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INFLUENCE OF POSTHARVEST LOSSES ON HOUSEHOLD WELFARE AMONG AQUAFARMERS IN KENYA

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ABSTRACT

Research background: The trend in aquafarming has been increasing over the years, thereby meeting the deficit in fish production caused by capture fisheries. Aquafarming is a source of income and food for most Kenyan populations. Despite the increased fish production, postharvest losses in fish production have remained a challenge over the years. These postharvest losses resulted from high transport costs, poor preservation methods, inadequate storage facilities, and poor handling and mismanagement. The postharvest losses result in quality and quantity losses in fish production, thereby affecting the income received by farmers.
Purpose of the article: This paper analyses the effects of postharvest losses on household welfare among aquafarmers in Kenya.
Methods: Primary data was collected in Kiambu, Kirinyaga, Nyeri, Kakamega and Siaya Counties in Kenya. Semi-structured questionnaires were used to collect the data on a sample size of about 300 farmers. This study used a two stage least square was used to analyse the effects of postharvest losses on household welfare. Access to preservation facilities and distance to the market were considered instrumental variables in the model.
Findings & Value added: Results indicated that postharvest losses were negatively significant on household welfare. On the other hand, farmer's age, ownership of land, and the size of land under crop were also significant on household welfare. Due to inaccessible markets, postharvest losses result in to decline in farmers' income, hence welfare loss. The study recommended investment in preservation facilities and road infrastructure to reduce the number of postharvest losses in fish in an attempt to improve the welfare of farmers.

Keywords: aquafarming; household welfare; postharvest loss
JEL Codes: C12; C36; C83

INTRODUCTION

The global capture fisheries have been declining over the years due to increased fishing and high population growth (**Opiyo *et al.*, 2018**). On the other hand, aquaculture production has been rising over the years and has formed the large volume of fish consumed by humans. Aquafarmers have continued to experience high postharvest losses due to challenges in accessing the market (**Jacobi, 2013**). In the Second Medium-Term Plan (2013-2017) of the Vision 2030, the Government of Kenya emphasized the value of marine resources. The government introduced measures that ensured enforcement of fishing regulations and effective management practices to improve the potential for the fisheries and protect the biomass of fish. In addition, the blue economy blueprint, which is one of Kenya's Big Four Agenda, is a policy tool adopted in 2017 to help achieve the vision 2030 development agenda. The blue economy concept recommends methods for use in aquacultures such as cage culture (found in lakes, dams, ocean, and rivers), aquaponics or greenhouse, pens, breeding, and restoring commercially indigenous species **(Blue Economy, 2017)**.

Fish marketing is significant in poverty alleviation, food security, and sustainable agriculture **(Nyaga *et al.*, 2016)**. A study done by **Tesfey & Teferi (2017)** indicated that a colossal amount of postharvest loss resulted from inadequate storage facilities, poor handling and mismanagement, high transport costs, and outdated preservation methods. Without an assured market, large quantities of fish end up spoilt with implications on farmer's income, hence contributing to welfare loss **(Nyaga *et al.*, 2016)**.

Several efforts by the government of Kenya are primarily focused on the production side with less emphasis on marketing. These efforts are initiated because aquafarmers have continued to experience challenges in selling fish from their farms due to inadequate investment in the market, including storage facilities and preservation methods **(Nyaga *et al.*,2016; Meena, 2014)**. Hence, it limits the ability of the farmers to sell fresh fish, which attracts higher prices. Furthermore, organizing aquafarmers to access and actively participate in the market remains a significant challenge facing fish marketing **(Mohammed *et al.*, 2019)**. As a result, due to the highly perishable nature of fish, it has been observed that most aquafarmers have challenges accessing formal market outlets. The intermediaries have taken advantage and offered relatively lower prices for the fish, hence reducing farmers' household income. Therefore, this paper intends to analyse the influence of postharvest losses on household welfare.

LITERATURE REVIEW

According to **Diei-Ouadi *et al*. (2011)**, postharvest losses in the fisheries sector are highest among all other sectors. Postharvest losses in fish may result in financial losses since poorly processed fish or spoiled fish are sold or discarded at a low price. The low price leads to low household income. Since there is a high global demand for fish, a reduction in postharvest losses would significantly satisfy the consumer demand for fish through improvement in the quality and quantity of fish **(Opiyo *et al*., 2018)**.

