academicJournals

Vol. 9(10), pp. 98-107, November 2017
DOI: 10.5897/IJFA2017.0638
Article Number: BDF708466822
ISSN 2006-9839

http://www.academicjournals.org/IJFA

International Journal of Fisheries and Aquaculture

Full Length Research Paper

Physical losses of fish along the value chain in Zambia: A case study of Barotse Floodplain

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Received 2 July, 2017; Accepted 29 August, 2017

The study was conducted in three districts of Western Province of Zambia namely; Mongu, Nalolo and Senanga that lie along the Zambezi River in the Barotse Floodplain. The study employed two main data tools aimed at understanding the extent of post-harvest losses in the fishing, processing and trading nodes in the fish value chain study sites. The tools were the Exploratory Fish Loss Assessment Method (EFLAM) study and a Quantitative Loss Assessment Method (QLAM) survey. The study found that physical fish losses occur at three nodes in the value chain and differ significantly ($P < 0.05$) between the nodes. On average, the processors lose the largest volume of fish (7.42%) followed by the fish traders (2.9%). The fishers experience the least physical losses at 2% although, this is not significantly different ($P > 0.05$) from the fish lost at trading node. The major cause of physical loss was found to be breakages at processing and trading nodes. There is need to introduce improved processing technologies that can reduce breakages. Furthermore, economic and nutrient losses should also be profiled to fully understand the total losses that occur within the Barotse Floodplain fish value chain.

Key words: Fish, physical losses, fishing, processing, trading.

INTRODUCTION

The fisheries subsector that includes both aquaculture and capture fisheries is important in the economy of Zambia as it supports around one million people both directly and indirectly (Central Statistics Office, 2014). Furthermore, fish contributes more than 53.4% of animal protein in the diets of Zambians (FAO, 2012) and is recognised for its nutritional quality and health benefits that have been documented elsewhere (Kawarazuka, 2010; Beveridge et al., 2013; Béné et al., 2015). Although global fish consumption per capita has grown from 9.9 kg in the 1960s to a record high of 20 kg in 2014 (FAO, 2016), the scenario in Zambia has remained subdued at 9.1 kg lower than in 1970s (Department of Fisheries, 2017). However, the fish supply per capita statistics for Zambia are calculated from the catch data from capture fisheries and production data from aquaculture, as well as including the imports. Post-harvest losses (PHL) occur along the fish value chain (FVC), yet are not accounted

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for in these statistics. Fish is a highly perishable commodity and is, therefore, likely that fish supply per capita is even lower than what is recorded. Fish losses affect negatively on the amount of fish consumed by the people and income generated by the actors along the fish value chain. The widening gap between supply and demand due to annual human population growth of around 3% in Zambia means that there is every need to reduce the losses that occur during harvest through to trading.

According to de Lucia and Assennato (1994), PHL refers to measurable quantitative and qualitative food loss in the post-harvest food system. Although fish losses along the value chain have not been determined in Zambia, they result in annual economic losses of $2 to $5 billion in sub-Saharan Africa (Béné, 2011). In Africa it is estimated that about 10% of the total weight of the world's fish catch is lost with small scale fish processing losing as much as 40% (FAO, 1984; Moes, 1980). It is reported, however, that around 70% of the total loss is due to quality losses and that in sub-Saharan Africa only around 5% of the total small-scale production is totally wasted/discarded (FAO, 1996; Akande and Diei-Ouadi, 2010).

Fish losses are categorised into two main types: the quality and physical losses. Quality loss results in the fish value chain actors sell their fish for a low price due to spoilage or damage. These fish can also be sold for a lower price due to the forces of the market (if the demand becomes lower than supply) (Diei-Ouadi and Mgawe, 2011). On the other hand physical losses are those that result in fish becoming unsaleable due to severe insect infestation and breakages or poor post-harvest handling. In this case, no income is gained and no fish is consumed since the fish is physically lost.

