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Assessment of post-harvest fish losses among artisanal fishers in northeast Nigeria

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Abstract. Fish is a perishable commodity whose quality must be maintained along the production and supply chain. The study aimed at assessing post-harvest fish losses among artisanal fishers in Northeast Nigeria. A multistage random sampling procedure was adopted to select 227 respondents. Quantitative data were collected with the use of close-ended questionnaires. Data collected were subjected to descriptive statistics and a multiple linear regression model. The results of the study revealed that the majority of the fishers were uneducated married men, with mean age and fishing experience of 46 and 8 years respectively. On average, 23.15% of fish caught are lost daily at post-harvest which could be attributed to the non-availability of infrastructural facilities, low literacy level, and management problems. Furthermore, results from multiple linear regression show that age, educational qualification, fishing experience, packaging materials, the time frame of fishing activities, and days of fishing in a week were found to be statistically significant ($p < 0.05$) with post-harvest fish losses. Conclusively, to improve the livelihood, ensure food security, and reduce the cost incurred by the Nigerian government on food importation post-harvest losses should be averted through policy formulation geared towards reducing post-harvest losses, provision of infrastructural facilities, training, and retraining of fishers.
Keywords: Artisanal fishers, Food security, Post-harvest losses, Northeast Nigeria

Introduction

Food losses have been reported to cause a drastic reduction in food availability among the teaming population (Natsa 2015, Kikulwe *et al*. 2018), pose a serious threat to climate change (Chaboud and Daviron 2017), causes a sharp reduction in farmer's welfare (Natsa 2015) and conflicting with the global goal of putting an end to poverty and hunger (United Nations 2016). Unfortunately, developing countries are far from reaching this global goal, due to severe post-harvest losses in food value chains, especially those of perishable agricultural products (Kruijssen *et al*. 2020). Fish and fisheries products are the most consumed animal-based protein in both developed and developing nations (Kruijssen *et al*. 2020). In Africa, Nigeria is the second-largest producer of fish after Egypt (FAO 2016). Despite this, the country still experiences a huge shortfall in fish demand, this shortfall could be reduced if post-harvest losses are checkmated. This has made her solely depend on fish importation to augment this shortfall which cost the country over USD 625 million annually (Ashley-Dejo and Adelaja 2021).

Fish is one of the perishable commodities alongside other agricultural products whose quality must be maintained along the production-supply chain (Alam *et al*. 2021). The main cause of post-harvest losses is attributed to handling, types of packaging materials, storage facilities, and transportation network (Arah *et al*. 2015, Sinha *et al*. 2019) whereas Sub-Saharan Africa is not left out of these challenges. Fish and fisheries products are among the major food groups in Nigeria with a high level of post-harvest losses (Akpambang 2015). It has been established that about 12.1 million individuals in Nigeria are faced with severe food insecurity (FAO 2019). Unfortunately, the country is known as a food producer but her farm products are not directly

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proportional to her domestic food demand which makes her rely on food importation to meet up with her domestic demand (Ashley-Dejo and Adelaja 2022).

Annual food loss in Africa was estimated to be above USD 4 billion, exceeding the food relief fund received in the last decade which is equivalent to the annual calorie requirements of about 48 million individuals in Africa (Zorya *et al*. 2011). Nigeria's food shortfall has been attributed to a lack of technical know-how, inadequate finance, poor storage facilities, a bad road network, etc. (Kitinoja *et al*. 2019). Thus, hunger, food insecurity, and malnutrition could be traced to post-harvest losses. Food sufficiency will invariably increase food availability, reduce the amount of money spent on food and improve consumers' income (Sheahan and Barrett 2017), and reduce food spoilage due to contamination which has been reported as one of the major factors influencing post-harvest losses (Arah *et al*. 2015). It will also result in the efficient and effective use of farm input (Sheahan and Barrett 2017), reduce the cost of production, and give a better profit margin for principal actors within the production-supply chain (Obayelu *et al*. 2014). The aim of the study was to identify and measure the type and extent of fish post-harvest losses being experienced among artisanal fishers, evaluate knowledge, attitude, and practices (KAP) of fishers on post-harvest fish loss, and suggest strategies for reducing post-harvest

Materials and Methods

Study area: The study was carried out in River Yobe, Yobe State, Northeast, Nigeria. This water body is the main perennial water that flows into Lake Chad through Nigeria and took its course from the Hadejia-Nguru wetlands. The geographical location is between Latitude 10º30"N – 13 º5"N and Longitude 8º20"E – 15º5"E, with a catchment area of almost 32,900km^2 (Ashley-Dejo *et al*. 2022a).