Tesfay & Teferi (2017) carried out a study assessing fish postharvest losses in Tekeze dam and Lake Hashenge Fishery Associations in Northern Ethiopia. The results showed that the fishery associations were experiencing massive postharvest losses due to poor postharvest handling, poor storage facilities, and mismanagement. These postharvest losses contribute to Ethiopia's economic and nutritional waste, which was at risk of protein malnutrition. In addition, high postharvest failures lead to low household income and poor livelihood. **Tesfay & Teferi (2017)** proposed various measures to reduce postharvest losses, including introducing retaining cages, proper management of the refrigerators, decreasing fish harvest when refrigerators are already full, easy access to the storage area and refrigerated area. In addition, there is a need to have complete control of the refrigerators, and separating the spoiled fish from the healthy fish was proposed. The study also suggested that there should be careful treatment in handling and processing fish to increase the farmers' income. The study found that preservation is an essential aspect of the fishery associations.

A study was carried out by **Cole *et al*. (2018)** on postharvest fish losses. Unequal gender relations in Zambia revealed that 65 percent of the fish extracted from capture fisheries was processed using the open-air sun drying technique and the smoking methods due to inadequate cold chains and longer distance between the point of harvest and the market. The results showed that women were experiencing three times more physical losses than men. Fish losses among the fish value chain actors averaged 29.3 percent, with the quality losses at 22.9 % and the material losses at 6.4%. **Diei-Ouadi *et al*. (2011)** indicate that in Sub-Saharan Africa, the majority of the fish losses are quality losses; hence, there is a need to reduce postharvest losses that would improve household income.

Bolorunduro & Adesehinwa (2005) studied the status of awareness and adoption for the disseminated improved postharvest fisheries technologies among the fish processors in the North-western Zone of Nigeria. The study revealed that only 43.1% of the respondents knew about improved fish smoking kilns disseminated in the zone. Some of the constraints associated with this improved technology include scarcity of the kilns, high prices for the kilns, and technical features that were difficult to understand. These enhanced fish processing technologies can reduce postharvest losses, resulting in increased household income.

DATA AND METHODS

Study Area

This study was conducted in Kenya in five counties, including Kiambu, Siaya, Nyeri, Kirinyaga, and Kakamega. These counties were selected since they offer provide market for fish, have high population that is potential for fish consumers. Furthermore, these counties have favourable climatic conditions necessary for aquaculture production. Figure 1 shows the map of the study area.

Sample size

The sample size was determined using the formula given by **Kothari (2004)** (Equation 1).

$$n = \frac{z^2pq}{e^2} \qquad (1)$$

Where: n desired sample size; z the critical value (1.96) obtained at 95 percent confidence level; p the proportion of the population of interest (0.5). It is set at 0.5 to get a reliable and sufficient estimate; q the weighting variable; $1 - p$ and e *is* the acceptable error.

Kothari (2004) accepts an error of less than 10 percent; thus, this study used an error of 0.0566, which is precise hence a smaller sample size that could fit the budget for the study.

$$n = \frac{1.96^2 0.5 * 0.5}{0.0566^2} = 299.79$$

This was approximated to get a sample size of 300 fish farmers. The farmers to be interviewed were calculated using the population size in the various counties according to the data from Kenya National Bureau of Statistics, 2009 **(KNBS, 2019)**.

Table 1: Distribution of Sample size in the Counties

County	Population	Percentage in proportion	Number of Households
Nyeri	693,558	12.98	39
Siaya	842,304	15.75	47
Kiambu	1,623,282	30.35	91
Kirinyaga	528,054	9.87	30
Kakamega	1,660,651	31.05	93
Total	5,347,849	100	300

