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Fish Losses for Whom? A Gendered Assessment of Post-Harvest Losses in the Barotse Floodplain Fishery, Zambia

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Abstract: Few studies examine post-harvest fish losses using a gender lens or collect sex-disaggregated data. This mixed-methods study assessed fish losses experienced by female and male value chain actors in a fishery in western Zambia to determine who experiences losses, why, and to what extent. Results indicate that participation in the fishery value chain is gendered and most losses occur during post-harvest activities. Discussions with fishers, processors, and traders suggest the value chain is more fluid than often depicted, with people making calculated decisions to sell fresh or dried fish depending on certain conditions, and mostly driven by the need to avoid losses and attain higher prices. The study shows that gender norms shape the rewards and risks offered by the value chain. This could be the reason why a greater proportion of women than men experienced physical losses in our study sample. 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 post-harvest losses. Addressing unequal gender relations in value chains, whilst also promoting the use of loss-reducing technologies, could increase fish supply and food security in small-scale fisheries.

Keywords: gender; post-harvest losses; small-scale fisheries; value chains; Barotse Floodplain; Zambia

1. Introduction

Reducing food loss and waste has garnered increased attention as an important means to improve food security and environmental sustainability [1–3]. The reduction of global food waste is one of the targets of the United Nation's Sustainable Development Goals (SDGs)—Goal 12: "Responsible Production and Consumption". Reducing food loss and waste is especially pertinent to fish value chains in low-income countries [4,5], where millions of people rely on aquatic resources for food and income [6,7]. It is estimated that a third of all the food that is produced globally is lost or wasted [8,9], though post-harvest losses are rarely estimated in fish value chain or stock assessments [10]. Fish is a highly perishable commodity where food loss and waste are expected to be higher, especially in low-income countries [4,11]. The importance of fish as a key source of macro and micronutrients is now well recognized [12–14]. Fish products are central in the diets of some 200 million Africans who rely on fish as their primary source of protein [15] and combating post-harvest losses would contribute to increased fish supply [16].

A lack of improved processing technologies, poor storage and handling practices, traveling long distances to markets, and the absence of more sophisticated processing and market infrastructure are frequently cited as causes of food loss and waste across agricultural commodity value chains [2,17–19]. In small-scale fisheries in low-income countries, a lack of technologies forces millions of people to process fish using low-cost, often sub-optimal methods, such as open-air sun drying or smoking [20]. Most losses, therefore, occur further down the value chain when fish is processed, stored, transported, or traded [5,21,22]. These nodes of the value chain are primarily occupied by women [23–28]. It is estimated that women make up 60% of people who participate in post-harvest fish value chain activities in Africa [29], which means that the burden of dealing with food loss and waste in fish value chains is gendered [30]. Thus, tackling the issue of food loss and waste also requires addressing issues of gender inequality, i.e., SDG Goal 5: "Achieving Gender Equality and Empowering All Women and Girls".

Fish value chains are embedded in complex social systems [31]. Social and cultural norms shape the roles women and men play in and outside of fish value chains [30]. Sex-disaggregated data on who participates in fish value chains have not been collected by past studies that examine loss and waste specifically, which could surface whether gender differences in food loss and waste exist in different nodes of fish value chains. Such information could further inform the design of more equitable fisheries development policies and programs [32]. The study presented in this paper collected sex-disaggregated data to answer a central research question: "do women experience more losses than men in the Barotse Floodplain fishery in Zambia?" The Barotse Floodplain in Western Province is an important fishery in Zambia, where fishing is a key food production activity that contributes over 70% to mean household income [33]. People leave their upland villages and convene at temporary fishing camps located throughout the floodplain in the peak fishing season when water levels are lowest. This study collected qualitative and quantitative data with female and male fishers, processors, and traders to better understand who, but also why, and to what extent people experience fish losses in the value chain. More broadly, the study explores the interface between food production and consumption (including loss and waste) and gender equality.

2. Post-Harvest Losses in African Fisheries

The term post-harvest loss refers to a measurable food loss or waste in a food system [34], where loss is regarded as an unwanted discard of a food commodity along the value chain and waste refers to discarded food products usually due to negligence at the end of the food chain, mostly by retailers and consumers [35]. The implications of food loss and waste in small-scale fisheries is a reduction in total fish supply and nutrient intake, as well as a potential degradation of nutrient quality when fish products are processed and/or sold at a lower quality, thus also presenting further food safety concerns.

Measuring food loss and waste of fish commodities is particularly difficult because of the perishability of fish and the complexity that characterizes fisheries and fish value chains, especially in low-income countries [11,36]. In this study, we focused more specifically on food loss in a capture fishery value chain. There are two main categories of fish losses in terms of the microbial degradation of a product: physical and quality losses. Physical loss occurs when fish is totally discarded, wasted, or spoiled, while quality loss occurs when fish is sold at a lower price due to damage or slight spoilage (see Reference [37]). Losses can be determined by calculating the mass of a consignment of fish that was totally discarded or the mass of fish that was sold at a lower price due to degradation or damage, respectively. When added together, these determine a total loss calculated as the percentage of the mass of fish that was discarded plus the percentage of the mass of fish that was sold at a lower price. Another type of loss not considered in the scope of this study, though equally important, is nutritional loss. Nutritional losses are calculated by determining the net nutrient value of a consignment of fish that is not accrued by consumers or the changes in the nutrient composition of fish products as a result of product degradation or from value subtraction through processing (e.g., smoking) [38].

Losses are also, invariably, about economic forfeiture, where the percentage of the value of the fish that was discarded or sold at a lower price creates a loss in potential revenue. This can be referred to as an economic loss and is an alternative representation of fish losses, used by calculating the price of a product and the amount of revenue not accrued as a result [38]. It is often used to represent quality losses since fish is not always discarded but sold off to the next actor in the chain [39]. Some post-harvest loss assessment studies also use the term market-force loss to go beyond food loss and waste and describe economic misfortunes faced by actors in the value chain due to unfettered market biases, such as an over-supply of fish products in the market that create further economic and/or physical or quality losses [16,22]. The Food and Agriculture Organization of the United Nations (FAO) definitional framework of food loss, however, does not include a reduction in the market value of commodities as a food loss unless a product suffers microbial degradation that leads to depreciation in market value or total discard [35]. In this study, we focused on physical food loss and waste but not on market-force and economic losses, though we acknowledge the value of examining the latter in certain contexts (for example, see Reference [40]).