Sampling procedure and sample size: A multistage random sampling procedure was adopted for this study, which was divided into two stages. Stage I; selection of landing sites which was done randomly by selecting 40% from the list of landing sites obtained from the Yobe State Ministry of Agriculture (Fisheries Department). This resulted in eight (8) landings being sampled. In stage II, 227 respondents were randomly selected. This sample size was arrived at by adopting the formula developed by Cochran (1977). This formula is as follows:

$$n = z^2 X\ p\ X\ \frac{q}{e^2} \quad \text{..... (v)}$$

Where, n = sample size, Z = standard normal deviation set given as 1.96 at 95% confidence level, p = estimated proportion (the proportion of artisanal fishers 18% according Arthur *et al*. (2005)), q = 1 – p and e is the level of precision (an error of 5%).

Thus, $$n = 1.96^2\ X\ 0.18\ X\ \frac{0.85}{0.05^2} \quad \text{..... (vi)}$$

which gives 227 and was taken as the number of respondents to be sampled. At the end of questionnaire administration, 27 questionnaires were discharged due to incomplete information. Thus 200 questionnaires were used for data analysis.

Data collection and analysis: Questionnaires were administered at the landing site. Farmer's consent was sought and enumerators were well trained before the commencement of questionnaire administration. Quantitative data such as demographic characteristics were collected with the use of close-ended questionnaires. Also, information on fishery activities, fishing equipment, handling, knowledge, attitude, and practices (KAP) on post-harvest fish losses and causes of post-harvest fish losses were captured in the questionnaire. Data collected were subjected to descriptive

statistics (frequencies, percentages, mean, minimum, maximum, and standard deviations). Also, a multiple linear regression model (equation ii) was used to assess factors influencing post-harvest fish losses. The model was adopted because of the continuous dependent variables.

Conceptual Framework: Losses in agricultural products are classified as either quantitative or qualitative which occur along the production-supply chain (Kulwijila 2021). According to existing literature, it has been established that there is a hypothetical link between factors influencing losses and post-harvest losses. These factors have been categorized as either biochemical, mechanical, psychophysical, or environmental (World Bank 2012, Mebratie *et al.* 2015), it reduces the quality and quantity of agricultural products along the production-supply chain (Kikulwe *et al*. 2018). Therefore, this study focused on the assessment of post-harvest fish losses of artisanal fishers in Northeast Nigeria which have not been empirically studied.

Analytical techniques: In assessing the influence of demographic factors on post-harvest fish losses, Cobb-Douglas function was adopted. According to Hossain and Miah (2009), this production function can generally be written as

$$Y_i = \beta_{0i} X_{1_i}^{\beta_1} + X_{2_i}^{\beta_2} + X_{3_i}^{\beta_3} + \dots\dots\dots X_{n_i}^{\beta_n} e^{\varepsilon} \quad \text{..... (i)}$$

Where, Yi = Dependent variable (percentage fish lose); β_0, β_1 - β_n = set of parameters to be estimated; Xi = vector of independent variables as shown in Table I; and ε = error term assumed to follow normal distribution with mean equal to zero and constant variance σ^2. The equation above was transformed to obtain a linear relationship between the dependent variable and explanatory variable as shown in equation (ii).

$$LnYi = ln\beta 0 + \beta 1 lnX1 + \beta 2 lnX2 + \dots + \beta 10 lnX10 + \varepsilon \quad \text{.....(ii)}$$

Where, Yi = Dependent variable (percentage fish lose); β_0, $\beta_1 - \beta_{10}$ = set of parameters to be estimated; $X_1 - X_8$ = vector of independent variables; and ε = error term assumed to follow normal distribution with mean equal to zero and constant variance σ^2.