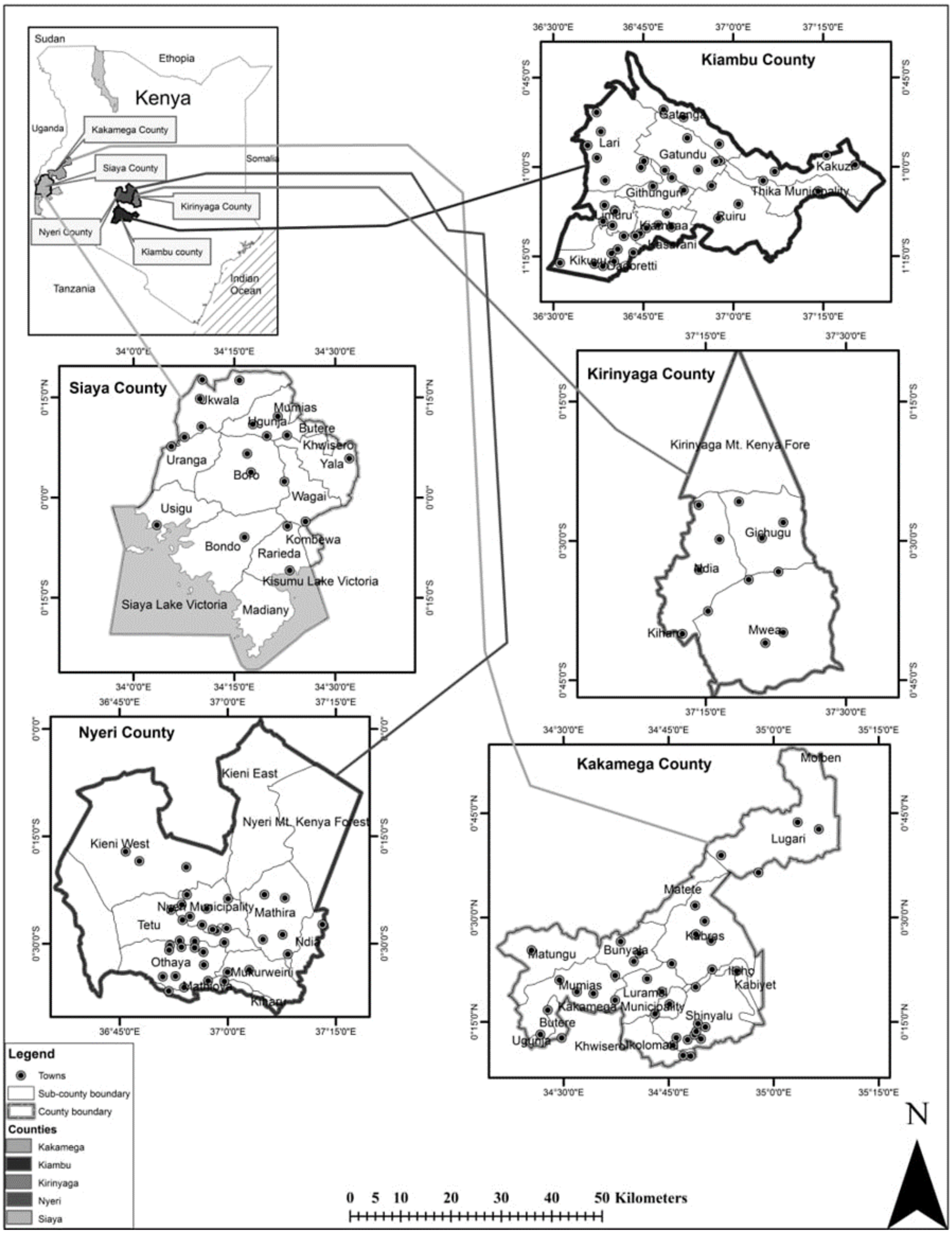

Figure 1: Map of the study area

Empirical Model

This study used the instrumental variables (IV) method, specifically the two-stage least squares (2SLS) regression analysis. Household income was used as an indicator of household welfare. While other indicators of measuring household welfare include true welfare indexes, total household expenditure, and total household income, this study preferred the total household income since it is simpler to use. The IV method is used in handling models with endogenous explanatory variables. It is used when at least one of the right-hand side variables in a regression model is correlated with the error term. This method was appropriate given the possible reverse causality between postharvest loss and household income. The Ordinary Least Squares (OLS) technique cannot be used in this case, given the apparent violation of the exogeneity assumption. The influence of postharvest losses on household income cannot be predicted directly since postharvest loss is an endogenous variable hence the use of the IV method.