Roughly 10% of the total weight of the world's fish catch is thought to be discarded (physical loss), and as much as 40% of fish can by lost in the processing node of a value chain alone [22]. In a study of five countries in sub-Saharan Africa, around 5% of the total fish yield in small-scale fisheries was determined to be totally discarded, though some fisheries, such as Lake Victoria, experienced physical losses as high as 20% of the total fish yield [22]. When added together with quality losses, the average loss for these five fisheries was around 30% of the fish that was caught, processed and traded. Seventy percent of this loss was attributed to quality losses, meaning that fish was still sold or consumed, albeit at a lower price because of degradation of the product [22]. Similar results are seen along the value chains in Malawi [39] and Ghana [40]. The average total fish loss calculated in six countries in the Volta basin was 27% [16]. The range among the countries was between 13.5% and 45.5%, indicating significant variation depending on the setting. Similar disparities are often found in food loss and waste assessments in other agricultural commodity value chains, with losses ranging from 10% to 70% [1,5,8,41].

A limited number of post-harvest loss assessments in fish value chains have been carried out in Africa to date [16,20,22,36], and few studies have considered the socio-economic factors that contribute to post-harvest fish losses (see Reference [16]). Thus, little is known about the link between food production (including in this case loss and waste as a component of production), food and economic security, and gender, in especially small-scale fisheries in Africa. This paper begins to enrich this body of literature by providing results from a gendered, mixed-method post-harvest loss assessment carried out in the Barotse Floodplain, Zambia. The next section provides details on the project that supported this study and describes the materials and methods utilized. Section 4 presents the qualitative and quantitative results using a gender and fish losses narrative. Section 5 discusses the results, reflecting on their implications for women and men value chain actors and relevance for future research and policies aimed at tackling the issue of post-harvest losses. We provide a brief summary of the study and some concluding remarks in the final section.

3. Materials and Methods

The post-harvest loss assessment formed part of a larger research project that was implemented from 2015 to 2016 in the Barotse Floodplain fishery in western Zambia. The project was led by the Department of Fisheries (DoF) of the Government of the Republic of Zambia in partnership with WorldFish and the University of Zambia—see Reference [42] for the overall project design. The post-harvest loss assessment was carried out in 2015 in six fishing camps located in the floodplain. Researchers also collected data on women's empowerment and tested a social change intervention during the project period. Improved fish processing technologies were introduced and assessed to determine their efficacy from the viewpoint of the participants who participated in the evaluations—see Reference [43,44] for more details on this body of research. The assessment presented in this paper details the initial exploratory approach used to investigate and describe losses occurring in the fishing camps in the floodplain.

3.1. Data Collection and Analysis

The study employed a mixed-methods approach, designed by the FAO, to assess the types, reasons, percentage, and frequency of fish loss and waste. We adapted the original methods and employed a two-stage process. Qualitative data were collected first for exploratory purposes, and then used to inform the development of a tool that aimed to quantify fish losses and corroborate what was found in the qualitative assessment. These tools, described below, are commonly used in tandem as part of a post-harvest loss assessment method in fish value chains. We use a recent post-harvest losses review by Kruijssen et al. (2020) to define value chain as "a sequence of integrated economic activities and actors that bring a certain good or service to the market, adding incremental value to the product at each node"—Reference [45] cited in Reference [46]. Whilst this study uses this concept, we did not employ a typical value chain analysis, which often requires an assessment of the social, economic, and environmental dimensions particular to a chain [47]. Loss assessments are generally costly and time consuming and thus may not always constitute a full value chain assessment [46].

In April 2015, qualitative data were collected from groups of people using the Exploratory Fish Loss Assessment Method (EFLAM) [38]. The EFLAM explored the types, reasons for and broad frequencies of losses for value chain actors and probed for who experienced more losses and why. The project selected the sites aiming to have three fishing camps represented in the two main districts of Mongu and Senanga (see Figure 1), both of which also have the largest harbor markets. These sites were chosen with the intent to cover as much of the vast geographic area as possible. The north of the floodplain is mostly made up of a protected area called Liuwa National Park, and thus, fishing activities are restricted. Other sites were selected because they were situated along the main Zambezi River channel and relatively accessible by boat. Certain camps in the floodplain are located in isolated lagoons and thus inaccessible at certain time of the year.

As part of the EFLAM, the study team carried out focus group discussions (FGDs) at each camp with around 15 female and male fishers, processors, and traders (groups on average consisting of around 30% females). Meetings to introduce the research study to people living in the camps were scheduled by a DoF officer a day earlier via telephone. The research team arrived the next day and conducted the FGD with everyone who joined the introductory meetings. Over a two-week period, the research team visited each site and held a total of nine FGDs. The team also carried out discussions with two trader associations in the two largest fish markets in the province (Mongu and Senanga), as well as an interview with an owner of a cold chain business in Mongu who transports fish to Lusaka (the capital city). In May 2015, a knowledge sharing and learning workshop was held in Senanga with 24 representatives from the six fishing camps (12 females and 12 males) to discuss the root causes of post-harvest losses and potential solutions. The data collected from all these discussions comprise the qualitative dataset analyzed for this study.

Shortly after collection, the EFLAM data were analyzed with the intention of using the findings to help inform the design of the quantitative post-harvest loss instrument: the Questionnaire Loss Assessment Method (QLAM) [38]. This method was purposefully implemented after the EFLAM to triangulate the qualitative finding that losses could be gendered, primarily because we found that women tended to process and trade fish (where losses seemed to be highest) and that women discussed unique challenges in their abilities to process and trade fish. The QLAM used a seven-day recall asking female and male value chain actors in the same six camps to recollect their consignments of fish and trace the consignments from the point they were caught or bought to where they were sold. The mass of one consignment of fish from the previous seven days was calculated per person (using local units of measurement and subsequently converted to kilograms), as well as the mass of the fish consignment that was discarded (physical loss) and/or the mass of the fish consignment that was sold at a lower price due to degradation (quality loss).

