et al* 2024). The lack of reliable cold storage and transportation, combined with high ambient temperatures and limited hygienic practices, accelerates fish deterioration (De Silva 2011, Diei-Ouadi and Mgawe 2011, FAO 2017). Financial constraints, weak policy enforcement and underdeveloped markets further hinder the adoption of improved technologies and practices (Ames 1992, FAO 2022).

Latin America, while also facing challenges in fish processing and storage (13%), has made more significant investments in modern processing infrastructure compared to Africa (FAO 2008, Noswad 2010). Regulatory frameworks, gender equity, and capacity building remain key areas needing improvement to further reduce losses. Additionally, managerial challenges can lead to inefficient handling and processing practices, further contributing to weight loss (Keerthana *et al* 2022). Furthermore, the region's diverse geography and varying levels of infrastructure development mean that some areas experience higher losses due to logistical challenges in transporting fish to markets.

Fish physical losses at capture and landing are highest in Asia, exceeding those in Latin America and Africa. Although Africa is often assumed to experience higher losses because many fisheries operate with fewer resources, our estimates show the opposite. The lower estimates in Africa could be due to location of fishing communities near coastal or inland water bodies in Africa allowing for faster processing and reduced exposure to conditions that may cause weight loss such as prolonged transportation or delays (Mramba and Mkude 2022, Ejeta *et al* 2024). In addition, the fishing techniques used in Africa often involve generally passive fishing methods, such as stationary nets and traps, which often result in less physical damage to the fish upon capture (Mramba and Mkude 2022). This contrasts with some practices in Asia and Latin America, where active fishing methods like trawling can cause more significant physical damage, leading to higher immediate post-capture losses (De Silva 2011, FAO 2022).

Asia and Latin America often engage in increased scale fishing with extended voyages, increasing the risk of fish deterioration before landing (Diei-Ouadi and Mgawe 2011). The species targeted in African fisheries may have different spoilage rates compared to those in Asia and Latin America. Certain species prevalent in African waters might be more resilient to handling and environmental conditions, leading to reduced weight loss (Mgawe 2008, Abelti and Teka 2024, FAO 2024). Traditional preservation methods, such as smoking and drying, are commonly employed in Africa immediately after landing, which can effectively reduce moisture content and weight loss. While these methods may impact nutritional quality, they help in maintaining the physical weight of the catch (Keerthana *et al* 2022). Furthermore, In Africa, the immediate sale and consumption of fresh fish due to high local demand and limited cold storage facilities encourage rapid processing and distribution, minimising weight loss (Mgawe 2008, FAO 2017). In contrast, Asia and Latin America have more complex supply chains with longer storage and transportation times, increasing the likelihood of weight loss (FAO 2022). Although Africa may experience lower weight loss at the capture and landing stages, quality and nutritional degradation can still be significant due to high temperatures and inadequate preservation infrastructure and expertise (Mgawe 2008, Kruijssen *et al* 2020).

The estimated losses at each value chain stage showed variation, as reflected by the large standard deviations. This variability was largely influenced by differences in fishing locations, target species, seasonal conditions, and measurement methods. Fish waste at the consumption stage is minimal in Africa, Asia, and Latin America averaging less than 2% and significantly lower than in high-income regions like Europe, where it reaches about 8.6% (Cederberg and Sonesson 2011, FAO 2024). Data on fish waste in low- and middle-income regions remain limited possibly due to lack of standardised measurement methods, complexity of tracking waste sources, limited funding and variability in consumption patterns (Akande and Diei-Ouadi 2010). The findings should be interpreted with caution due to potential bias arising from the reliance on perceived loss data, which may not fully reflect actual quantitative losses. Moreover, the absence of standardized metrics for assessing quality and nutritional degradation limits the comparability and precision of the results.

The economic impact of FLW is evident through monetary losses calculated from measured physical losses. Asia, being the largest producer of fish, experiences greater financial impacts compared to Africa and Latin America. Reducing these losses would help preserve financial returns for small-scale fisheries, thereby enhancing their livelihoods.

4.3. Causes and solutions of FLW in low- and lower middle-income countries

FLW occur across the entire value chain, driven by distinct challenges at each stage. Targeted interventions are necessary to manage FLW across economic, environmental, social, cultural, policy and governance dimensions. A multi-dimensional approach to mitigating FLW is recommended, encompassing seven key pillars: policy, regulatory framework, gender, knowledge and skills, infrastructure, technology, and marketing (Ward and Peñarubia 2025). Economically, investing in infrastructure such as cold storage and efficient transportation can significantly reduce post-harvest losses and enhance economic benefits (Torell *et al* 2020, Keerthana *et al* 2022, FAO 2024). In addition to infrastructure, financial support for fishers, such as microloans and subsidies for improved processing and storage technologies, can help mitigate economic losses (Emam *et al* 2021, FAO 2022).