2SLS is a method that uses the instrumental variables in computing the estimated values for the predictors' variables (first stage); the calculated values are then used in the second stage to assess the dependent variable's linear regression model. A valid instrumental variable must be correlated with the endogenous variable but not with the error term. In the first stage of the 2SLS, the instruments including preservation, distance, and access to value addition were regressed on endogenous explanatory variable (postharvest loss) in computing the estimated predicted postharvest loss. The first stage equation of the 2SLS was represented by Equation (2).

$$R_i = \beta_0 + \beta_i X_i + \beta_i Z_i + \lambda_i \quad (2)$$

Where: R_i represents postharvest loss; β_0 constant; β_i vector of parameters; X_i exogenous variables, including age, years of education, gender, household size, distance to the market, land size under crop, land size under aquaculture, linkages to fingerlings market, access to income from other businesses and access to income from off-farm labour. Z_i instrumental variables, including preservation and distance to the market; λ_i the error term.

The predicted value of the postharvest loss was therefore used in the second stage to estimate the influence of postharvest losses on household income, as illustrated in Equation (3). The predicted value obtained in stage one replaced the endogenous variable. OLS was then applied to the structural equation to get consistent estimates of the parameters.

$$Y_i^* = \alpha_0 + \alpha_i X_i + \alpha_i\, prdctpsthlos + \mu_i \quad (3)$$

Where Y_i^* represents household income, *prdctpsthlos* is the predicted postharvest loss; α_0 and $\alpha_i X_i$ are the coefficients to be estimated and μ_i is the error term.

Diagnostic tests

A test to check the multicollinearity that was conducted to verify the validity of the model was carried out. In detecting the presence of multicollinearity, variance inflation factor (VIF) was used to test for correlation between two or more independent variables and the strength of correlation. VIF value of 1 is good for the model since it indicates no correlation between the independent variables. VIF values between 1 and 5 show moderate correlation, which requires no measures to be taken. On the other hand, a VIF value of more than 5 indicates a critical value of multicollinearity. Some potential solutions to solve multicollinearity are combining independent variables linearly and analysing highly correlated variables, including partial least squares and principal component analysis. Durbin and Wu-Hausman test was used to test for endogeneity. F-test was used to test for the validity of the instrument. Good instruments satisfy the condition (Equation 4).

$$\mathrm{Cov}(Z_i, \varepsilon_i) = 0 \quad (4)$$

Z affects Y only through X.

Bad instrument, however, satisfies the condition in Equation (5).

$$\mathrm{Cov}(Z_i, \varepsilon_i) \neq 0 \quad (5)$$

Where β_{IV} need to be asymptotically inconsistent.

Sargan test was used to test for over-identifying restrictions validity of the instrument, while Basman test was appropriate in testing for over-identification.

RESULTS AND DISCUSSION

Two-stage least square was used to examine the influence of postharvest losses on household welfare, where household income was used as a proxy. The variables included in the model include gender, age, education level, household size, land size under crop, land size under aquaculture, access to off-farm income, ownership of land, linkages with fish market, and linkages with feed market facilities. The likelihood ratio test in the model (Chi2 (11) = 261.43) probability > Chi2 =0.0000) was significant, indicating that the association between the independent variables was statistically significant. R-Squared and Root Mean Squares of Errors (RMSE) were the determining coefficients of the model. Results indicated an R-squared value of 52.35 percent, implying a higher percentage of variability of the dependent variables. However, the 2 SLS model does not consider the number of variables used to fit in the model. Thus, RMSE was deemed to be appropriate. The RMSE was 80.12 percent; hence the model was fit.

Durbin and Wu-Hausman tests were conducted in testing for endogeneity, where Durbin (score) Chi2 (1) = 7.14422 (p= 0.0075) and Wu-Hausman F (1,253) = 6.98261 (0.0087). These p values were less than 0.05; the null hypothesis was rejected, indicating that postharvest loss was endogenous in the model. Hence, we can rely on the results of the two-stage least squares, in addition to postharvest losses, age, land size under crop, and ownership of land significantly affected household income.

Access to preservation facilities and distance to the market were used as instruments in the model. In testing for the strength of the instruments, results indicate that the partial R-Square was 54.31%, which implies that the variables still fit the model after excluding the instruments. The F statistics (25.70) were more significant than any of the critical values in Table 2; thus rejecting the null hypothesis that the instruments were weak; hence the instruments were considered strong.