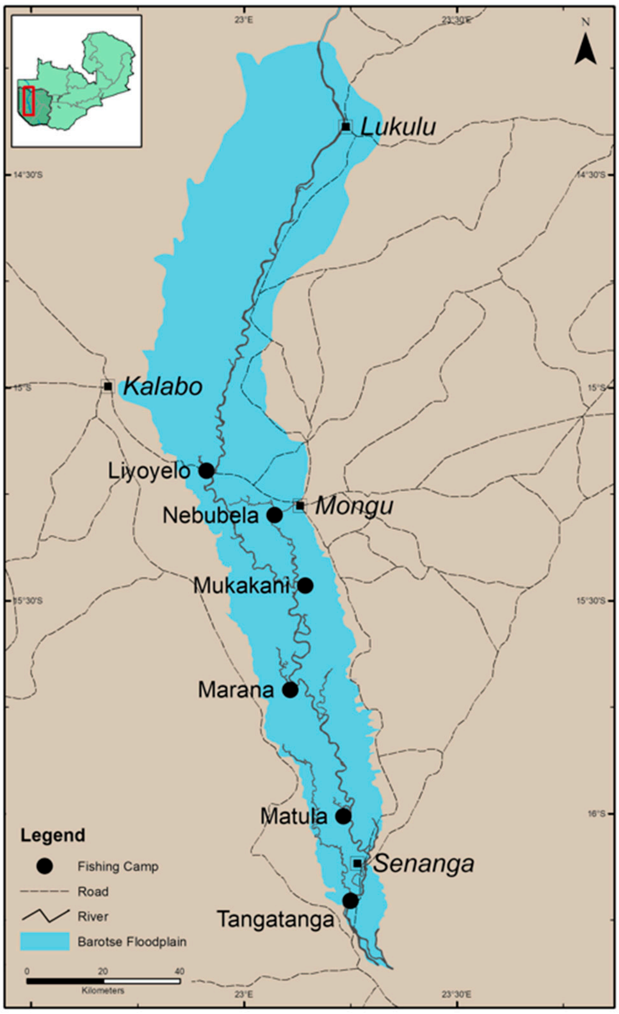

Figure 1. Map of the study sites (fishing camps) in the Barotse Floodplain with district towns.

The QLAM was purposively administered in July and August 2015 to fishers, processors and traders on the six fishing camps. The period June to October is peak fishing season in the floodplain when water levels decrease and fishing activities in various channels and isolated lagoons increase. Populations on the camps in this fishery are relatively small, comprising on average 20 to 50 temporary housing arrangements. There were no population statistics available for the camps to aid in the drawing of a random sample of people to participate in this study. The numbers of people living in the camps begin to increase as water levels recede and fish become easier to catch in the floodplain. The fluctuations of people both within and across seasons makes sampling for research purposes quite challenging. Therefore, as was executed for the EFLAM, introductory meetings on the fishing camps were scheduled via telephone the day before. At the meeting the following day, enumerators introduced the study and selected all the people who were present and willing to participate in the research. A total of 176 people (33% females and 67% males) from the six camps were interviewed for the QLAM. Thirty fishers also processed their consignments of fish, and thus, responded to both the fisher and processor sections of the QLAM survey, making the actual sample size larger at 206 observations. Some missing values for two observations brought the sample size down to 204. A total of 151 people indicated they sold their consignments of fish, thus making up the sample of people who could report on quality losses.

The quantitative data were analyzed using Stata Version 16 (StataCorp, College Station, TX, USA). Summary statistics are presented in this paper. A *t*-test was carried out to determine whether percent differences were statistically significant at or below the 5% confidence level.

The qualitative data were analyzed using a deductive content analysis approach [48]. Three central themes emerged when analyzing the data and informed how we structured the presentation of the results below. The first theme, Gender Roles and Division of Labor, explores the differences in how female and male actors describe their participation in the value chain. The second theme, Decision Making and Risk, looks at how the risk of loss and waste factors into women's and men's decisions when engaging in activities. Finally, Gender Norms and Beliefs, reveals how gender attitudes and prescribed roles affect the performance of carrying out activities in the value chain.

Ethical clearance to implement the research was granted by the University of Zambia's Research Ethics Committee. Informed consent was obtained before conducting interviews.

3.2. Limitations of the Study

This study collected cross-sectional survey data on fish losses with value chain actors in each of the six fishing camps using a seven-day recall period. The post-harvest loss assessment only measured losses experienced by people living in the camps and did not include fish lost further down the value chain by other actors. Seasonality certainly plays a role in determining fishing and post-harvest strategies during the year; therefore, further research is required to determine the effects of seasonality on fish supply and post-harvest losses in this context by collecting longitudinal survey data. In addition, the study was unable to randomly sample respondents on the fishing camps before administering the questionnaire. The camps are mostly temporary in this fishery, built for a few months during the dry season when water levels are lowest. Seasonal human migration is common for most people as they adapt to the flooding regime throughout the year [49], and there are no census data available for these camps. The quantitative results are, therefore, not generalizable to the larger floodplain community, yet are nonetheless important in bringing to surface women's and men's experiences dealing with losses in this fishery.

4. Results

4.1. A Description of The Value Chain and Products

The EFLAM highlighted that various fish species are caught and traded, mostly Tilapiine Cichlids, Mormyridae, and Claridae, in either fresh or dried form. Larger fish, such as *Hydrocynus vittatus* (African tigerfish), are rarer but highly valued in this fishery and are often frozen and sold in Lusaka by a few established trading companies with cold-room facilities in Mongu town, the main trading point in Western Province (see Figure 2a). Juvenile tigerfish are smoked and dried by informal traders. Other large fish, such as *Clarias* spp. (*ndombe*), are generally dried and smoked, and a high amount of losses are experienced when processing these species because of their size and fattiness, which results in a longer time needed to smoke the product (see Figure 2d).

Figure 2. Photographs depicting the value chain—Mongu harbor (**a**); smoked tilapia with flies in market (**b**); dried fish on elevated reed racks (**c**); and smoking kiln made from a barrel and bicycle rim (**d**).

Small mormyrids (*nembele*), such as *Marcusenius altisambezi,* and other small fish are mostly dried, and, whilst they tend to spoil less, they break easily in dried form, mostly owed to conditions during handling and transport. Tilapiine cichlids, for instance, *Coptodon rendalli* and *Oreochromis andersonii*, make up most of the fish catch in the value chain [50] and are caught in all sizes, after which they are generally split, sun dried, and/or smoked when they cannot be sold fresh (see Figure 2b). The quantitative data from the QLAM confirmed this, with tilapia species (*lipapati*) making up 75% of the fish consignments assessed in this sample, *nembele* comprising around 15%, and others (e.g., *ndombe*, tigerfish, bottlenose) the remaining 10% of the fish consignments.

