# Socio-economic factors affecting the uptake of fish solar tent dryers in the Lake Chilwa Basin

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## ABSTRACT

This study investigates the socio-economic factors influencing the adoption of fish solar tent dryers in the Lake Chilwa basin, Malawi. The research employs a mixed-methods approach, combining qualitative and quantitative data collection techniques. Data were gathered through focus group discussions with 25 participants and surveys administered to households in Kachulu and Nchenga, targeting adopters and non-adopters of fish solar tent dryers. The analysis included logistic regression to assess the impact of socio-economic characteristics, such as age, sex, marital status, education, access to savings accounts, extension services, and fish processing training, on the uptake of fish solar tent dryers. The findings reveal that fish processed with fish solar tent dryers are of higher quality, cleaner, have a longer shelf life, and command better market prices than traditional methods. Access to extension services and training significantly increases adoption rates. However, economic challenges hinder widespread adoption, particularly the high costs of constructing and maintaining fish solar tent dryers. The study concludes that enhancing extension services and providing financial support can significantly improve the uptake of fish solar tent dryers, thereby promoting sustainable fisheries management and improving the economic status of fish processors in the Lake Chilwa basin.

**Keywords:** *Extension Services, Fisheries, Lake Chilwa, Logistic Model, Postharvest Losses, Sun Drying.*

## 1.0 INTRODUCTION

Reducing post-harvest losses and maximizing profits from fish catches can reduce overfishing and improve the conservation of fisheries resources in developing countries (Affognon *et al*., 2015). Over the years, the use of "Fish Solar Tent Dryer (FSTD)" has been promoted as a strategy to reduce post–harvest fish losses (Cole *et al*., 2018). In Malawi, the common methods for fish processing include; sun-drying, smoking, para-boiling and pan-roasting (Nankwenya *et al.*, 2017) and it has been reported that post-harvest fish losses in Malawi are as high as 40% caused by spoilage and loss of quality (Kawiya, 2016). Research aimed at facilitating the development, promotion and increased uptake of improved fish processing technologies is essential.

Lake Chilwa Basin is one of the most productive water bodies in terms of fish production per unit area (Chiotha *et al*., 2018). It is located in the southern region of Malawi and covers Machinga, Phalombe, and Zomba Districts. The Lake is the second largest wetland in Malawi and because of its rich biodiversity Lake Chilwa became a Ramsar site in 1997 (Jorstad, 2012). The basin is characterized by weak capital assets, particularly natural, financial, human and physical resources (Binauli *et al*., 2011). It is reported that its major natural resources (water, forestry and fishery) are valued at US$21 million annually (Chiotha and Jamu, 2012) and provides direct support to 1.5 million people who live within the basin and beyond its boundaries (Luhanga, 2012).

It is estimated that 55.9% to 83.2% with an average of about 70.5% of the people in the Lake Chilwa basin live below the poverty line and 19.3% to 50.6% with an average of around 32.8% are considered ultra-poor (NSO, 2021). The fishery sector is the engine of the basin's economy and the fishery output is estimated between US$11 million and US$17 million annually (Nagoli and Mwanza, 2005). Consequently, endeavours aimed at maximising profits for fisher folk in the area would not only pay dividends to livelihoods directly in the fishery sector but also other sectors such as small-scale farmers who sell food to the fisher folk, small business in the wholesale, retail as well as the transport sector (Kefi *et al*., 2017).

Fish smoking and sun-drying are the main traditional methods of fish processing in the basin (Luhanga and Jamu, 2013). These traditional processing methods are associated with high postharvest losses, low-quality products resulting in low product prices and consequently poor economic status of fish processors (Jorstad, 2012).

Sun drying method is used for small-sized fish especially *Engraulicypris sardella* (local name: usipa) that is boiled and then sun-dried (Kapute, 2008). There is contamination by dust and insect infestation as the fish are dried on mats spread on bare grounds (Kawiya, 2016). Consequently, sun drying results in an increase in

spoilage of fish which fetch low market prices and therefore reduces the profit margin aimed at fish processors (Banda et al., 2017). However, one of the key benefits of FSTD is that it is an economically viable investment for Malawi (Kawiya, 2016).

In 2007, Leadership for Environment and Development, in the Faculty of Science at Chancellor College, in partnership with World Fish-Malawi introduced FSTD at the Lake Chilwa basin (Kayamba-Phiri *et al.*, 2020). In 2010, the Lake Chilwa Basin Climate Change Adaptation Programme introduced a new FSTD with additional innovations that were spacious for more efficient processing and increased quantitative output of the dried fish (Chiotha et al., 2018). Furthermore, Canada's International Development Research Centre and the Australian Centre for International Agricultural Research jointly launched the "Cultivate Africa's Future Fund (CultiAF)" research project 'Tipindule ndi Nsomba' in 2013 that was implemented by Chancellor College introduced FSTD with a modified design to ensure that it delivers the right balance of ventilation and warmth (McLean *et al*., 2016).