The Barotse floodplain in the Western Province of Zambia is the second largest floodplain in Zambia, after the Bangweulu complex. It helps meet important resource needs for its human inhabitants including their cultural and socio-economic needs (https://en.wikipedia.org/wiki/Barotse_Floodplain). The floodplain starts from the Zambezi River's confluence with the Kabompo and Lungwebungu Rivers in the north, to a point about 230 km south, above the Ngonye falls and south of Senanga. The Zambezi River that runs through the floodplain is the largest River in the country and is important in the communication and transportation of goods and services in the floodplain. In fact the country's name Zambia is derived from the Zambezi River. The flood plain is an important fishery harbouring 80 fish species and employing an estimated 4,350 fishers (Department of Fisheries, Zambia, 2012). According to the Department of Fisheries (DOF) (2016), a total of 7, 714 metric tons of fish were caught from the upper Zambezi fishery.

Although, the catch per unit effort has declined in the last three decades from 3.1 to 1.2 tons/fisher due to the increased number of fishers (Kefi and Mofya, 2015), the fisheries is still the main economic stay and source of livelihood for many dwellers along the floodplain. Subsistence and commercial fishing, and angling tourism, are major activities throughout the system, which includes several large lakes and numerous, highly productive floodplains (Tweddle, 2010; Tweddle et al., 2015). Fish provides an important source of income and protein. Consumption of fish by local residents in Western Province is estimated at about five times the national average (Baidu-Forson et al., 2014). The quantities of the fish lost between harvesting and consumption are thought to occur, but exact details remain unknown and post-harvest losses are not recognised in government databases or in national policy. This weakens the role that fish plays in the food and nutrition security of people in the region and country on the whole (Longley and Kruijssen, 2014).

The scope of this paper is to describe a study that quantitatively assessed the amounts of the physical fish post – harvest losses incurred by the actors (fishers, processors and traders) along the fish value chain (FVC), in order to shed light on this important component that should be addressed in fisheries management and policy debates. In the context of this paper FVC is defined as a full range of activities that the fish undergoes through harvest to consumption with the major nodes being fishing, processing and trading. In addition, an attempt has been made to determine the causes of the physical losses at each of the FVC nodes (excluding consumption) in the Barotse floodplain of Western Province, Zambia.

MATERIALS AND METHODS

Study areas

The study was conducted in three districts of Western Province; Mongu, Nalolo and Senanga that lie along the Zambezi River in the Barotse Flooplain (Figure 1). Six fishing camps were selected purposively in a multistage sampling technique. A fishing camp is a seasonal, temporary site where women and men conduct fishing, processing and trading activities as the water levels recede between May and October every year.

In Mongu District, Liyoyeli, Nebubela and Mukakani were the fishing camps selected while Marana was the only site in Nalolo district. Tangatanga and Matula were the sites chosen in Senanga District. The sites were selected based on the following criteria: number of fishers / processors / traders distance to the market and the availability of fish based on the catch assessment surveys conducted by Department of Fisheries (DOF). However, the main markets within the three districts were also sites for fish traders.

Data tools and sampling

This study employed two main data tools aimed at understanding the fishing, fish processing and fish trading in the study districts. These were Exploratory Fish Loss Assessment Method (EFLAM) and Quantitative Loss Assessment Method (QLAM) tools. Prior to