The value chain extends to nearby markets, district towns, cities outside the province, and into Angola and the Democratic Republic of Congo. The short value chain within the temporary fishing camps is limited to small islands and lagoons in the floodplain, which is dictated by seasonal flooding regimes and human migration. People generally talk about having two villages, with the primary village located on higher ground in areas that are not inundated by water. These villages have schools, clinics and other public facilities whereas the fishing camps generally do not. The migration from the floodplain back to higher ground is marked by a yearly ceremony called *Kuomboka*, where the Litunga (king of Lozi people) marks his movement from his palace in the floodplain up to higher ground. Such ceremonies reveal the importance and cultural relevance of the migration and flooding regime to people living in the floodplain.

The fishing camps exist primarily for the harvesting, processing and stockpiling of fish. Since this mostly occurs during the colder, drier winter months, crop production is not regularly practiced, though cattle graze on the newly accessible grasslands in the floodplain. Men will generally spend the days fishing from dugout canoes, whilst women tend to gardens, smaller livestock and household tasks. Families will travel to and from the primary village to sell fish and collect supplies, such as food, fishing gear, and wood for smoking fish. The commute, usually taken by dugout canoe, is an important characteristic of this value chain as it affects how people capture, process and move fish, and influences whether fish will incur losses and/or waste. Most consignments of fish will be processed and bundled into large stacks tied with papyrus reeds. These stacks can be found in markets all over the region and some traders will spend weeks selling fish harvested from the Barotse Floodplain in areas hundreds of kilometers away.

4.2. Gender Roles and Division of Labour

The results from the EFLAM indicate that many value chain activities, including fishing, processing, and trading, take place on the fishing camps. Participants in the group discussions spoke of value chain activities being gendered, with men predominantly fishing and women primarily involved in processing and trading. The QLAM data revealed that 98% of sampled fishers were male, and 80% of traders were female, providing confirmation of the gendered nature of nodes in the value chain.

There were more men than women in our sample who had indicated that they processed fish; however, these were men who made up part of the fishing population and then went on to process their own fish. The QLAM results showed that only women indicated that they processed fish without fishing or trading the same consignment of fish. In reality, this is more complex as the EFLAM showed that no focus group participants referred to themselves (or identified) as a 'processor', but rather used the terms 'fisher' or 'trader' instead. This likely indicates that processing takes place on the camps as a necessary means of reducing (further) losses and sometimes as a paid economic activity but not as a full-time profession such as fishing and trading; and unlike other fish value chains around the world where people can seek formal employment in the processing node (e.g., scaling, freezing or packaging fish). Thus, whilst many people can be hired by fishers and traders to process fish, it is also an unpaid task performed mostly by women (and children) as part of a household's division of labor. Overwhelmingly, therefore, women either process fish caught by their spouses or they purchase fish from male fishers. In some cases, female traders hire women on the camps to process, though, in peak season, when there is a larger supply of fish, it is common to see men processing fish to avoid losses.

Male fishers tended to talk about the need to sell fish in fresh form for the highest price, but, when this was not attainable, they would then give the fish to their spouses to be processed or sell the fish to female processors and traders. Smaller fish, like *nembele*, that has established dried fish markets are immediately processed and so women tend to market these products. Men will attempt to market larger fish in fresh form or otherwise sell the fish to processors. Certain products in this value chain are thus handled predominantly by women or men and processing different species can have consequences on the types of losses experienced.

One female trader explained that large fish, such as catfish and tigerfish, have higher losses:

> "They [large fish] are the most sensitive . . . they spoil the fastest and also contain so much fat . . . when they are smoked the flesh of the fish can fall off the fat that is dripping out . . . this can also make it burn". (Senanga, 11 May 2015)

The descriptions of processing procedures, mostly recounted by women, indicate that processing fish demands a significant number of hours and care, especially if fish are larger and thus spoil easier, or take longer to process. This means that processors need to take care and ensure that the fish does not burn, which requires many hours of attention and work. Fish of all sizes are dried on elevated reed mats for around 12–24 h (see Figure 2c). Large catfish and tigerfish can take even longer to process. The reed racks are elevated to avoid being attacked by insects, rodents or dogs. Additionally, processors will need to swat away flies and chase away birds throughout the drying phase. These reasons explain why drying and smoking usually take place close to the homestead so that processors can complete other tasks, from gardening or cooking to caring for children, whilst also processing fish.

4.3. Decision-Making and Risk

The qualitative inquiry indicated that all species have different prices, which decrease when fish is dried or smoked. Tilapia species are a prized catch and fetch higher prices when sold fresh. People living in the floodplain are hours or even days from the nearest market. There are few motorized boats in the floodplain as many people travel by dugout canoe or by bicycle and walking when water levels are low enough. The decision to process these species was often defined as a "gamble", where participants in group discussions described their attempts to offload fish in fresh form as fast as possible. If they were unsuccessful, they then made the decision to process the fish to avoid losses. However, it was explained that some actors preferred to process immediately, knowing from experience that it is difficult to sell their fish in fresh form or because they secured a market for processed fish in distant towns outside the province. One man described how he and other fishers first try to sell fish in fresh form if possible:

> "Sometimes we wait at the intersection to sell fish to [passing] vehicles. If no vehicles come, we can lose all our fish because we are trying to sell it fresh. It is a gamble. Others [other fishers], they will play it safe and just dry the fish . . . The further we go, the more fish is lost. We can even come back with no profits". (Tangatanga, 12 May 2015)

One female trader described the reliance on infrastructure and transportation as a major factor in her decision to process fish:

> "Transportation to Lusaka usually leaves on Monday, so sometimes we try to rush back [from the floodplain] to make it [i.e., board the vehicle] to sell the fish . . . if we miss the transportation then we can be left with spoiled fish because it has not dried properly". (Senanga, 11 May 2015)

The decision to process fish can also depend on other circumstances or conditions, such as temperature and humidity or distances to and oversupply in markets, all of which present different conditional risks that are assessed day by day. Such variables play a role in the degradation of fish products and hence the decision on whether or not to process the fish and avoid further losses. For example, one male trader explained the changes throughout the season that will determine how fish is traded:

> "In the low season [when water levels are high, and fish is in low supply] we have to rely on our clients [fishers] . . . we need to rely on them using a canoe or vehicle to transport to us. The fishers must process the fish and bring it to us [traders in Mongu market]". (Mongu, 8 May 2015)

It was evident from group discussions that, once the water levels recede, and people can traverse the floodplain on foot or using vehicles or bicycles, the value chain shifts dramatically as traders start to venture into the floodplain and purchase fish directly from fishers. A male cold-chain business owner in Mongu described how the traders who travel into the floodplain set the rules of the transactions:

> "They [traders] pay fishers in alcohol, snacks and clothes . . . as a sort of bribe . . . the traders will get the fish and not pay cash at first point-of-sale. This is seen as a factor which is leading to the fishermen remaining poor". (Mongu, 8 May 2015)

During a discussion with one of the trader associations, one man described the rush for fish at the peak of the season, saying that fish "pass many hands, maybe six or seven hands before it reaches us, and each time it is more expensive" (Mongu, 8 May 2015). The quote indicates how fish is handled several times before reaching the consumer. At each change of hands, the probability of loss and waste increases.