The adoption of improved agricultural technologies is significantly influenced by socio-economic and institutional factors associated with the users of such technologies (Bolorunduro and Adesehinwa, 2004). Adoption variables can be generalized in terms of socio-economic characteristics such as age, education, literacy, social status, income, living standards, possession of wealth, occupational prestige, self-perceived social class identification, degree of upward social mobility, size of units, commercial or subsistence economic orientation, attitude toward credit, and specialized operations (Rogers and Williams, 1983).

In Malawi, age and gender have been found to respectively positively and negatively influence the adoption of fish farming (Kapanda *et al.*, 2005). There is a growing number of women receiving technical support from various projects to improve fish processing in Malawi (Manyungwa-Pasani *et al.*, 2017). The uptake of FSTDs holds significant potential to minimize overfishing by reducing post-harvest losses and maximizing the profitable marketing of fish from the Lake Chilwa Basin. Increased uptake of FSTDs is essential for the successful diversification of fish species in Lake Chilwa and the conservation of the surrounding forests. However, fish processors face challenges in adopting FSTDs due to various socio-economic factors (Kayamba-Phiri, 2020). Therefore, investigating the socio-economic factors affecting the uptake of fish processing technologies is crucial.

The adoption of FSTDs in the Lake Chilwa basin can be understood through several key theoretical frameworks from development economics and technology adoption literature. The Diffusion of Innovations Theory (Rogers, 1962) provides a comprehensive framework for analyzing how new technologies spread within a

culture, emphasizing the roles of socio-economic factors, communication channels, time, and social systems. Additionally, the Technology Acceptance Model (TAM) (Davis, 1989) highlights the importance of perceived usefulness and ease of use in determining technology adoption. Finally, the Sustainable Livelihoods Framework considers the influence of various assets—human, social, financial, physical, and natural—on individuals' and communities' ability to achieve sustainable livelihoods. Together, these frameworks provide a robust theoretical grounding to examine the socio-economic factors affecting the uptake of FSTDs in the Lake Chilwa basin.

Rogers (1962) theory has been widely used to study the spread of agricultural technologies, highlighting how socio-economic characteristics, peer influence, and communication channels impact adoption rates. Studies applying this theory in similar contexts have found that factors such as education, income, and access to information significantly influence the adoption of new technologies according to McLean *et al.* (2016), Kayamba-Phiri (2020), Rogers and Williams (1983) and Kapanda *et al.* (2005). The TAM has been utilized to understand user acceptance of various technologies, demonstrating that perceived usefulness and ease of use are critical determinants of adoption. Research using TAM in agricultural contexts has shown that farmers are more likely to adopt technologies they perceive as beneficial and easy to use (Davis, 1989). The Sustainable Livelihoods Framework provides a holistic view by considering the interplay of different assets in shaping livelihood outcomes. In the context of technology adoption, this framework has been used to analyze how access to resources and institutional support systems affect the ability to adopt and benefit from new technologies.

Numerous studies have been conducted to describe the socio-economic characteristics of fish processors in Malawi by Banda *et al.* (2017), Binauli *et al.* (2011), Njaya (2009), Nagoli (2016) and Manyungwa-Pasani *et al.* (2017). However, fish processors struggle to adopt FSTDs due to various socio-economic factors (Kayamba-Phiri, 2020). Therefore, an investigation into the socio-economic factors affecting the uptake of FSTDs in the Lake Chilwa basin is necessary.

Kayamba-Phiri (2020) examined how the usage of solar dryers improved the livelihoods of fish processors within the context of a Sustainable Environment and Enterprise Development for Climate Change Adaptation in Fisheries Project in Chipala and Vinthenga villages in Nkhotakota, Malawi. The study revealed that the location of fish processors was the only determining factor for participation in solar drying activities. However, the context of fishing communities varies across the country, and thus the involvement of different stakeholders, especially those directly affected by the project, would ensure a sustainable structure that empowers fish processors to assume ownership and successfully manage resources. Consequently, a study on the factors influencing the usage of CultiAF project FSTDs on Nchenga

and Kachulu beaches in the Lake Chilwa basin is essential to contribute to the body of knowledge in fish processing.

This study was undertaken to investigate the socio-economic factors affecting the uptake of FSTDs among fish processors along the Lake Chilwa basin, Malawi. Specifically, it aims to determine the socio-economic characteristics of adopters and non-adopters and to assess the effect of socio-economic factors on the uptake.

## 2.0 MATERIALS AND METHODS

This was a cross-sectional study conducted in May and June 2017. The research study used a mixed method of research, by collecting and analysing qualitative and quantitative data. The study used a semi-structured questionnaire on adopters and non-adopters of FSTD. "Focus Group Discussions (FGDs)" notes and secondary data sources obtained from the broader end-line survey of the CultiAF project were also used in this study. This design ensured that each method's weaknesses or biases that may occur were eliminated by a counterbalance of the other method.

FGD participants were selected through purposively sampling members of FSTD users. The participants were separated according to their gender ensuring participants to feel free when contributing. There were 13 men and boys aged 28 to 73 who were selected to participate in the discussions. In addition, 12 women and girls aged 19 to 55 were selected.