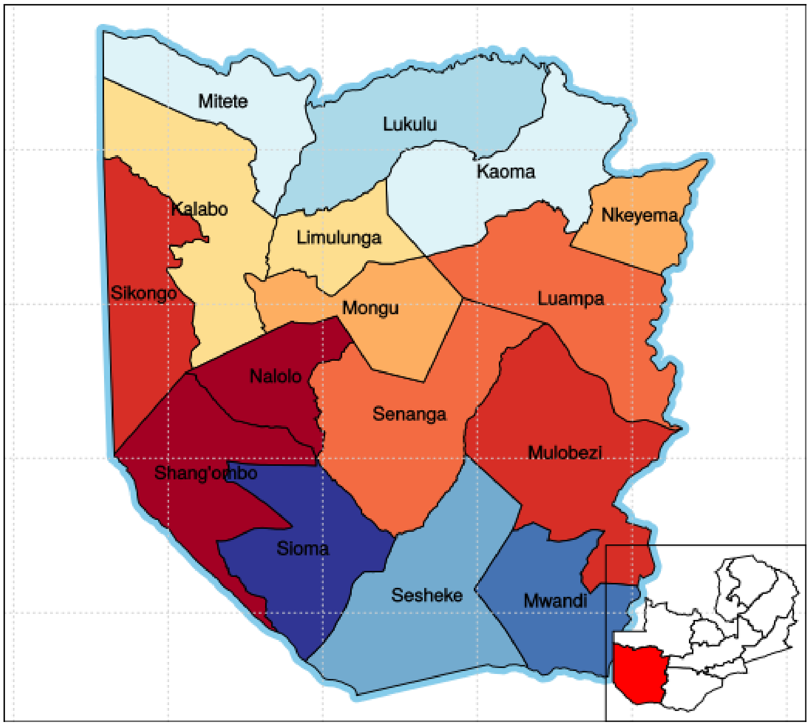

Figure 1. Map of Western Province showing the districts where the study was conducted.
Source: https://en.wikipedia.org/wiki/Western_Province, Zambia.

data collection, ethical clearance was sought from the University of Zambia, Humanities and Social Sciences Research Ethics Board (HSSREC) and consent was sought from respondents by trained enumerators. These enumerators (Department of Fisheries extension officers) were trained in data collection that included pre-testing the survey in Mongu District.

In order to calculate the size of the sample for the fishers, processors and traders, the methods employed by Cochran (1963) were used:

$$n = 1.96^2*(0.5)*(1 - 0.5)/0.05^2 = 385 \text{ fishers, processors and traders.}$$

Where $n = Z^2pq/e^2$ the sample size, z is the abscissa of the normal curve that cuts off an area at α at the tails (1 – α equals the desired confidence level e.g. 95%, therefore the precision is ± 0.05%), e is the desired level of precision , p is the estimated proportion and q is 1-p. We assumed that there were a lot of fishers, processors and traders and we took a highest variability (50%) (Israel, 2013).

However, a total of 207 fishers, 110 processors and 110 traders (total 427) were sampled with 32 people classified as being both fishers and processors. Interviews and FGDs from the EFLAM were spread over the period of three months (April to June 2015) before the QLAM across the three Districts was administered.

Exploratory fish loss assessment method and quantitative loss assessment method tools

In order to estimate the biomass losses, understand fish losses and people's experiences and attitudes around fish losses, an Exploratory Fish Loss Assessment Method (EFLAM) study was undertaken. EFLAM is a qualitative research tool that includes semi-structured interviews with individuals and Focus Group Discussions (FGDs) with groups of people.

Formally known as Informal Fish Loss Assessment Method (IFLAM), it helps to develop a qualitative understanding of losses and provides indicative quantitative data on the post – harvest fish losses (Diei-Ouadi and Mgawe, 2011). A key activity was a stakeholder meeting in Mongu (mainly involving the fishers, processors, traders, government workers and traditional leaders) which was held in February 2015. The fishers, processors and traders attending were drawn from all the selected fishing camps. The EFLAM was used to generate qualitative and indicative quantitative PHL data, that was used to develop the quantitative tool the Quantitative Loss Assessment Method (QLAM)(Annex), based on the methods described by Diei-Ouadi and Mgawe (2011). The QLAM was administered to fishers, processors and traders.

The QLAM is a formal questionnaire survey approach to quantitatively estimate the quantity of losses, type of losses incurred, reasons for losses and the variables that create loss, such as the type of fishing gear used or fish processing methods, etc. According to Akande and Diei-Ouadi (2010), QLAM is used to provide quantitative data on a wide range of issues that enables validation of data over a wide geographical area. In order to capture the effect of seasonality, the QLAM was administered for the entire fishing season from July to November 2015. Prior to data collection, the enumerators were trained in data collection and the questionnaires were pre tested in Mongu district to check any ambiguities that contained in the tools.