Sargan and Basman tests were used in testing over-identifying restrictions. The p values for Sargan and Basman tests were 0.3542 and 0.3654, respectively. The p values were larger than 0.1, indicating failure to reject the null hypothesis of no over-identifying restrictions, implying that the model was well specified. Table 3 presents the results of the first stage of the 2SLS model. Access to preservation facilities and distance to the market were treated as instruments of postharvest loss. Results indicate that both access to preservation facilities and distance to the market was significant in the first stage regression of 2SLS. In terms of access to preservation facilities, studies indicate that preserved food products are more stable, permit high diet diversity, improve the level of digestibility, and give buyers the ability to choose a variety of products as well as a range of vitamins and minerals **(Kiaya, 2014)**. As a result, this increases the willingness of the traders to purchase from farmers with preserved fish since most buyers prefer them.

Distance to the market was positively significant on postharvest loss. The positive relationship implies that a longer distance to the nearest market translates to a longer time to transport fish. Studies reveal that farmers would choose marketing points near the farm as long as they are more accessible **(Bardhan *et al.*, 2012)**. The finding by Ismail and **Changalima (2019)** indicated that the mode of transportation determined the number of postharvest losses in agricultural commodities, which affected profitability. Similar research by **Sheahan & Barrett (2017)** noted that poor road infrastructure is attributed to high postharvest losses in most sub-Saharan countries. This finding is closer to the study by **Ansah *et al.* (2018)**, which established that postharvest loss management positively influences the welfare of farmers. This study found other factors, including household size and land size under aquaculture, positively impacted postharvest loss. In contrast, the study found the age of the household head and ownership of farms for aquaculture negatively significant on postharvest loss. Table 4 presents results on the influence of postharvest loss on household welfare.

The results presented above in Table 4 indicate that the coefficient of postharvest loss was negative and statistically significant at a 1 percent level. It shows that a unit increase in postharvest losses decreases farmers' income by 0.1 percent. This finding aligns with the earlier assumption that farmers with high postharvest losses are more likely to have low household welfare **(Getu *et al.*, 2015)**.

Table 2: Testing for weak instruments

Variable	R-Squared	Adjusted R-Squared	Partial R-Squared	F(2,253)	Prob > F
postharvestloss	0.2345	0.1982	0.5431	25.69966	0.0038

Minimum eigenvalue statistic = 25.69966				
Critical Values	# of endogenous regressors:1			
Ho: Instruments are Weak	# of excluded instruments:2			
2SLS relative bias	5%	10%	20%	30%
	(not available)			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.93

Source: Field Survey, 2018

Table 3: Results of First of Stage Least Squares Regression

postharvestloss	Coef.	Std.Err.	P>|Z|	95% Confidence Interval	
Gender	-152.685	114.771	0.185	-378.714	73.344
Household size	24.909*	13.344	0.063	-1.371	51.188
Age	-5.699*	3.051	0.063	-11.709	0.310
Ownership of land	-488.109***	79.728	0.000	-645.123	-331.095
Access to off-farm income	-28.050	90.111	0.756	-205.512	149.412
log_landsizeaq	47.0549***	16.607	0.005	14.34914	79.76065
log_landsizecrop	72.864	60.549	0.230	-46.380	192.109
Linkages with fish market	61.318	101.863	0.548	-139.289	261.926
Linkages with feed market	66.2099	78.608	0.400	-88.599	221.019
Education level	5.091	11.483	0.658	-17.524	27.705
distance	2.429 ***	0.787	0.002	0.879	3.979
Access to preservation	-144.706**	88.639	0.014	-319.270	29.858
_cons	468.417	246.308	0.058	-16.658	953.493

Table 4: Results of the Two Stage Least Squares

log_household income	Coef.	Std.Err.P>|Z|	95% Confidence Interval	
Postharvest loss	-0.001***	0.0000.000	-0.002	-0.001
Gender of the farmer	-0.033	0.1590.838	-0.344	0.279
Household size	0.012	0.0200.541	-0.027	0.052
Age	-0.011**	0.0050.015	-0.020	-0.002
Ownership of land	0.583***	0.2220.009	0.148	1.018
Access to other business	-0.067	0.1150.560	-0.292	0.158
log_landsize aquaculture	0.037	0.0270.169	-0.016	0.090
log_land size crop	0.153*	0.0810.059	-0.006	0.312
Linkages with fish market	-0.136	0.1310.301	-0.394	0.122
Linkages with the feed market	0.018	0.1020.858	-0.181	0.217
Education level	0.013	0.0150.372	-0.016	0.043
_cons	13.065***	0.3460.000	12.387	13.742

Number of observations = 300

Wald Chi2 (12) = 345.83 Prob> chi2 = 0.0000 R-squared = 0.6625

Root MSE = 0.67437

Note: *, *** represents 10% and 1 % significance levels, respectively

The time between the harvesting of fish, preservation facilities, and delivery to the final marketplace determines the number of postharvest losses. These losses result in quantity losses, resulting in the low volume of fish available for sale and quality losses leading to low household income. As a result, inadequate storage and preservation facilities expose fish to damage before reaching the market.