The major units of analysis in the survey were households in which at least one member was a fish processor and those where none was a fish processor. Fish processors were selected from the study site through random sampling. Where it was not possible to interview an individual due to logistics, replacement based on accessibility was used. There were about 75 households in Kachulu and 95 households in Nchenga. 15 households in Kachulu and 25 households in Nchenga used improved fish processing technologies.

A standard statistical procedure was used to determine sample size and the sample size was denoted by the letter $n$. The marginal error $(ME)$ on the frame list of fish processors was at 0.05, z-score = 1.96 at 95% degree of confidence with proportion at 0.5. These were used to calculate the sample size for the research as follows:

$$n = \frac{\hat{p}(1-\hat{p})z^2}{ME^2} \quad (1)$$

Data was collected from 119 sampled respondents within fish processor communities. Data collected included respondent characteristics such as sex, age, marital status, education level, access to a savings account, access to extension services, training in fish processing and use of FSTD. The mean age of the respondents was 40 years with a minimum age of 21 years and a maximum of 75

years. Females dominated the sample with 66.4% representation while males were only 33.6%.

The study was conducted along Lake Chilwa at Nchenga and Kachulu beaches in the area of Traditional Authority Mkumbira of Zomba district (Figure 1). Lake Chilwa is a 683 $km^2$ basin lake located between latitudes 15°E and 15°30'NE and longitudes 35°30'NE and 36°E. Lake Chilwa is the second-largest lake in Malawi after Lake Malawi. Approximately 60km long and 40km wide, the lake is surrounded by extensive wetlands. There is an island in the middle of the lake called Chisi Island. The lake has no outlet, and the level of water is greatly affected by seasonal rains and summer evaporation.

Lake Chilwa fishery was dominated by *Barbus spp.* (matemba), *Oreochromis shiranus* (makumba), *Labeo cylindricus*, *Tilapia rendalli* and *Clarias gariepinus* (mlamba) (Chikuni, 2001). The lake supports a waterbird population of around 1.5 million with about 160 different species. Some of these migrate along the Asian - East African Flyway from Siberia each year. With twelve bird species, the number was over one per cent of their total flyway population. The surrounding human population was dense and growing, and waterbirds were hunted for food when the water level was low, and fishing was problematic. The study area had a diversified socio-economic profile and has had different forms of improved fish processing technologies introduced at several points previously (Likongwe *et al*., 2018). About 335 villages with over 60,000 inhabitants engage in fishing the lake, and pull in over 17,000 metric tons each year, 20% of all the fish caught in Malawi.

The survey data set collected from respondents included the following variables: X1 = Age of respondent (year of birth); X2 = Sex of respondent (A = Male, B = Female); X3 = Marital status (A = Married, B = Never married, C = Divorced/Separated, D = Widowed); X4 = Highest education level (A = No education, B = Std1 – Std5, C = Std5 – Std8, D = Form 1/2, E = Form 3/4); X5 = Access to a savings account (A = Yes, B = No); X6 = Access to extension services (A = Yes, B = No); and X7 = Fish processing training attendance (A = Yes, B = No).

The chosen methodology for this study, logistic regression, was well-suited to the theoretical frameworks guiding the analysis. The Diffusion of Innovations Theory suggests that various socio-economic factors influence the adoption of new technologies. Logistic regression was an appropriate method for identifying and quantifying the impact of these factors on the binary outcome of whether or not FSTDs are adopted. This model allows us to provide insights into how variables such as education, income, and access to extension services affect the likelihood of adoption. By framing the analysis within the context of the TAM, we can also assess how perceived benefits and ease of use, as proxied by variables like training and

usability, influence adoption decisions. Furthermore, the Sustainable Livelihoods Framework is incorporated by examining how access to various types of capital (e.g., financial, social, human) affects the adoption process.