Statistical analysis

The physical loss of fish was calculated from the QLAM by subtracting the total amount of fish that was discarded before consignment to move onto the next node. Prior to all the measuring

Table 1. Percent of physical losses (Mean±SD) of fish at fishing node (N = 207).

District	Fish loss (%)	Minimum (%)	Maximum (%)
Mongu	0.81 ± 4.69^{a}	0	33.3
Nalolo	1.93 ± 3.82^{ab}	0	12.5
Senanga	3.67 ± 10.88^{bc}	0	50
Average	2.03±7.70	0	50

Values with superscripts in a column are significantly different ($P < 0.05$).

Table 2. Percent of physical losses (Mean±SD) of fish at processing node (N = 110).

District	Fish loss (%)	Minimum (%)	Maximum (%)
Mongu	13.81 ± 19.45^{b}	0	50.00
Nalolo	12.16 ± 10.31^{b}	0	33.33
Senanga	5.11 ± 10.68^{a}	0	50.00
Average	7.42±12.73	0	50.00

Values with superscripts in a column are significantly different ($P < 0.05$).

units, fish lost were standardised by transforming all the local measuring units into metric units. This was done by weighing the local units in triplicates and taking the average weight for each unit.

One way Analysis of Variance (ANOVA) was used to test the percent that physical fish was loss at every node. The Duncan Multiple Range Test (DMRT) was used to separate the means if significant ($P < 0.05$).

RESULTS

Physical losses of fish at fishing node along the value chain

There were significant differences ($P < 0.05$) in the physical fish losses incurred at the fishing node among the surveyed districts. Senanga fishers recorded the highest amount of fish loss with Mongu recording the lowest physical losses. On average, losses were 2.03±7.70% at the fishing node with a lot of variation as evidenced by the large standard deviation. Some fishers lose up to half of their catch (50%) as observed in Senanga District (Table 1).

Causes of fish physical losses at fishing node along the value chain

Due to a small number of fishers (N = 23) who reported to have lost fish, no statistical analysis was conducted on the causes of the losses. However, the reasons for the losses mentioned were spoilage, squashing due to poor handling and pest infestation.

Physical losses of fish at processing node along the value chain

The total physical fish losses that were experienced at the processing level were averaged 7.42±12.73%. Senanga district processors experience significantly ($P < 0.05$) lower physical losses than the processors in the other two districts under the study. Although Mongu district processors had the highest percentage of physical losses of fish, they did not differ ($P > 0.05$) with the losses experienced by Nalolo district (Table 2).

Causes of fish physical losses at processing node along the value chain

Three major causes of physical fish losses were identified by the processors. The study revealed that breakages contributed significantly ($P < 0.05$) to the fish losses. Of the sample, 72.2% of the respondents indicated breakages as the main reason for loss whilst 19.4% attributed the losses to spoilage, although this has no significant different ($P > 0.05$) from pest infestation (8.3%)(Figure 2).

Physical losses of fish at trading node along the value chain

On average, the physical fish losses at the trading node amount to 2.87±8.26%. There were significant differences ($P < 0.05$) in the physical fish losses at the