From discussions with male fishers, it appears that they actually prefer when traders come to them because then they do not have to deal with losses, as one male fisher explained:

> "We want to sell only fresh fish. We only start processing here if we see that it [the fish] is going bad. Otherwise we quickly just sell the fish. The traders must come to us [in the floodplain]". (Nebubela, 14 May 2015)

A male fisher from another group discussion indicated that selling to traders soon after harvest enables fishers to pass on any of their losses to traders instead of absorbing these losses themselves, stating:

> "We transfer our losses to the traders because they will lose fish on their journey [back to their markets] and when they are handling the fish". (Tangatanga, 12 May 2015)

Traders discussed how their fish can be poorly handled during transportation, and it appears they have little control over preventing these losses, with one male trader stating:

> "Fish gets crushed in trucks, there are goats and heavy things. People are grabbing and they want lifts [i.e., hitchhiking] in the trucks and they step on the fish". (Tangatanga, 5 May 2015)

A female trader explained how dried fish is spoiled when transported in canoes, as the fish lies at the bottom of the canoe, and, after many hours of traveling along the river, the fish "becomes soft like *nshima* [common staple food made from maize or cassava meal, which is relatively soft in texture]" (Senanga, 11 May 2015).

From our analysis of the risks and rewards presented by the value chain, it seems losses occur throughout the value chain in different forms and, likely, in different quantities, depending on the node of the value chain. Importantly, women and men spoke about losses differently during the group discussions. Men focused primarily on monetary (economic) losses that resulted during bartering or trading rather than physical and quality losses, as defined in Section 2. Women tended to focus more on the physical losses they experienced during processing or transporting fish. Women and men agreed, however, that the bulk of losses occurred during processing, where fish is spoiled whilst drying on raised racks, stolen by birds and other animals, becomes infested with insects during the drying process (e.g., when rains prolong the drying period), or gets burnt while smoking. Additional losses occur during storage and transport, when fish is infested by insects, attacked by rodents, or damaged because of poor handling during packaging and stacking (especially dried or smoked products) or when dried or smoked fish is soaked when transported to larger markets in dugout canoes, as detailed above.

4.4. Gender Norms and Beliefs

The EFLAM exposed some of the characteristics specific to the floodplain fishery, where migratory fishing patterns, gender division of labor, and dependence on the fishery for livelihood security defines the social-ecological system. The system is partially governed by gender norms and beliefs that dictate how people access the value chain and what types of risks and rewards are associated with that participation. Men and women identified themselves during group discussions as mostly fishers and traders, respectively, although it was noted that women and men can occupy various nodes of the value chain at specific times in the year depending on the volume and types of fish catches. For example, whilst men generally fish with nets and handlines from dugout canoes, women fish with reed baskets at a specific time of year when water levels are lowest, accessing smaller fish trapped in ponds and grasslands. Women did not, however, refer to themselves as fishers per se, and some men justified the gendered nature of fishing. One male fisher said:

> "It is not good to take women out to fish because then you are treating her like an enslaved person [meaning forced labor on the boat], you must treat her like a woman and make sure she stays at home. We don't like to endanger our women because fishing is dangerous. Lots of people drown and there are crocodiles and *hippos* [hippopotami]". (Tangatanga, 5 May 2015)

A woman from another group discussion agreed that men should be the ones who fish, and women should be the ones who trade fish in a market, stating that:

> "Fishing is labor intensive, which we [women] cannot manage ... We have shared roles in the household ... while men are fishing, women are involved in other things like farming and

> taking care of children. The marketing [trading] is done by women because men will need to continue to fish while we spend the day selling fish to raise income". (Matula, 13 May 2015)

And whilst it is common to find men operating as traders in the value chain, male fishers spoke of not wanting to spend their time in markets. One male fisher expressed this idea, stating:

> "This [trading in a market] is a woman's job. Why should we sit in the market with the women? Our place is on the river". (Senanga, 11 May 2015)

While it was apparent during group discussions that participants believed certain tasks in the value chain are (or should be) gendered, female participants provided evidence of how losses are also gendered and influenced by rather strong norms. One woman described some of the issues specific to women who process and trade fish:

> "We [women] have the most losses. It is because we are the ones trading. We process and we also transport [the fish]. Sometimes we have to hire [male] paddlers or we have to hire someone at the market to help carry our fish. Women who are not married will have the most losses". (Nebubela, 14 May 2015)

This quote implies that women incur additional costs because they rely on the labor of men to paddle dugout canoes or to carry heavy consignments of fish in the market. Women who are unmarried will have to incur more costs due to there being no adult male labor to provide assistance when transporting or moving larger quantities of fish. Additionally, access to the market is controlled by the harbor master and market associations, where traders pay for space to trade their fish. In both Senanga and Mongu markets, this access is decided by men. Many traders, both women and men, trade their fish outside of the markets on the roads or at the landing sites along the river to avoid these costs.

A female trader described the costs she incurs when trading fish in the market:

> "We [women] cannot wait there [in the market] and sell our fish as we have to use the money that day to buy food for our families and still get back [home]. I have to get back [home] and give my children *nshima* [food], I cannot wait at the market too long, otherwise my fish will rot and so I have to sell my fish for a lower price". (Tangatanga, 5 May 2015)

This woman's reflection on the pressure she feels to attend to her family's needs whilst also trading fish is surely not unique and indicates the dual roles women play as traders and as caretakers of their homes. Some women from the focus group discussions explained how traders from outside the floodplain exploit these family responsibilities, knowing that those who are attempting to sell their fish in fresh form will either have to travel back to their fishing camps the same day or incur extra costs by lodging at the market. These "outside" traders are accused of waiting until the end of the day to offer lower prices for the fish, pointing to the lack of freshness as justification.