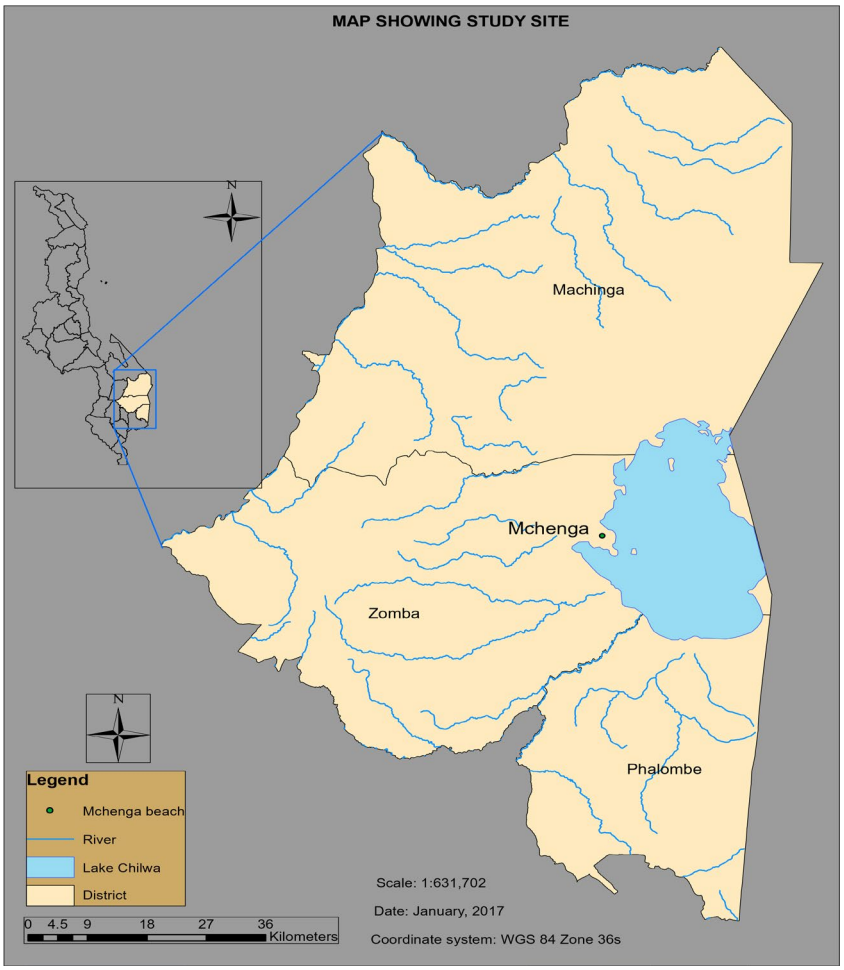


***Figure 1:*** *Study site in Lake Chilwa basin, Zomba, Malawi*

Logistic regression was selected as the appropriate analytical technique to assess the effect of socio-economic factors on the uptake of FSTDs. The choice of the logit model is justified by its interpretability, suitability for binary dependent variables, computational efficiency, flexibility, and consistency with existing research practices. These factors collectively ensure that the logit model provides robust, reliable, and easily interpretable results, making it the preferred choice for analyzing the socio-economic factors influencing the adoption of fish solar tent dryers in the Lake Chilwa basin. The uptake of FSTDs was used as the dependent variable, which was regressed on a set of socio-economic characteristics of fish processors.

The logit model was specified as follows:

$$L_i = In\left(\frac{P_i}{1-P_i}\right) = \beta_1 + \beta_2 X_i \ldots . + \beta_n X_n + e. \quad (2)$$

Where $P_i$ = probability of fish processor $i$ uptake of FSTD,

$\beta_1$ = constant (an overall propensity of uptake), $\beta_2, \ldots \beta_n$ = coefficients (or weights) attached to predictors, $X_1, \ldots X_n$ = predictors (independent variables –categorical), $e$= random error term.

Categorical and continuous data collected from the study was cleaned to fit in the binary logistic model, it included: $X_1$ = Age of respondent (year of birth) to (A = Youth, B = Elder), $X_2$ Marital status (A = Married, B = Never married, C = Divorced / Separated, D = Widowed, E) to (A = Married, B = Never married) and $X_3$ = Highest education level (A = No education, B = Std1 – std5, C = Std5 – std8, D = Form 1 / 2, E = Form 3 / 4) to (A = Educated, B = Not educated).

Logistic regression model one was for FSTD uptake with a function of different socio-economic characteristics. The independent variables were selected upon theoretical review of studies including McLean *et al.* (2016), Kayamba-Phiri (2020), Rogers and Williams (1983), Kapanda *et al.* (2005), Obiero *et al.* (2019), Onasanya *et al.* (2006), Ashley-Dejo *et al* (2017), Salau et al. (1997), Davies and Davies (2009) and Odediran and Ojebiyi (2017) revealed that the selected variables were important in the assessment of socio-economic characteristics influencing uptake of technologies. Table 1 below shows the definitions of variables used in the study.

The independent variables selected for the logit model were: $X_1$ = Age (A = Youth, B = Elder); $X_2$ = Sex (A = Male, B = Female); $X_3$ = Marital status (A = Married, B = Never married); $X_4$ = Education level (A = Educated, B = Not educated); $X_5$ = Access to a savings account (A = Yes, B = No); $X_6$ = Access to extension services (A, Yes, B = No); and $X_7$ = Fish processing training attendance (A, Yes, B = No).

## 3.0 RESULTS

### 3.1 Use of fish solar tent dryer

To understand the use of FSTD and the socio-economic status of the respondents the study sought the perceptions of FGDs participants. This exercise identified groups of fish processors in the community that were well-off or poor. Participants explained that a well-off person was someone who has fishing gear, and also has other businesses that they can depend on should fish sales be low. In addition, a well-off person was eager to learn new technologies and influence others to uptake.