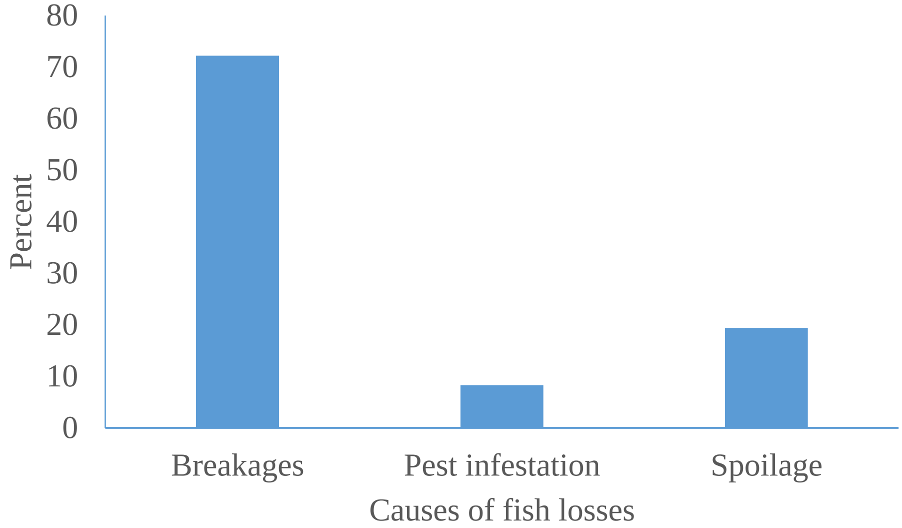

Figure 2. Causes of fish losses at processing along the value chain (values with superscripts at the top of the bars are significantly different ($P < 0.05$)).

Table 3. Percent of physical losses (Mean±SD) of fish at trading node (N = 110).

District	Fish loss (%)	Minimum (%)	Maximum (%)
Mongu	4.13±9.19^{b}	0	33.33
Nalolo	8.33±8.33^{b}	0	16.67
Senanga	1.55±7.16^{a}	0	40.00
Average	2.87±8.26	0	40.00

Values with superscripts in a column are significant different ($P < 0.05$).

trading node among the three districts. Nalolo experienced the highest fish losses followed by Mongu. The smallest losses were found in Senanga estimated at 1.55±7.16% with a high variation in responses (Table 3).

Causes of fish physical losses at trading node along the value chain

The survey revealed that there were only two causes of fish losses during trading and these were breakages and spoilage. Although there were no significant differences ($P > 0.05$) between the two causes of fish loss, the former (58.2%) contributed more to losses than the latter (41.8%).

DISCUSSION

The study of fish PHL along the value chain is the first of its kind in the Zambian fisheries subsector. And the results of this study are compared with previous fish loss assessments conducted in other parts of the world. There is a limited literature, on fish PHL globally and studies often combine with the physical and quality losses. This study revealed that fish physical losses occur throughout the value chain in the Barotse Floodplain, since every node recorded a positive loss. The estimated cumulative PHL of fish was 12.32%, with processors incurring the highest percentage loss of 7.42±12.73%.

The total losses translated to around six million United States dollars based on the fish catches was reported by Department of Fisheries (DOF) (2017). Fishers' consignments of fish experienced the lowest percentage of losses on average, and thus have the least liability in the value chain. Percentages of fish losses reported in other countries vary. According to Béné et al. (2015) the total estimated PHL of fish is around 20% in small-scale fisheries, to FAO (1996), fish losses in sub-Saharan Africa may be around 5 percent of the total artisanal production, while for the West African Region others indicate losses which occur between 10 and 20% (McConnery, 1994). Akande and Diei-Ouadi (2010), who studied PHL in five countries in sub-Saharan Africa, estimated PHL of fish at 5%, although physical losses in some countries were as high as 40%.

Therefore, the cumulative percentage loss found in the districts along the floodplain fishery is lower than the global average but within what has been reported in the region. It should be noted that discarding fish in artisanal fisheries is not common, where post-harvest methods typically utilize a wide range of species, including those that are of low commercial value (Akande and Diei-Ouadi, 2010). Nonetheless, such physical losses result in lost incomes for value chain actors and ultimately lost fish for consumers within and outside the province, including lost opportunities acquire nutritional benefits from these fish.

The major causes of fish losses in this setting were found to be node dependent. Breakages were found to be the most significant reason why physical losses occur at the processing and trading nodes. This can be attributed to the poor methods employed during processing and likely poor storage and handling in route or during trading. There is need to introduce improved processing, storage, and handling methods and technologies that can reduce breakages during processing, storage, transportation and retailing. The introduction of the cold chain within the region which provides primary preservation is key to reduce the losses incurred by the value chain actors especially those that deal in fresh fish.