One woman suggested a potential solution:

> "When we get fish we just make 'give-away' prices [low selling price]. To avoid these losses, we need ice. With ice I can keep fish for a few days and spend longer at the market looking for the right price. I don't have to sell that same day. This will allow us to control our prices. It gives us the power because they [other traders or consumers] will be the ones desperate to buy and we will not be desperate to sell anymore". (Nebubela, 14 May 2015)

4.5. A Gendered, Fluid Value Chain Depiction

The anecdotes explaining how actors deal with losses throughout the value chain, in many ways, indicate that operating in the floodplain fishery is complex and not easy to depict using typical value chain illustrations that portray simplistic linear pathways. These pathways usually show commodities moving through predetermined nodes that are mostly immutable. The decision to process and trade fish or whether a person will move from the fishing node into the processing node depends on daily conditions and circumstances. Different markets exist at different times of the year when water levels are low and smaller species are driven into lagoons and canals. This drastically changes the dynamic of the value chain. Dried or smoked products are notably cheaper than fresh products and actors make calculated decisions on whether they will sell their fish in fresh form and lose a part of their consignment to spoilage or sell larger quantities in dried/smoked form but risk losing fish to breakage or burning through smoking. The decision then to process fish is driven by the need to strike a balance between avoiding losses and securing the highest possible economic returns. This primary decision shapes the relations, behaviors, and interactions in the value chain, which is constantly changing and adapting to different circumstances throughout the year.

Based on our analysis of the EFLAM data, we present a diagrammatic representation of the fluidity in this localized value chain on the fishing camps (Figure 3), where fish products move between traditional nodes in the value chain and where certain actors move between nodes depending on their circumstances and the gamble decision described above. Women and men can occupy multiple nodes depending on the context and time of the fishing season, where activities are generally gendered but where circumstances depict a value chain with multiple pathways that can intersect. Whilst fish moves between traditional nodes from fishing to consumption, there are many variations where women and men can perform fishing, processing or trading duties. This can change from day to day as actors make decisions on whether to process their fish.

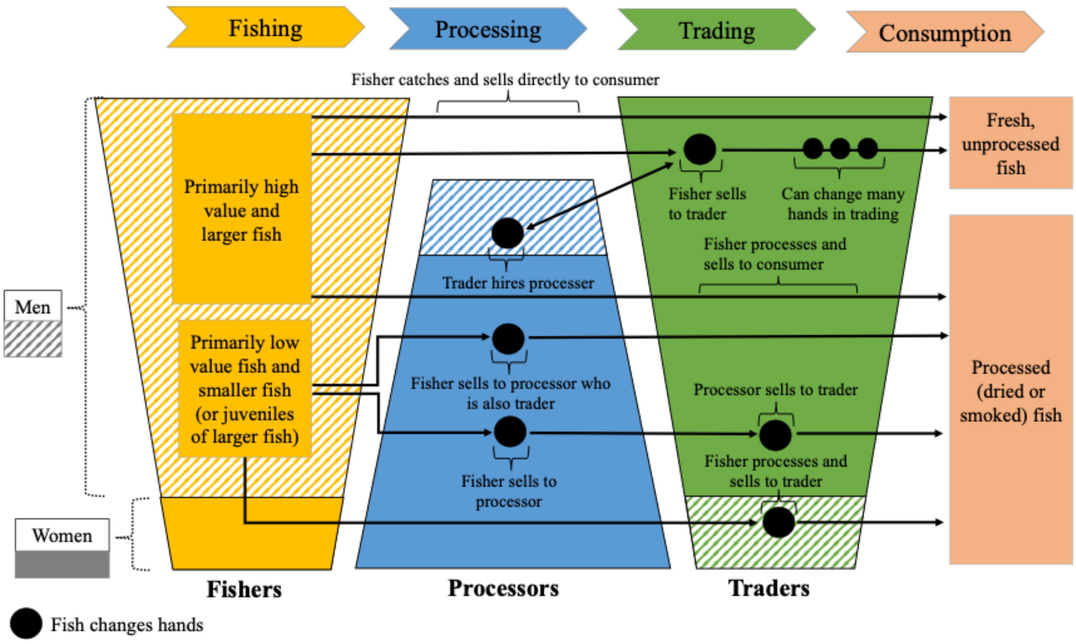

Figure 3. A fluid fish value chain from fishing camps to consumers. Note: The gender categories do not represent actual proportional differences in the nodes—they merely illustrate nodes that are primarily occupied by either women or men; nor do the arrowed lines necessarily go through the exact part of the nodes depicted as either female or male.

4.6. Quantitative Fish Loss and Waste Results

Over 26% of the sample experienced some level of physical losses (Table 1). A greater percentage of women experienced physical losses compared to men at 46.6% versus 18.5% ($p < 0.0001$). Around 15% of fishers experienced physical losses and 44.8% of processors and 30.0% of traders, with a greater percentage of female processors stating they incurred physical losses compared to the men who processed their fish ($p = 0.0228$). No gender differences were found in the proportion of value chain actors reporting they experienced quality losses. Overall, 47.7% of the sample who indicated they sold their fish consignments experienced quality losses, with 56.5% of women reporting they incurred quality losses compared to 43.8% of men ($p = 0.1520$). Similar findings of quality losses were found within each value chain node.

Table 1. Percentage of value chain actors who experienced some level of physical and quality losses, by sex.

	Total	Female	Male	p-Value
Physical losses				
Total ($N = 204$)	26.5	46.6	18.5	0.0000
Fishers ($n = 106$) *	15.1			
Processors ($n = 58$)	44.8	62.5	32.4	0.0228
Traders ($n = 40$)	30.0	34.4	12.5	0.2379
Quality losses				
Total ($N = 151$)	47.7	56.5	43.8	0.1520
Fishers ($n = 72$) *	44.4			
Processors ($n = 45$)	51.1	66.7	40.7	0.0921
Traders ($n = 34$)	50.0	50.0	50.0	1.0000

* Too few observations for female ($n = 2$), thus no test was carried out to determine if the percentage point difference was statistically significant.

Average weight of fish consignments for the sample was 33.2 kg, and no statistically significant differences between the average weight of women's fish consignments and the consignments of men were found at this aggregated level or at disaggregated levels (Table 2). The average weight of fisher's consignments was 37.6 kg and that of processors and traders was 21.7 and 38.3 kg, respectively.