Estimation of total percentage losses:

This was expressed as $= \frac{\text{Financial Losses}}{\text{Expected Income}} \times 100$ ..... (iii)

Where, Financial Losses =

$$\text{(Best price x overall weight low – quality fish) – (Reduced price x overall weight low – quality fish)}$$

.....(iv)

Table I. Description of determinants of post-harvest fish losses among artisanal fishers

Variables	Description	Unit
Gender	Dummy variable: (1 = male, 0 = female)	Dummy
Age	Artisanal fisher's age	Years
Marital status	Dummy variable: (1 = married, 0 = single)	Dummy
Household size	Number of artisanal fishers' family	Number
Educational level	Educational qualification of artisanal fishers'	Years
Fishing experience	Years of Fishing Experience	Year
Time frame of fishing activities (hour)	Hours spent per fishing trip	Hours
Days of fishing in a week	Number of days used for fishing/week	Number
Packaging materials	Dummy variable: (1 = yes, 0 = no)	Dummy

Results and Discussion

Demographic characteristics of the respondents: Table II revealed the demographic characteristics of artisanal fishers in the study area, it was observed that almost (90.5%) all the households were male-headed which agrees with African culture and beliefs. This shows that men are key players in fish production and also revealed the true picture of homeland agriculture in Northern Nigeria. This implies that fish losses will have a negative effect on the livelihood of the farmers. It was future observed that most (62.5%) of the respondents were married individuals. This gives a clear indication that fishers in this region are of labor advantage in production and post-harvest handling. Respondents' age ranged from 25 – 68 years with a mean age of 45.58 years. This suggested young, energetic, and productive individuals. The majority (48.0%) were within 31- 40 years, this age range has been tagged productive age as well as active economic age (Ashley-Dejo and Adelaja 2022, Ashley-Dejo *et al*. 2017). Literacy level was assessed through educational qualification, about 30.0% had post-primary education. This implies that respondents in the study area had low literacy levels which might negatively affect the efficiency and adoption of post-harvest handling practices among artisanal fishers in this region. However, farmers with secondary education had been identified to understand the dynamic of farming, adoption, and utilization of improved technology geared toward reducing post-harvest losses (Moloi 2008). Babalola *et al*. (2010) opined that farmers with low literacy levels hardily adopt nor appreciate most of the improved post-harvest technologies. The fish farming experience of artisanal fishers in this region could be considered moderate which could be used to avert post-harvest losses. The result further shows that artisanal fishers have large dependents which could be translated to high labor and on-farm and off-farm participation resulting in additional income. While on the other hand, it can result in high poverty level and having more people to carter for. It was also observed that few farmers belong to farmers' groups/associations for different reasons either for social recognition, means of assessing finance from government and non-governmental organizations, purchase of fishing inputs, etc. Majority of artisanal fishers in this region deprived themselves of these opportunities which might be blamed on their low literacy level. Farmers that are involved in farmer's groups/associations are expected to generate more income (Moloi 2008).

Table II. Demographic characteristics of artisanal fishers in the study area

Variables	Frequency	Percentage
Gender		
Male	181	90.5
Female	19	9.5
Marital status		
Single	47	23.5
Married	125	62.5
Divorced	15	7.5
Widowed	13	6.5
Age (years)		
Less than 31	10	5
31 – 40	96	48
41 – 50	16	8
51 – 60	34	17
Above 60	44	22
Mean $\pm$ std	45.58 $\pm$ 14.03	
Educational qualification		

No formal education	52	26.0
Primary education	86	43.0
Secondary education	49	24.5
Tertiary education	13	6.5
Fishing experience (Years)		
Less than 10	156	78.0
10 – 15	22	11.0
16 – 20	16	8.0
Above 25	6	3.0
Mean±std	8.37±6.38	
Household size		
Less than 10	125	62.5
10 – 20	61	30.5
Above 20	14	7.0
Mean±std	9.31±3.02	
Member of fish association group		
Yes	85	42.5
No	115	57.5

Fishery activities at the landing site: The results in Table III revealed the fishery activities adopted by fishers at landing sites in the study area. It was observed that most (58.5%) of the fishers spent between 11 – 12 hours per fishing trip while almost 40.0% spend more than 13 hours. On average, a fishing trip per day was estimated as 12 hours, and 192 hours monthly (16 days). This implies that the quantity of fish harvested in River Yobe is a function of time spent because the water body is abundantly rich in fauna and flora (Ashley-Dejo *et al.* 2022b). This shows that the fishery is self-sustenance and serves as a source of food and livelihood for thousands of fishers in this region. During the study, it was observed that fishers do not make use of ice cubes when transporting catch. This was blamed on the epileptic supply of electricity. Also, harvested fish are exposed directly to sunlight thus increasing the rate of spoilage. Fishers in this region are guilty of the aforementioned practices, during transportation and even at the point of sales. The result further shows that the majority (67.0%) of the fishers acknowledge that they do experience losses while some still believed that so far they were able to sell their harvest, not minding the price, this is not termed losses. On average, 23.15% of fish caught are lost daily to post-harvest. Yohanna *et al*. (2011) submitted that inappropriate handling practices on harvested fish will expose the fish earlier to deterioration after 12 hours of harvest. Also, Diei-Ouadi and Mgawe (2011) and Nguvava (2013) opined that harvested fish exposed to sunlight directly deteriorate faster compared to fish that are prevented from direct contact with sunlight. However, high percentage losses recorded in this study could be blamed on the aforementioned practices, but surprisingly, fishers in this region hardly trash spoilt fish, the fish will still be purchased in as much it has not gone beyond rigor. This could be attributed to the poverty level in this region. Northeast Nigeria has the highest poverty headcount rate of 71.86% in the country **(**Bukar *et al.* 2018) coupled with the fact that this region is highly populated and the most consumed animal based-protein in this region is fresh fish.