Furthermore, economic and nutrient losses should be profiled to understand the total losses that occur within the value chain in the Barotse Floodplain. There is need for further studies of the fish losses according to fish forms or products in the fish value chain.

CONFLICTS OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

We are indebted to the International Development Research Center (IDRC) and the Australian Centre for International Agriculture Research (ACIAR) for funding the project “Improving Livelihood Security and Gender Relations in Rural Zambia and Malawi through Post-Harvest Fish Value Chain Innovations and Social Change Interventions’’. It is through the project that this study was conducted. Many thanks go to fishers, processors and traders who accepted to be interviewed.

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Annex: QLAM Questionnaire

1. Date of interview……………../…………./……………..
Enumerator’s Name………………………………………
2. CultiAF site: [ ]
Mukakani=1 Nebubela=2 Liyoyelo=3 Marana=4 Matula=5 Tangatanga=6

3. Name of fishing camp :……………………………………………………………………………………….

4. Name of respondent :………………………………………. 5. Gender: [ ] *Female = 0 Male = 1*

6. Contact # :……………………………(optional)

7. Marital status : [ ] *Single=1 Married=2 Polygynous=3*
Cohabitating=4 Divorced=5 Widowed=6

8. Education – years of schooling: ……………………years or grade

9. Where is your permanent place of residence? ……………………………………………………………

10. Did you fish, process, and/or trade fish in last 7 days? YES / NO
If yes continue; if no, finish the interview and thank the respondent.

11. What fish-related activities did you engage in during the last 7 days? (underline or circle)

1. Fishing	**2. Processing**	**3. Trading (buying and selling fish)**
a. Multifilament gill net	a. smoking	a. fresh fish – no ice
b. Monofilament gill net	b. sun drying	b. fresh fish – with ice
c. Trap	c. frying	c. sun dried fish
d. Hook	d. salting	d. smoked fish
e. Spear & light	e. Other:……………………	e. fried fish
f. Seine net		f. salted fish
g. Other:………………………………………………………………		g. Other:………………………………

Instructions for the enumerator

If the respondent has done fishing in the past 7 days, please complete Section B.
If the respondent has done processing in the past 7 days, please complete Section C.
If the respondent has done processing and trading, please complete Section C.
If the respondent has done trading (but not processing), please complete Section D.

All questions in Sections B, C and D refer to the most recent catch or ‘batch’ or ‘consignment’ of fish that was caught, processed, or bought and then sold. In addition, all responses within each section should refer to a single species of fish (any species that is most predominant among the different species that might have been caught, processed or bought). All responses within each section should also refer to a single product type (e.g. fresh, smoked, sun-dried). It is necessary to be very clear with the respondent about which species and product type is being referred to from the start of each section to avoid confusion.

SECTION B: FISHING.
This section should only be completed by those who have done fishing in the past 7 days.

B.1 What was the most predominant species of fish caught the **last time** you went fishing?

Species: [ ] *Lipapati=1 Nembele=2 Ndombe =3 Other=4 (specify)..........................*

B.2. Approximately how much fish of this species did you catch the **last time**?

Unit:..................... Number of units:…………… [*Unit might be pieces, bafa , plate, etc]*

B.3. Was any of the fish of this species lost from the time of catching to the time of selling (if sold fresh) or processing (if processed)? YES / NO [*If Yes, proceed to Qu. B.4. If no, go to Qu. B.6.]*

B.4. How much fish of this species did you lose **last time** you went fishing?

Unit:..................................Number of units:...........................

B.5. How did you lose this fish (physical loss)?

Main reason:…………………………………………………………………...

Other reasons*:………..

B.6. Was the fish of this species that you caught the last time processed? YES / NO
[If yes, please go to Section C. If no, please continue with the remaining questions in Section B.]

B.7. If this fish was sold fresh, where (place) did you sell this fish **last time**? ………………………………………

B.8. What was the highest price you received for this fish **last time**? ZK..............Unit…………………....

B.9. How much fish of this species did you sell for a high price last time?