Sustainable fishing and bycatch reduction are essential to minimising FLW. Overfishing and harmful practices lead to significant environmental damage, with many fish discarded due to poor handling and size restrictions. Investment in improved gear selectivity, fisher training, bycatch reduction technologies and strict enforcement of sustainable quotas is recommended (Mgawe 2008, FAO 2022, Anteneh *et al* 2023).

Social and cultural factors contribute significantly to FLW. Studies have shown that traditional consumption preferences, harmful fishing practices and limited awareness often result in unnecessary discards (Akande and Diei-Ouadi 2010, Emam *et al* 2021, FAO 2022). In some areas, parts like fish heads are thrown away, increasing food waste. Promoting alternative preservation methods, diverse consumption habits and fish postharvest training for fishers, traders and consumers can foster sustainable handling and reduce losses (Akande and Diei-Ouadi 2010, Tesfay and Teferi 2017, Ward and Peñarubia 2025).

Effective policy and governance are essential for reducing FLW. However, many low- and lower middle- income countries lack comprehensive frameworks to monitor and manage these losses (Delgado *et al* 2003, Wen *et al* 2020). Strengthening regulations on fish handling, improving market access and enforcing quality and food safety standards can mitigate losses (Delgado *et al* 2003, FAO 2024).

The review encountered several limitations, including constraints in identifying relevant information sources and limited data availability. An additional specific limitation relates to language, as much of the grey literature originating from low- and lower middle-income countries is published in non-English languages (e.g. Spanish, French, Portuguese), which may have restricted the breadth of studies captured.

5. Conclusion and recommendations

FLW have significant economic consequences in low- and lower middle-income countries, with distinct critical loss points across regions. In Africa, major losses occur during processing (15%) and marketing (14.5%). In contrast, Asia experiences the highest losses at the capture and landing stage (12.6%) and during distribution (10%). Latin America's primary loss hotspot is processing (13%). Less fish is wasted during consumption in low- and lower middle-income countries (1.5%) compared to high-income countries like those in Europe (8.6%). These losses directly impact national economies and severely affect the livelihoods of small-scale fishers. Asia experiences the highest fisheries losses, estimated at USD 29 billion annually, comprising USD 16 billion during capture and landing and USD 13 billion during transportation and distribution. Africa records annual losses of approximately USD 9 billion, primarily during processing (USD 3.5 billion) and trading (USD 3.4 billion). In Latin America, processing and storage losses amount to USD 2.8 billion, contributing to a total regional loss of about USD 7.8 billion per year.

To effectively mitigate these issues, interventions must be tailored to the specific value chain stages most affected in each region. Recommended strategies include investment in infrastructure such as cold chain systems, adoption of improved technologies for fishing, processing, and distribution, enhanced training in fish handling, better market access, financial support mechanisms and reforms in policy and regulatory frameworks. A holistic, multi-dimensional approach is essential to reduce losses and improve sustainability in the fisheries sector.

While interest in FLW is increasing across low- and middle-income countries, individual nations are urged to assess and report their fish losses and waste. This effort supports the achievement of key UN SDG specifically SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 12 (Responsible Consumption and Production) which aim to halve postharvest losses and promote sustainable food systems. Research on FLW should encompass all stages of the value chain, rather than concentrating solely on fishing, landing, and processing, while neglecting upstream segments that are equally important.

The adoption of standardised methodologies such as FAO's IFLAM, QLAM, and the LT approach is recommended to ensure accurate and unbiased estimation of FLW. Furthermore, it is essential to assess all categories of loss, including quality, nutritional, market-driven and economic losses, rather than focusing solely on physical or weight-based losses. Notably, fish may remain visually intact but suffer significant deterioration in nutritional value and overall quality.

Although some studies (23%) encompassed multiple fish species, it is strongly recommended to focus loss estimation efforts on specific species. This approach allows for the development of targeted interventions, as biological characteristics and handling practices vary across species. Additionally, incorporating gender-disaggregated data in FLW assessments is essential, as men and women often encounter distinct challenges along the value chain. Tailoring interventions accordingly not only enhances effectiveness but also promotes gender equality and empowerment.

Collaborative efforts between governments, international agencies, local communities and the private sector are needed to enact policies targeting the underlying causes of loss across the fish value chain thereby ensuring food and nutrition security.

Data availability statement

The data that supports the findings of this study are openly available in the supplementary files of this article.

Supplementary data available at https://doi.org/10.1088/2976-601X/ae38e3/data1.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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