Age of the farmer was found to be negatively statistically significant at a 5 percent level. An increase in the farmer's age by a year decreases the household income by 1.1 percent. A plausible reason is that younger farmers are receptive to new ideas in the market and are less risk-averse; hence they would probably take new ideas related to fish production and marketing. This finding ties with **Langyintuo & Mungoma (2008)** study that as the farmer gets older, they usually become risk-averse; hence they will not be willing to venture into new areas that they are not sure of. At the same time, younger farmers are more flexible in their decision-making process in adapting to new farming practices.

Results indicate that access to land ownership increases household income by 58.3% at a 1% significance level. Land ownership is related to crop, livestock, and aquaculture production. Land ownership is expected to influence aquaculture activities and income generation activities. Farmers who own good proportions of land can access credit and thus diversify into various income-generating activities, including non-farm activities. The results are similar to the findings by **Winters *et al.* (2017)**, which indicate that improved land access is directly linked to agricultural production hence would improve household welfare.

Land size under crop was found to influence household income at a 1% significance level positively. Results indicate that a unit increase in land size increases household income by 15.3%. A plausible reason is that increase in farm size increases the output per unit of labor which translates to higher total income by the farmers. Medium-sized farms are more commercialized than small farms in both input market participation and sale of the output. This finding confirms the results obtained by **Noack and Larsen (2019)**, which indicate that farmers with large farm sizes are more likely to have more income.

CONCLUSIONS AND RECCOMENDATIONS

The findings indicate that postharvest loss is an endogenous variable on household welfare. The study found access to preservation facilities and distance to the market influenced the amount of postharvest loss. Results indicate that postharvest loss negatively affects household welfare, implying that reduced postharvest losses lead to high household income hence increased household welfare. The study found out that age of the farmer negatively influenced household welfare. On the other hand, land ownership and land size under crop are positively significant on household welfare.

The study offered opportunities to farmers to meet the local demand for fish through aquafarming. The policy should include having many extension contacts, training, and providing credit to farmers to enhance fish marketing. The government needs to increase the provision of title deeds to increase the number of farmers who own land rights. Title deeds act as collateral when one needs to apply for credit in banks and other financial institutions. As a result, farmers would be able to have resources that are necessary for postharvest loss management.

To reduce postharvest losses among farmers, the government needs to invest in preservation facilities and low-cost processing technologies that address quality without moving up fish prices. Different private actors, including commercial banks and Sacco's, need to facilitate the postharvest value chain in fish by increasing credit access through providing loans to farmers that would make them invest in storage facilities. As a result, this would minimize the areas of postharvest losses.

REFERENCES

ANSAH, I. G. K., EHWI, J., & DONKOH, S. A. (2018). Effect of postharvest management practices on welfare of farmers and traders in Tamale Metropolis and Zabzugu Districts, Ghana, *Cogent and Food and Agriculture*, *4*(1). http://dx.doi.org/10.1080/23311932.2018.1475916

BARDHAN, D., SHARMA, M. L., & SAXENA, R. (2012). Market participation behaviour of small holder dairy farmers in Uttarakhand: A disaggregated analysis, *Agricultural Economics Research Review*, *25*(2), 243-254. https://www.semanticscholar.org/paper/

BLUE ECONOMY (2017): Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries. https://openknowledge.worldbank.org/bitstream/handle/10986/26843/115545.pdf

BOLORUNDURO, P., & ADESEHINWA, A. (2005). Adoption of Improved Fish Preservation Technologies in Northwestern Nigeria. https://www.researchgate.net/publication/45266421

COLE, S., MCDOUGALL, C., KAMINSKI, A., KEFI, A., CHILALA, A., & CHISULE, G. (2018). Postharvest fish losses and unequal gender relations: drivers of the social-ecological trap in the Barotse Floodplain fishery, Zambia. *Ecology and Society*, *23*(2). http://dx.doi.org/10.5751/ES-09950-230218