Unit..................... Number of units……………

B.10. What was the lowest price you received for this fish **last time**? ZK………………Unit……………………..…

B.11. How much fish of this species did you sell for a low price **last time**?

Unit......................Number of units………………

B.12. Why did you sell fish for a low price **last time**?

Main reason:…………………………………………………………………..

Other reasons*:……
[*Include issues related to transport type, time, packaging etc.]*
** Remember to probe for non technical and gender related causes as well*
SECTION C. PROCESSSING. ***This section should only be completed by those who have done processing in the past 7 days, or those who have done processing and trading (see Qu. 11).***

C.1 What was the most predominant species of fish processed the **last time** you were processing?

Species: [ ] *Lipapati=1 Nembele=2 Ndombe =3 Other=4 (specify)..........................*

C.2. What was the product that you processed of this species: [ ]
Fresh=1 Smoked=2 Sundried=3 Salted=4 Other=5 (specify)…………………………….………

C.3. Approximately how much fish of this species did you process in this way the **last time** you processed and sold processed fish?

Unit:..................... Number of units:…………… [*Unit might be pieces, bafa , plate, etc]*

C.4 Was any of the fish of this species lost the last time you were processing, from the time of processing up to the time of sale? YES / NO. If Yes, proceed to Qu. C.5. If no, go to Question C.7.

C.5. How much fish of this species did you lose the **last time** you processed and sold fish?

Unit:............................. Number of units:...........................

C.6. How did you lose this fish (physical loss)?

Main reason:………………………………………………………………………..

Other reasons*:…….

C.7. Where (place) did you sell the processed fish of this species **last time**? ………………………………………

C.8. What was the highest price you received for this fish **last time**? ZK...............Unit…………………....

C.9. How much fish of this species did you sell for a high price last time?

Unit........................ Number of units………………

C.10. What was the lowest price you received for this fish **last time**? ZK………………Unit…………………..…

C.11. How much fish of this species did you sell for a low price **last time**?

Unit........................ Number of units………………

C.12. Why did you sell fish for a low price **last time**?

Main reason:………………………………………………………………………..

Other reasons*:……
[*Include issues related to transport type, time, packaging etc.]*
** Remember to probe for non technical and gender related causes as well*

SECTION D. TRADING. ***This section should only be completed by those who have traded but not processed fish in the past 7 days (see Qu. 11).***

D.1 What was the most predominant species of fish purchased the **last time** you bought fish?

Species: [ ] *Lipapati=1 Nembele=2 Ndombe =3 Other=4 (specify)..........................*

D.2. In what form was the fish when you bought it?

Form: [ ] *Fresh=1 Smoked=2 Sundried=3 Salted=4 Other=5 (specify)…………………*

D.3. Approximately how much fish of this species and form did you purchase the **last** time you bought fish for trading purposes?

Unit..................... No. units…………… *NB: Unit might be pieces, bafa , meda, plate, etc.*

D.4 Was any fish of this species lost from the time of purchase up to the time of sale? YES / NO.
[If yes, proceed to Question D.5. If no, go to Question D.7.].

D.5. How much fish of this species did you lose **last time**?

Unit:.................................. Number of units:...........................

D.6. How did you lose fish (physical loss)?

Main reason:………………………………………………………………………......................................

Other reasons*:………………………………………………………………………………………………………

D.7. Where (place) did you sell the fish of this species **last time**? ………………………………………

D.8. What was the highest price you received for this fish **last time**? ZK..............Unit…………………....

D.9. How much fish of this species did you sell for a high price last time?

Unit..................... Number of units……………

D.10. What was the lowest price you received for this fish **last time**? ZK………………Unit……………………..…

D.11. How much fish of this species did you sell for a low price **last time**?

Unit...................... Number of units………………

D.12. Why did you sell fish for a low price **last time**?

Main reason:………………………………………………………………………..

Other reasons*:……
[*Include issues related to transport type, time, packaging etc.]*
** Remember to probe for non technical and gender related causes as well*

THANK THE RESPONDENT FOR THEIR TIME