***Table 1:*** *Definition of variables*

| Dependent variable | Conceptual | Operational |
|---|---|---|
| Fish solar tent dryer | A fish solar tent dryer refers to a collapsible movable shelter consisting of a plastic cover held up by poles and kept in place by ropes and pegs that receive its energy from the sun to dry fish. | For this research, a solar tent dryer uptake was measured by asking respondents about the technology. |
| Independent Variable | | |
| Socio-economic | Socio-economic refers to relating to or involving economic and social factors. | For this research, socioeconomic was measured by asking respondents about their demographic, social and economic status in the communities. |

The participants of FGDs revealed that they regard a poor person as someone lacking basic essential life needs like food and general basic essential needs. However, the effects of climate change were making people to be vulnerable. For example, when one has a lot of debts and is failing to pay them back or when their business is not doing well hence, 3% of the population in the community was categorised to be in this group. This negatively influenced the uptake of new technologies as this population tends to search for peace work to find food and other necessities rather than being engaged in a technology that was being used by well-off people.

The FDGs also allowed for observations to be made on how gender was discussed and negotiated within these communities and both male and female fish processors expressed how there was a 50:50 participation of women and men in fish processing and women and men are all freely doing businesses. However, economic decisions made in a family came from men. The CultiAF project empowered women to be economically independent hence some of them were able to make economic decisions to assist men and to raise a family in case of a woman-headed family. Further, the discussions also revealed that the co-existence of women and men was influencing other people to use FSTD.

The discussions also revealed that the implementation of the CultiAF project at Lake Chilwa basin introduced FSTD which resulted in better fish processing and

management, less post-harvest losses and natural resources management. The groups perceived the future to have more FSTDs.

The participants of the FGDs indicated that the existence of challenges in accessing fish is due to higher prices on the landing sites. No major challenges were mentioned about FSTD use apart from breakages of the facility due to heavy winds and long periods required to dry the fish as compared to open fish drying which was affecting the regular use of the dryer. But fish from FSTD was reported to be of high quality, free from dust and with longer shelf life hence no loss of fish due to spoilage and it attracts good prices on the market. The participants also reported that; FSTD can be used all year round even during rainy days and is easy to utilize since there is no need to turn the fish as compared to other local methods.

A female participant in the discussion highlighted the main disadvantage of using the tent

*"This tent is expensive to construct and maintain. With the scarcity of the fish, we cannot even manage to contribute MK 10,000.00 each for its construction and maintenance"*

FGD's further revealed that the income generated from fish processing was equitably shared among participants. This equitable distribution of proceeds empowers women to make independent decisions regarding income expenditure. Despite the general gender balance in fish processing activities, the findings indicate that women show a higher enthusiasm for processing fish.

### 3.2 Socioeconomic characteristics of respondents

The socio-economic characteristics of fish processors at Lake Chilwa Basin were analyzed using quantitative data collected from the fishing communities of Kachulu and Nchenga beaches. The characteristics examined included age, sex, marital status, education level, access to a savings account, access to extension services, and participation in fish processing training (Table 2).

The mean age of the respondents was 40 years, with ages ranging from 21 to 75 years, indicating that both youth and elders participated in the study. Notably, 40.3% of the respondents were classified as youth (Table 3), demonstrating a substantial interest and involvement in FSTDs among younger individuals.

Females constituted 66.4% of the sample, while males represented 33.6%. This disparity highlights that women are more engaged in fish processing activities than men. Additionally, 86.6% of the respondents were married (Table 2), suggesting that fish processing is predominantly a family-oriented activity, with significant participation from women.

***Table 2:*** *Socio-economic characteristics of respondents*

| Socio-economic characteristic | | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Age | | Mean = 40<br>Minimum = 21<br>Maximum = 75 | |
| Sex | Male | 40 | 33.6 |
| | Female | 79 | 66.4 |
| Marital status | Married | 103 | 86.6 |
| | Never married | 5 | 4.2 |
| | Divorced / Separated | 9 | 7.6 |
| | Widowed | 2 | 1.7 |
| Education level | No education | 7 | 5.9 |
| | Std1 – std5 | 47 | 39.5 |
| | Std5 – std8 | 44 | 37.0 |
| | Form 1/ 2 | 10 | 8.4 |
| | Form 3/ 4 | 11 | 9.2 |
| Access to a savings account | Yes | 46 | 38.7 |
| | No | 73 | 61.3 |
| Access to extension services | Yes | 63 | 52.9 |
| | No | 56 | 47.1 |
| Fish processing training attendance | Yes | 60 | 50.4 |
| | No | 59 | 49.6 |

The results in Table 2 indicate that most of the respondents 39.5% attained primary education from standard 1 to 5. The other respondents at 37.0% also attended primary education from standard 5 to 8. This indicated that most of the fish processors attended primary education and a few of them attained higher education. However, education did not stop them from participating in processing fish using the modified IFPT. 38.7% of the respondents had access to a savings account. This means that some of the respondents practised sound financial management.

Table 2 shows that 52.9% of the respondents reported having access to extension services that helped them know of modified designs and out of these 50.4% reported having attended training related to fish processing. Thus, the respondents who attended fish processing training were in touch with the extension officers in their area who invited them to training.

Table 3 shows variables that were cleaned to fit onto cross-tabulations and logistic regression models.