DIEI-OUADI, Y., & MGAWE, Y. (2011). Post-harvest fish loss assessment in small-scale fisheries: A guide for the extension officer. http://www.fao.org/3/i2241e/i2241e.pdf

GETU, A., MISGANAW, K., & BAZEZEW, M. (2015). Post-harvesting and major related problems of fish production. *Fish Aquaculture Journal, 6*, 154. (2021). https://www.longdom.org/abstract/postharvesting-and-major-related-problems-of-fish-production-43447.html

ISMAIL, J. I., & CHANGALIMA. I. A. (2019). Postharvest losses in maize: Determinants and effects on profitability of processing agribusiness enterprises, *East African Journal of Social and Applied Sciences*, *1*(2), 203-211. https://mocu.ac.tz/wp-

content/uploads/2020/01/P16-ISMAIL-J-ISMAIL-ISMAIL-A.-CHANGALIMA.pdf
JACOBI, N. (2013). Examining the Potential of Fish Farming to Improve the Livelihoods of Farmers in the Lake Victoria Region, Kenya. Assessing Impacts of Governmental Support. https://skemman.is/bitstream/1946/15901/1/Thesis_Full_2.pdf
KIAYA, V. (2014). Postharvest losses and strategies to reduce them. *Technical Paper on Postharvest Losses.* https://www.actioncontrelafaim.org/en/publication/post-harvest-losses-and-strategies-to-reduce-them/
KNBS. (2019). Kenya Population and Housing Census. Kenya National Bureau of Statistics, 2019. https://www.knbs.or.ke/?p=5621/
KOTHARI, C. R. (2004). Research methodology. Methods and Techniques. *New Dheli: New age international.*
LANGYINTUO, A. S., & MUNGOMA, C. (2008). The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food policy*, *33* (6): 550-559. http://dx.doi.org/10.1016/j.foodpol.2008.04.002
MEENA, M. (2014). The Impact of Farmer to Market Linkages on Livelihoods and Natural
Resource Management in Uganda. *The Journal of Agricultural Education and Extension*, *20*(4), 449-450. http://dx.doi.org/10.1080/1389224X.2014.909198
MOHAMMED, K. H., BIRHANE, Z., & ALEMAYEHU, G. (2019). Determinants of market outlet choice decision of tomato producers in Fogera Woreda, South Gonder zone, Ethiopia. *Cogent Food and Agriculture*, *5*(1). http://dx.doi.org/10.1080/23311932.2019.1709394
NOACK, F., & LARSEN, A. (2019). The contrasting effects of farm size on farm incomes and food production. *Environmental Research Letters. 14*: 084024. http://lfs-noack.sites.olt.ubc.ca/files/2019/09/CV-Frederik-Noack_2019-09-24_Short.pdf
NYAGA, J., NYIKAL, R., & BUSIENEI, J. (2021). *Factors influencing the choice of marketing channel by fish farmers in Kirinyaga County*. AgEcon Search. Retrieved 30 August 2021, from https://ageconsearch.umn.edu/record/249338
OPIYO, M., MARIJANI, E., MUENDO, P., ODEDE, R., LESCHEN, W., & CHARO-KARISA, H. (2018). A review of aquaculture production and health management practices of farmed fish in Kenya. *International Journal of Veterinary Science and Medicine*, *6*(2), 141-148. http://dx.doi.org/10.1016/j.ijvsm.2018.07.001
SHEAHAN, M., & BARRET, C. B. (2017). Review: Food losses and waste in Sub-Saharan Africa. *Food policy*, 70: 1-12. http://dx.doi.org/10.1016/j.foodpol.2017.03.012
TESFAY, S., & TEFERI, M. (2017). Assessment of fish post-harvest losses in Tekeze dam and Lake Hashenge fishery associations: northern Ethiopia. *Agriculture and Food Security*, *6*(1): 2-12. http://dx.doi.org/10.1186/s40066-016-0081-5
WINTERS, P., DAVIS, B., & CORRAL, L. (2002). Assets, Activities and Income Generation in Rural Mexico, Factoring in Social and Public Capital. *Agricultural Economics* *27*(2): 139-156. http://dx.doi.org/10.1111/j.1574-0862.2002.tb00112.x