Table 2. Average weight (kilograms) of fish consignments, by sex of the value chain actor.

	Total	Female	Male	p-Value
Total ($N = 204$)	33.2	32.5	33.5	0.8675
Fishers ($n = 106$) *	37.6			
Processors ($n = 58$)	21.7	28.5	16.8	0.1114
Traders ($n = 40$)	38.3	36.4	46.0	0.4666

* Too few observations for female ($n = 2$), thus no test was carried out to determine if the percentage point difference was statistically significant.

In total, 28.0% of the mass of fish recorded in the assessment was lost, 5.7% of which was absolutely discarded (physical loss), and 21.9% was sold at a lower price due to quality losses (Figure 4). A similar trend in losses was observed within each value chain node.

When disaggregated by sex of the value chain actor, statistically significant percent differences in total losses and in physical (but not quality) losses were found (Table 3). In total, a greater percentage of women's fish consignments were lost (41.4%) compared to men's fish consignments (22.1%). The percent point difference was statistically significant at the 1% confidence level ($p = 0.0009$). Over 11% of women's consignments experienced physical losses compared to only 3.4% of men's consignments, and the percent point difference was statistically significant at the 1% confidence level ($p < 0.0001$). Close to 52% of female processor's consignments of fish was lost, while only 24.9% of male processor's consignments was lost. The percent point difference was statistically significant at the 5% confidence level ($p = 0.0191$). Female processors experienced over three times more physical losses than male processors (16.5% versus 5.4%, respectively), and the percent point difference was statistically significant at the 1% confidence level ($p = 0.0092$).

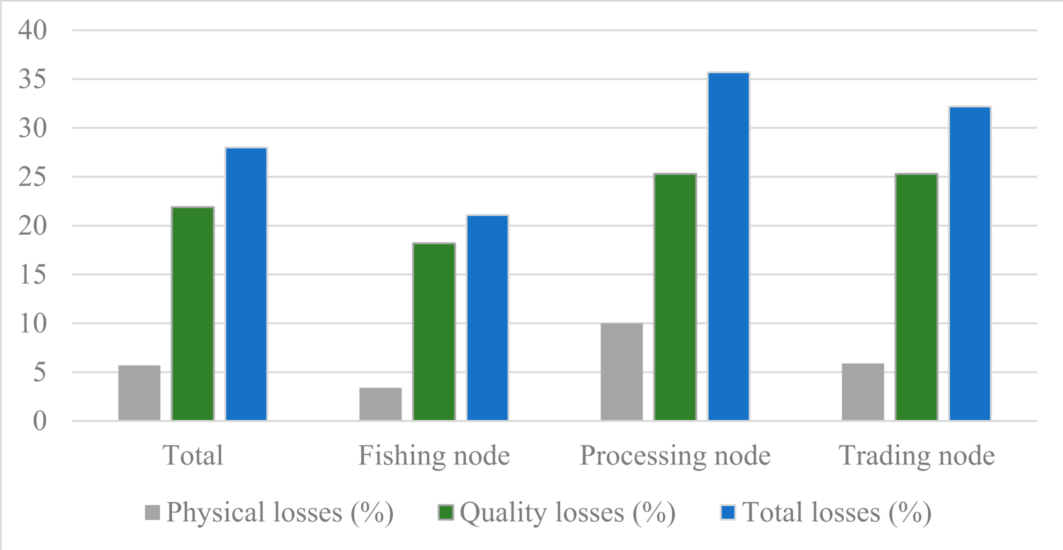

Figure 4. Percentage of overall fish consignments that experienced physical losses, quality losses, and total losses in different nodes of the floodplain fishery value chain.

Table 3. Percentage of fish consignments that experienced physical losses, quality losses, and total losses in different nodes of the value chain, by sex of the value chain actor.

	Physical Losses (*N* = 204) *			Quality Losses (*N* = 151) ^			Total losses (*N* = 151) ^		
	Total	Female	Male	Total	Female	Male	Total	Female	Male
Fishing node †	3.4	...	...	18.2	...	...	21.1	...	...
Processing node	10.0	16.5 [a]	5.4 [b]	25.3	34.4 [a]	19.2 [a]	35.7	51.9 [a]	24.9 [b]
Trading node	5.9	7.0 [a]	1.6 [a]	25.3	25.3 [a]	25.4 [a]	32.2	33.9 [a]	26.9 [a]
Total	5.7	11.5 [a]	3.4 [b]	21.9	28.5 [a]	19.0 [a]	28.0	41.4 [a]	22.1 [b]

* Sample sizes for fishing (106); processing (58, female = 24, male = 34); trading (40, female = 32, male = 8); and total (204). ^ Sample sizes for fishing (72); processing (45, female = 18, male = 27); trading (34, female = 26, male = 8); and total (151). † Too few observations for female ($n = 2$), thus no test was carried out to determine if the percentage point difference was statistically significant. Values not sharing common superscripts significantly differ at $p < 0.05$.

We found no statistically significant gender differences in the causes of losses. Overall, spoilage of fish was the main cause of physical losses reported by fishers (at 53.3%) and breakage of fish was mentioned as the predominant cause of such losses in both the processing and trading nodes at 61.5% and 66.7%, respectively. Spoilage of fish was again the main cause of quality losses for fishers who indicated they sold their fish (at 68.8%), while for processors and traders, breakage and spoilage of fish were the primary causes of quality losses at 56.5% and 56.2%, respectively.

5. Discussion

5.1. Women Are at Greater Risk of Experiencing Losses

The results presented in this paper show that post-harvest losses were significant for this sample of value chain actors operating on fishing camps in the Barotse Floodplain fishery, with almost a third of the mass of fish experiencing physical and quality losses. This result is similar to results from other studies that estimated total losses to be around 30% and that physical losses can make up between 5–10% of these losses [5,16,22]. The results from the EFLAM suggest that the perceived risk of fish loss and waste (i.e., the gamble decision) shapes the way value chain actors move fresh or processed fish through various nodes resulting in different types, frequencies, and volumes of losses throughout the fishing season. The risk of losing fish is juxtaposed with the potential reward for a higher price, seemingly influencing how value chain actors interact with each other.