***Table 3:*** *Cleaned socio-economic characteristics of respondents*

| Socio-economic characteristic | | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Age | Youth | 48 | 40.3 |
| | Elder | 71 | 59.7 |
| Marital status | Married | 103 | 86.6 |
| | Never married | 16 | 13.4 |
| Education level | Educated | 112 | 94.1 |
| | No education | 7 | 5.9 |

### 3.3 Socio-economic characteristics affecting uptake of FSTD

Table 4 indicates that 28.6% of the respondents uptake the FSTD and 71.4% did not uptake the technology. This study finds that access to extension services especially the training on fish processing had a significant contribution to the uptake as 76.5% of the participants revealed to have access to extension services specifically fish processing training at 76.5%. This shows that there was a need to continue enhancing access to extension services especially fish processing training as they were essential to boost the interest of fish processors to use FSTD.

The research findings in Table 5 show that fish processors that attended fish processing training had a positive (2.10) influence and a p-value of 0.035 had a strong significant effect on the uptake of FSTD. The probability of FSTD uptake increased with fish processing training attendance by 1.12%. This means that with an increase in fish processing training attendance, the probability of FSTD uptake by respondents increases as well.

Fish processors access to extension services had a positive (1.70) influence and a p-value of 0.090 had a weak significant effect on the uptake of FSTD. The probability of FSTD uptake increased with access to extension services by 0.90%. This means that with an increase in access to extension services, the probability of FSTD uptake increases (Table 5). Other variables (sex, age, marital status, education level, access to savings account) are not statistically significant, suggesting they do not have a strong influence on the uptake of the Fish Solar Tent Dryer in this model.

The likelihood ratio chi-square (LR chi2) value of 17.16 with a p-value of 0.0164 indicates that the model as a whole is statistically significant (Table 5). The pseudo

R-squared value (0.1205) provides an indication of the model's explanatory power, suggesting the model explains about 12% of the variance in the outcome variable.

***Table 4:*** *Association between socio-economic characteristics and adoption of FSTD*

| Socio-economic Characteristic | | Uptake status on FSTD (%) | | Chi-Square Value | P-value |
|---|---|---|---|---|---|
| | | Adopters (28.6) | Non-adopters (71.4) | | |
| Age | Youth | 41.2 | 40.0 | 0.014 | 0.906 |
| | Elder | 58.8 | 60.0 | | |
| Sex | Male | 35.3 | 32.9 | 0.060 | 0.806 |
| | Female | 64.7 | 67.1 | | |
| Marital status | Married | 88.2 | 85.9 | 0.116 | 0.734 |
| | Not married | 11.8 | 14.1 | | |
| Education level | Educated | 97.1 | 92.9 | 0.744 | 0.388 |
| | Not educated | 2.9 | 7.1 | | |
| Access to extension services | Yes | 76.5 | 43.5 | 10.578a | **0.001** |
| | No | 23.5 | 56.5 | | |
| Fish processing training | Yes | 76.5 | 40.0 | 12.922a | **0.000** |
| | No | 23.5 | 60.0 | | |
| Access to a savings account | Yes | 44.1 | 36.5 | 0.599 | 0.439 |
| | No | 55.9 | 63.5 | | |

Values in the same row followed by different letters are significantly different at *P<0.10

The Omnibus Tests of Model Coefficients in Table 6 assess whether the predictors in the model collectively improve the model compared to a model with no predictors. The significant chi-square value (p = 0.025) indicates that the predictors as a whole contribute significantly to the model, implying that the model fits the data better than a null model.

***Table 5:*** *Logistic regression model (1): characteristics affecting uptake of FSTD*

| Variable | Coefficient | Z -value | P – value |
|---|---|---|---|
| Sex of respondents | 0.1537689 | 0.32 | 0.753 |
| Age of respondents | 0.173353 | 0.37 | 0.713 |
| Marital status | 0.1993436 | 0.29 | 0.769 |
| Education level | 0.7119135 | 0.59 | 0.554 |
| Access to savings account | 0.2434956 | 0.53 | 0.598 |
| Access to extension services | 0.9075753 | 1.70 | **0.090** |
| Fish processing training | 1.125486 | 2.10 | **0.035** |
| Constant | -3.290904 | -2.10 | 0.035 |
| Number of observations = 119 | | | |
| LR $chi^2$ (7) = 17.16 | | | |
| Probability > $chi^2$ = 0.0164 | | | |
| Pseudo $R^2$ = 0.1205 | | | |
| Log likelihood = -62.611643 | | | |

Notes: Significant at 90% confidence level

***Table 6:*** *Omnibus tests of model coefficients*

| | Chi-square | df | Sig. |
|---|---|---|---|
| Step | 16.002 | 7 | 0.025 |
| Block | 16.002 | 7 | 0.025 |
| Model | 16.002 | 7 | 0.025 |

Table 7 provides a model summary revealing the -2 Log likelihood value indicates the goodness of fit of the model. Lower values suggest a better fit. The Cox & Snell R Square and Nagelkerke R Square indicates the amount of variation explained by the model. The values (0.126 and 0.180, respectively) suggest that the model explains between 12.6% and 18% of the variance in the outcome variable, which is relatively modest.