Table III. Fishery activities at landing site

Variables	Frequency	Percentage
Daily fishing trip (hours)		
Less than 10	15	7.5
11 – 12	117	58.5
13 – 15	30	15.0
16 and above	38	19.0
Mean±std	11.73±5.01	
Weekly fishing trip (days)		
1 – 2	58	29.0
3 – 4	60	30.0
5 and above	82	41.0
Mean±std	4.12±0.83	
Do you experience loss/losses?		
Yes	134	67.0
No	66	33.0
Fish loss per day		
1 – 5	8	4.0
5 – 10	9	4.5
11 – 15	15	7.5
Above 15	102	51.0
Mean $\pm$ std	23.15 $\pm$ 5.93	

Knowledge, attitude, and practices of fishers on post-harvest losses: The results in Table IV revealed the knowledge, attitude, and practices of fishers on post-harvest losses. It was quite unfortunate that most of the fishers in the study area do not adopt nor adhere to the basic recommendation of the Food and Agricultural Organization in preventing losses of perishable agricultural products. Fish is highly perishable; this makes it liable to deteriorate faster coupled with the harsh climatic condition of the region. Several authors have opined that harvested fish should be gutted almost immediately after the catch to retain it freshness and delay spoilage (Enujiugha and Nwanna 1998). Harvest fish that are not gutted immediately deteriorate faster than gutted ones Jeeva *et al*. (2007). Mungai (2014) and Oyeroand Oladele (2016) further stress that gutted fish after catch retains its quality longer than the ungutted catch. Yohanna *et al*. (2011) revealed that harvested fish could retain its freshness and wholesomeness if properly handled for a minimum period of 12 hours. Thus, there is a tendency of recording high post-harvest losses in a region or location where fishers are not well-informed nor adopt appropriate post-harvest handling practices.

Table IV. Knowledge, attitude, and practices (KAP) of fishers on post-harvest fish loss

Variable description	Yes Freq %	No Freq %
Ensuring/adopting specific time for setting, checking, and hauling set nets	15 (7.5)	185 (92.5)
The use of insulated containers to calm the temperature of harvested fish during transportation and at the point of sale	72 (36.0)	126 (64.0)
Placing of harvested fish under cool or shady area during transportation and at point of sale	53 (26.5)	146(73.5)
Washing and gutting of harvested fish before transporting it to point of sale	59 (29.5)	141 (70.5)
Involve in any training on fish handling and post-harvest losses	35 (17.5)	165 (82.5)
Observation of changes in fish coloration after harvest, during transportation, or at the point of sale	6 (3.0)	194 (97.0)

Causes of post-harvest fish losses in the study area: The results in Table V revealed the causes of post-harvest fish losses in the study area. Out of eight factors identified as a key player of post-harvest losses in this region, lack of ice, cold room, and insulating materials to preserve harvested fish results to quality losses was rated high followed by lack of covering materials of harvested fish, especially at the landing site and point of sales results to quality losses. While the high temperature was rated third. The case of bumper harvest during the rainy season was rated least. The cause was assessed using Five-Point Likert Scale and a mean above 3 points was adopted as the causes of post-harvest fish losses. Although all the causes of post-harvest fish losses in the study area are of importance and should be improved upon to better the livelihood of fishers' households and ensure food security in Nigeria. Bataringaya (2007), Nguvava (2013), Mungai (2014) and Tesfay and Teferi (2017) opined that harsh temperature, and lengthy time intervals during hauling contribute immensely to post-harvest losses.