Our results suggest that there are gendered differences in total losses across the sample and specifically for physical losses, which, theoretically, translate into economic and nutritional losses. Specifically, processing appears to be the node at most risk of experiencing physical losses for the sample in this local value chain, similar to results from other post-harvest loss assessments in Africa [16,22,39,40]. Our review of the existing literature found no prior studies that disaggregated their analyses of post-harvest fish losses by sex of value chain actors. The findings from this study suggest that whilst post-harvest losses were highest in the processing node, dealing with losses in this node is gendered, with women facing three times more physical losses than men. Given the extensive amount of recent social and gender research that has been carried out in the Barotse Floodplain (e.g., see Reference [51–53]), it is argued here that fish losses are partly caused by deeper-rooted gender issues that especially complicate or constrain women's abilities to adequately process fish with minimal losses in the processing node. These studies highlight unequal differences in women's and men's access to assets and their decision-making powers, reinforced by unequal gender norms, attitudes, and beliefs surrounding women's roles and capabilities. These gender constraints could partly explain why our study found differences in post-harvest fish losses between women and men.

5.2. Gender Dynamics and Fish Loss and Waste

Few studies have explored how gender impacts on loss and waste in fish value chains [16,54,55]. There has been an effort to include gender within agriculture value chain and food security research. For example, one study revealed how gender roles impacted on crop choice in Tanzania [56] or on the gender gaps in food security status between women and men in Malawi [57]. Little is known, however, on how gender influences food loss and waste specifically. This is important as the economic and nutrition implications of food loss and waste in small-scale fisheries and in other contexts could, in theory, be addressed by also considering gender relations in value chains, as well as understanding the central role of women in food production systems. Addressing food loss and waste and realizing the goals of the SDGs, therefore, should also mean addressing gender equality.

Women's gendered role as caretakers of their homes, where they disproportionately perform the majority of unpaid tasks (e.g., cooking, washing clothes, caring for children, the sick, and the elderly), for example, influences how, when, and where women process, store, transport, and trade fish [54]. Women's limited decision-making powers in certain rural African contexts dictate how much time, effort, and money they can invest in fish value chain-related activities [58]. This is evident in gender studies carried out in the Barotse Floodplain [52,53]. Power relations can further constrain groups, especially women, from accessing key resources [31]. Power relations also influence women's abilities to make decisions to forgo the completion of domestic (unpaid) tasks that they are expected to perform, and instead, engage in work outside the home that generates income [24,30], which is also evident in the Barotse Floodplain [51,53]. Certain gendered practices, such as men restricting women's movements outside the home and residence norms that limit women's overall access to land when they shift from their natal village to reside with their husbands, are still relatively common in the region. Together, these norms, practices, and power relations shape women's and men's opportunities and the benefits they derive from their natural resource base [51,53].

Certain social factors play a role in enabling and constraining women's abilities to process fish [16]. A study in Zanzibar found that women's lack of access to cold storage facilities influenced the amount of losses incurred [55]. In Nigeria, poor access to capital, technologies, extension services, training, and markets were major constraints that female processors faced compared to their male counterparts [59]. In Ghana, little or no training on how to use improved fish processing technologies negatively influenced the adoption rates for women processors [60]. None of these studies, however, provide a statistical, sex-disaggregated analysis of the seemingly inherent gendered reality of fish loss and waste. Since such social and technical constraints are evident in other studies situated in the Barotse Floodplain, we can surmise that they are a likely contributing factor to why women may have experienced higher losses than men from our study sample. Further research should aim to uncover causal links, that are social and technical, in any analysis of food production, loss and waste.

5.3. Future Research on Post-Harvest Loss Assessments

Gender-blind research tools are incapable of uncovering deeper levels of nuance to explain complex social relationships and their links to post-harvest losses. Losses are mostly framed as 'technical' and not 'social' issues that in turn require technology-based solutions to help mitigate losses. If the claims made in this study are valid, this means women will continue to bear the brunt of losses compared to men regardless of the attempts made to increase their access to improved fish processing technologies. This means loss reduction strategies that are developed to pursue SDG targets may fail if gender issues are not taken into account. Collecting sex-disaggregated data on losses can help to identify who experiences post-harvest losses in a given context. This can also help with targeting specific groups for technical and social interventions aimed at reducing losses. For example, if women primarily process and trade fish and experience severe losses through burning whilst smoking fish, technologies could be developed to help reduce these losses from a technical perspective (e.g., improved smoking kilns). They should also, however, look to reduce the time and work burdens that women may face in carrying out other (un)paid tasks within or around their homes, which may be a factor in causing losses in addition to the use of sub-optimal technologies. Failing to consider the potent impact of gender when assessing food loss and waste and designing loss-reducing strategies could hinder the achievement of SDG 12.

Whilst some of the literature suggests that the success of projects that aim to reduce post-harvest losses depends on the effective transfer of technology and information [16,27], this paper argues that the sustained use of such technologies by women and men value chain actors requires implementing interventions that also focus on improving unequal gender relations in these contexts. The knowledge and learning on how to better incorporate gender-aware approaches into post-harvest loss-reducing and other fish value chain-related projects is lacking (see Reference [61]). Research on how women and men can work together and lessen the burden of losses and make better, more-informed decisions on value chain engagement and post-harvest activities could lead to improved, sustained outcomes through the design and implementation of gender transformative approaches. Such approaches specifically address the underlying causes of gender inequalities (see Reference [62]) and, when combined with technological innovations, aim to empower women and men to work together and benefit more equitably from development efforts. See Reference [43,44] on how the results presented in this paper led to further interventions that took into account these social and technical constraints.

6. Conclusions

Worldwide, post-harvest losses are often not considered when formulating fisheries management strategies [20]. As losses occur, more fish is harvested to compensate for the loss in would-be revenues (see Reference [16]). Reducing post-harvest losses is an important strategy to enhance food and nutrition security and environmental sustainability [3] and is one of the key goals of the SDGs. This paper aimed to build on the existing literature on food (fish) loss and waste in Africa by presenting results from a gendered assessment of post-harvest losses in the Barotse Floodplain fishery in western Zambia. The key results showed that fish losses are gendered, especially physical losses, and that the highest losses occurred within the processing node, with women experiencing three times more physical losses than men. Women and men make calculated decisions to avoid losses and attain their desired prices, sometimes leading to a gamble-like decision often influenced by various technical and social constraints, as well as a constantly changing social-ecological environment. Future research should explore gender issues related to post-harvest fish losses in more depth to shed additional light on the relationship between gender, food production (including loss and waste), and food and nutrition security. To be able to attain the targets of the SDGs, particularly on food loss and waste, researchers and practitioners must also strive for greater gender equality.

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