***Table 7:*** *Model summary*

| Step | -2 Log likelihood | Cox & Shell R Square | Nagelkerke R Square |
|---|---|---|---|
| 1 | 126.386[a] | 0.126 | 0.180 |

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than 0.001

The Hosmer and Lemeshow test in Table 8 assesses the goodness of fit of the logistic regression model. A non-significant chi-square value (p = 0.444) indicates that the model fits the data well, as there is no significant difference between observed and predicted values.

***Table 8:*** *Hosmer and lemeshow test*

| Step | Chi-square | Df | Sig. |
|---|---|---|---|
| 1 | 7.893 | 8 | 0.444 |

Table 9 shows the observed and expected counts for both outcomes (using and not using a FSTD) across deciles of risk. The observed counts are generally close to the expected counts, supporting the conclusion that the model fits the data well.

***Table 9:*** *Contingency table for hosmer and lemeshow test*

| Do you use a FSTD? | No | | Yes | | Total |
|---|---|---|---|---|---|
| Step | Observed | Expected | Observed | Expected | |
| 1 | 13 | 11.868 | 0 | 1.132 | 13 |
| 2 | 9 | 11.549 | 4 | 1.451 | 13 |
| 3 | 13 | 12.191 | 1 | 1.809 | 14 |
| 4 | 10 | 9.986 | 2 | 2.014 | 12 |
| 5 | 9 | 9.042 | 3 | 2.958 | 12 |
| 6 | 8 | 7.867 | 4 | 4.133 | 12 |
| 7 | 6 | 4.612 | 2 | 3.388 | 8 |
| 8 | 7 | 7.504 | 7 | 6.496 | 14 |
| 9 | 6 | 6.593 | 7 | 6.407 | 13 |
| 10 | 4 | 3.787 | 4 | 4.213 | 8 |

The logistic regression model identifies fish processing training and access to extension services as significant predictors of the adoption of the FSTD. The model fits the data well according to the Hosmer and Lemeshow test, but it explains a

modest portion of the variance in the outcome variable, indicating that other factors not included in the model may also play an important role.

## 4.0 DISCUSSION

The findings of this study can be interpreted through the lens of the theoretical frameworks discussed. The results align with the Diffusion of Innovations Theory by demonstrating that socio-economic factors such as education, income, and access to extension services significantly influence the adoption of FSTDs. These findings support the notion that communication channels and social systems play a critical role in technology diffusion. The study also corroborates the TAM, showing that perceived usefulness and ease of use, indicated by higher quality and ease of operation, are crucial determinants of adoption. Additionally, the analysis within the Sustainable Livelihoods Framework highlights that access to financial and human capital, such as savings accounts and training, significantly impacts the ability to adopt FSTDs. These results suggest that improving access to resources and support systems can enhance technology adoption and promote sustainable livelihoods.

The binary logistic regression analysis indicates that access to extension services and fish processing training for fish processors had a significant effect on the uptake of FSTDs (Table 5). The p-values of the model were measured at a 90% confidence level, with fish processing training showing a significant effect at $p = 0.035$, and access to extension services at $p = 0.090$. These results confirm the findings of Mantey *et al.* (2020), which revealed that access to extension services increased the likelihood of adopting fisheries technologies. Additionally, studies by Salau *et al.* (1997) and Das *et al.* (2014) support that fish processors who attended fish processing training were significantly more likely to adopt improved fisheries technologies.

Fish processing techniques learned from training sessions were crucial for FSTD adoption, with training attendance increasing the probability of uptake by 1.12% (Table 5). Conversely, gaps in technical skills among fish farmers were shown to hinder the uptake of innovative technologies and best management practices (Obiero *et al*., 2019). Bolorunduro and Adesehinwa (2017) also identified a lack of technical support as a major constraint in technology adoption.

The research results indicate that access to extension services increased the probability of FSTD uptake by 0.90%. Similarly, Ashley-Dejo *et al*. (2017) found that fish farmers with good contacts with extension workers had a positive perception of extension services in fish farming. Further, institutional factors such as prior involvement in extension/research programs also shaped adoption decisions (Kumar *et al*., 2021).

The study reveals that 52.9% of respondents had access to extension services and 50.4% had attended fish processing training (Table 2). Respondents who attended fish processing training were often in contact with government extension officers who invited them to training sessions. Olatinwo *et al.* (2020) advocate for proper funding of extension delivery services by the government to enable these services to reach a larger number of fish processors, thereby increasing the adoption of improved fish processing technologies. Similarly, Patrick and Kagiri (2016) suggest that greater government involvement in providing technology and extension services, along with increased participation of women in projects, is ideal for promoting technology adoption.

While the logistic regression analysis in this study identifies significant socio-economic factors associated with the adoption of FSTDs, it is important to acknowledge the potential endogeneity issues and the limitations regarding causality. The results should be viewed as indicative of correlations rather than definitive causal relationships. Policymakers and stakeholders should consider these limitations when designing and implementing interventions to promote the adoption of fish solar tent dryers. Further research using causal inference techniques is recommended to establish more robust evidence on the factors influencing FSTD adoption.