Table V. Causes of post-harvest fish losses in the study area

Causes	Weighted mean	Ranking
Lengthytime interval between fishing, and transportation of harvested fish to point of sale results in losses	3.97	4th
High temperature	4.02	3rd
Inappropriate fishing gear used by the fishers causes quality loss	3.78	7th
Poor handling of harvested fish results in quality losses	3.83	6th
Lack of covering materials of harvested fish, especially at the landing site and point of sales results in quality losses	4.13	2nd
Lack of ice, cold room, and insulating materials to preserve harvested fish results in quality losses	4.14	1st
Bumper harvest during the rainy season cause post-harvest losses	3.63	8th
Time spent in hauling of harvested fish might result in poor quality harvest	3.97	4th

Relationship between demographic factors and post-harvest fish loss: A linear regression model was adopted to determine the relationship between demographic factors and percentage loss. Table VI revealed that the estimated Adjusted R-square value was 71.4% which implies that the variables listed in the model were essential and of a good fit with a good predictive ability and it accounts for 71.4% of adjustment in post-harvest fish losses in the study area. Age, educational qualification, fishing experience, and packaging materials were negatively significant ($p< 0.05$).

The estimated coefficient parameters show that every unit increase for negatively significant independent variables will result in to decrease in the dependent variable and vice versa. Additional years in artisanal fisher's age will reduce post-harvest loss by 2.73%. This implies that an increase in artisanal fisher's age will lead to a decrease in post-harvest losses. As artisanal fishers gain knowledge on fishing activities over time this affects post-harvest losses positively. Also, age is a vital demographic feature as it influences the size and quality of the workforce. Fish post-harvest losses will reduce by 1.01% with an increase in formal education acquired by fishers in this region. High post-harvest losses observed in this study could be attributed to low literacy level among artisanal fishers. High literacy level and training as the potential to improve farmers' wiliness of evaluating and adopting improved post-harvest technologies, is also directly proportional to the complexity of post-harvest technologies. Farmers are considered literate when they acquired post-primary education and illiterate when there is no record of any form of formal education or only had primary education (Ashley-Dejo 2016). Furthermore, fish post-harvest losses will reduce by 0.297% with a unit increase in fishing experience. This implies that as fishing experience increases post-harvest losses decreases. Experience is the acquisition of more knowledge, skills, and practices which often results in the adoption of improved technologies among fishers. A unit increase in packaging materials will reduce post-harvest losses by 0.18%. This implies that the adoption of packaging materials will reduce post-harvest losses, boost farmers' income and ensure food security throughout the region and country at large. The time frame of fishing activities and days of fishing in a week were found to be positively significant ($p< 0.05$). The result indicated that there is a likelihood of an increase in post-harvest losses if the time frame of fishing activities and days of fishing increase. This will result in more catch, and high post-harvest losses as a result of inadequate storage/packaging materials.

Table VI. Regression model on effect of demographic factors and percentage total loss

Variables	Coefficient	Std. Error	T	p-value
(Constant)	0.941	0.452	2.082	0.000*
Age	-2.73	0.84	-3.250	0.000*
Marital status	0.021	0.63	0.033	0.650
Educational qualification	-1.103	0.341	-3.235	0.000*
Fishing experience	-0.297	0.164	-1.811	0.000*
Household size	0.531	0.217	2.447	0.543
Time frame of fishing activities (hour)	0.186	0.089	2.090	0.000*
Days of fishing in a week	0.246	0.114	2.158	0.000*
Packaging materials	-0.183	0.429	-0.427	0.000*
R^2	0.729			
Adjusted R^2	0.714			
F-value	57.429			
P-value	0.000			

*Significant ($p< 0.05$)

Post-harvest losses are one of the major challenges faced by artisanal fishers in northern Nigeria. Despite the effort of artisanal fishers toward food security, this region still suffers food insecurity which could be attributed to several factors such as non-availability of infrastructural facilities (post-harvest handling, electricity, accessible road network, and provision of storage facilities), low literacy level, and management problems. The availability of the aforementioned factors will avert wastage due to post-harvest losses, ensure freshness of catch, command good price, increase farmers' take-home, and prevent disease outbreaks. Therefore, government policy geared towards reducing losses as a result of post-harvest losses should be given adequate

attention and special consideration. A significant reduction in food wastage due to post-harvest losses will reduce the cost incurred by the Nigerian government to augment the fish deficit thereby reducing the country's current debt profile.

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