## 5.0 CONCLUSION AND RECOMMENDATION

This study significantly contributes to the field of development economics by advancing our understanding of the socio-economic factors influencing technology adoption in a developing context. By integrating the Diffusion of Innovations Theory, the TAM and the Sustainable Livelihoods Framework, the research comprehensively analyses the determinants affecting the uptake of FSTDs in the Lake Chilwa basin. The findings suggest that policies aimed at improving education, access to financial resources, and extension services can significantly enhance the adoption of FSTDs, promoting sustainable fisheries management and improving the economic status of fish processors. Future research should continue to explore these relationships using causal inference methods to further strengthen the evidence base for policy interventions.

Improving fish processing technologies is a powerful strategy for reducing post-harvest losses and overfishing. The increased efforts to reduce fish losses have encouraged fish processors to seek new and sustainable fish processing technologies. An FSTD is crucial for fish processors and has beneficial impacts on environmental conservation. Malawian fish processors, such as those around Lake Chilwa, could be strategically positioned to benefit from the use of an FSTD. Thus, this study explored the socio-economic characteristics that facilitate the uptake of FSTDs as a

way of promoting the sustainable utilization of fisheries resources in the Lake Chilwa basin, Malawi.

The socio-economic characteristics influencing adopters and non-adopters of FSTDs were determined using cross-tabulations. Access to extension services and fish processing training had a statistically significant relationship with the adoption of FSTDs in the Lake Chilwa basin. These socio-economic characteristics should be enhanced by all fisheries sectors to ensure the sustainability of the FSTDs being introduced in the fisheries industry.

The effect of socio-economic characteristics on the uptake of FSTDs was assessed using logistic regression models. The analysis showed that access to extension services and attendance at fish processing training had significant effects on the uptake of FSTDs. This underscores the importance of extension services and training in encouraging fish processors to adopt and realize the benefits of modern fish processing technologies. Without these services, fish processors may lack the skills and knowledge necessary to use FSTDs effectively.

The study focused on the Kachulu and Nchenga beaches population of the Lake Chilwa basin. Due to resource limitations, the study was not replicated across the entire basin. As a result, the findings may not be entirely representative of the whole basin or the entire country due to the limited sample size.

In conclusion, access to extension services and fish processing training significantly affects the adoption of FSTDs in the Lake Chilwa basin, Malawi. The study recommends that the Malawi Government and other stakeholders in the agricultural sector plan initiatives to enhance access to extension services and fish processing training to facilitate the uptake of FSTDs. Projects aimed at improving fish processing technologies in fishing communities should always consider the socio-economic characteristics of the beneficiaries, as these have a significant influence on the uptake of technologies. Innovators should consider diverse socio-economic characteristics to promote the successful adoption of innovations. Fish processing extension services and training should be provided in a series to attract a broader base of technology users.

The findings of this study highlight several important policy implications that could significantly enhance the uptake of FSTDs and promote sustainable fisheries management in the Lake Chilwa basin. These implications are outlined as follows:

1. Strengthening Extension Services:

- Policymakers should invest in comprehensive training programs specifically tailored to fish processing techniques using FSTDs. By enhancing the capacity of extension officers and ensuring they are well-equipped to disseminate

knowledge and practical skills, fish processors can be better supported in adopting and efficiently using FSTD technology.
- Ongoing support and follow-up services should be provided to ensure that fish processors troubleshoot issues and optimize the use of FSTDs.

2. Financial Assistance and Subsidies:

- Implementing financial assistance programs such as subsidies or grants to help fish processors cover the initial costs of constructing and maintaining FSTDs can remove a significant barrier to adoption. Targeted financial aid can make this technology more accessible to economically disadvantaged communities.
- Developing microfinance options tailored to the needs of small-scale fish processors can provide the necessary capital for investing in FSTDs and other related technologies.

3. Community Engagement and Awareness Campaigns:

- Conducting widespread awareness campaigns to educate local communities about the benefits of FSTDs can help shift perceptions and increase willingness to adopt new technologies. These campaigns should highlight the superior quality, cleanliness, extended shelf life, and higher market prices associated with fish processed using FSTDs.
- Engaging local communities in the planning and implementation of FSTD projects ensures that the technology meets the specific needs and circumstances of the users. Community involvement fosters a sense of ownership and commitment to the successful adoption of the technology.

4. Policy Integration and Coordination:

- Policymakers should integrate FSTD promotion into broader fisheries management and development policies. This includes aligning FSTD initiatives with national strategies for food security, sustainable fisheries, and rural development.
- Coordinating efforts among various governmental and non-governmental organizations can enhance the efficiency and reach of FSTD promotion programs. Collaborative efforts can pool resources, expertise, and networks to support fish processors better.

5. Market Development and Support:

- Improving market infrastructure and access can help fish processors realize the full economic benefits of using FSTDs. Policies aimed at developing better transport, storage, and marketing facilities can enhance the profitability of fish processed with this technology.

- Introducing measures to stabilize fish prices can help ensure that fish processors receive fair compensation for their higher-quality products, making the investment in FSTDs more attractive.

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