

A CONTINGENT VALUATION APPROACH TO ESTIMATING WILLINGNESS TO PAY FOR FISH SOLAR DRYING TECHNOLOGY: CASE OF WESTERN SHORE OF LAKE MALAWI

Makwinja R^{1,2*} and F Kapute³



Rodgers Makwinja



Fanuel Kapute

*Correspondence author email: makwinjarodgers@gmail.com / rodgers.makwinja@aau.edu.et
ORCID: <https://orcid.org/0000-0002-0818-4727>

¹PhD Candidate, African Center of Excellence for Water Management, Addis Ababa University, P.O. Box 1176, Addis Ababa, Ethiopia

²Research Officer, Senga Bay Fisheries Research Unit, P.O. Box 316, Salima, Malawi

³Professor, Mzuzu University, Department of Fisheries & Aquatic Science, Private Bag 201, Luwingu, Mzuzu 2, Malawi



ABSTRACT

For many years, open sun drying (OSD) has been the common way of preserving fish among the fishing households in Malawi. The main limitations of this technique have been increased fish quality deterioration and microbial contamination. Two fish solar dryers (FSD) were constructed under the SEEDFISH project along the Western Shore of Lake Malawi (WSLM) as a way of minimizing the effects of using OSD and provide a better way of drying fish in the area. The FSD though adopted, the fishing households have been seeking alternatives for its sustenance. This study estimates the households' willingness to pay (WTP) and their influencing factors while using contingent valuation (CV) approaches. A wide range of data collection methods (exploratory surveys, focus group discussions, key informant interviews, and field observations) was employed. A total of 200 fishing households were randomly interviewed. The results showed that 144 (72.4%) of the respondents were willing to pay because the FSD was seen as a way of mitigating the climate change impact, improving livelihoods, and reducing post-harvest losses. The mean annual aggregate WTP amount was estimated at MK3,648,750 (US\$4,865). Those households (27.6%) not willing to pay argued that they had a low level of income while others could not see any value of the FSD. The regression coefficients of age and gender of household head (GHH) were negative ($\beta = -6.02$ and Wald of 5.34, $\beta = -6.92$, Wald of 2.01) and significant ($p < 0.05$) suggesting that young people were more WTP than their counterpart. Males also coded as 0 were more willing to pay than females. On the other hand, household literacy level (HLL), household involved in fish processing (HIVFP), household social trust (HST), household institutional trust (HIT), household level of income (HLI), household experienced fish post-harvest losses (HEFPL), household access to extension services (HAE) and household social network (HSN) were positive ($\beta = 2.97$, Wald of 7.11, $\beta = 6.37$ and Wald of 5.41, $\beta = 3.03$ and Wald of 6, $\beta = 11.2$, Wald 9.02, $\beta = 2.42$, Wald of 8, $\beta = 0.93$, Wald of 4.81 and $\beta = 2.50$, Wald 2.10) and significant ($p < 0.05$) suggesting that those HIVFP, had high HLL, HLI, HST, HIT, HSN and HEFPL were more willing to pay than their counterpart. These findings provide comprehensive baseline data for local government and communities in the development of more effective and holistic approaches to improving communities' climate change resilience.

Key words: Contingent valuation, Fish solar dryer, Lake Malawi, Willingness to pay



INTRODUCTION

Malawi is a country traditionally associated with capture fishery [1]. Fisheries resources play a vital role in supporting the livelihoods of the majority of lakeshore populations. The current estimate indicates that fish contributes over 40% of the dietary animal protein intake [2,3,4]. Although Malawi has recently registered increase in total annual fish landings estimated at 80,000 metric tons in 2010 and 157,267 tons in 2017 [3] mainly due to high catches of *Engraulicypris sardella*, which contributes over 70% of the total annual landings [3,4,5], about 40% of the catches are lost through post-harvest [3] due to poor handling [6]. Such losses have a serious adverse impact on the fish supply chain in Malawi. To reverse the situation, two fish solar dryers (Plate 1) (with a design of greenhouse structure, made of a wooden frame and wrapped with Ultraviolet (UV) 200 µm polyethylene plastic sheet) were constructed under Sustainable Environment and Enterprise Development project in two communities (Vinthenga and Chipala) in Nkhotakota District along the WSLM as a way of minimizing effects of using OSD and provide a better way of drying fish in the area[7]. The project adopted an economic approach where the market value was attached to the technology [8] rather than providing such capital technology free of charge which otherwise undermines the sustainability of the intervention [9,10,11,12]. Though the theory of attaching market value to the communal project is highly praised, some scholars disputed that this approach has many uncertainties [13,14,15] particularly in Africa and emerging economies due to diversity of human-sociological systems and multifaceted socio-cultural linkages that influence the perception of the society [16]. However, some scholars have on the other hand disputed that estimating the value of FSD that reflects the socio-economic importance of the technology is the most prerequisite for better management choices.





Note: plate 1a shows the processed solar drying fish and plate 1b shows the fish solar drying process

Plate 1: The FSD and dried fish at Vinthenga fish landing site on the WSLM (Photo was taken by Enock Rhino during the exploratory survey)

It is further argued that this economic school of thinking is the only approach that can show the values of services rendered by a communal project such as FSD to the communities, which technically cannot be traded on the real market [17,18]. The purpose of this study was to estimate an individual household benefit and aggregate these benefits to the relevant population [19, 20, 21]. To achieve the objective of this paper, contingent valuation and logistic regression approaches were adopted to estimate communities' willingness to pay (WTP) and their influencing factors [22, 23, 24].

MATERIALS AND METHODS

Study area

The study was conducted on the WSLM in the Nkhotakota District, which lies between latitude 13° 0' and 13° 30' S, and longitudes 33° 50' and 42° 20' E (Figure 1) in the Central Region of Malawi [25].

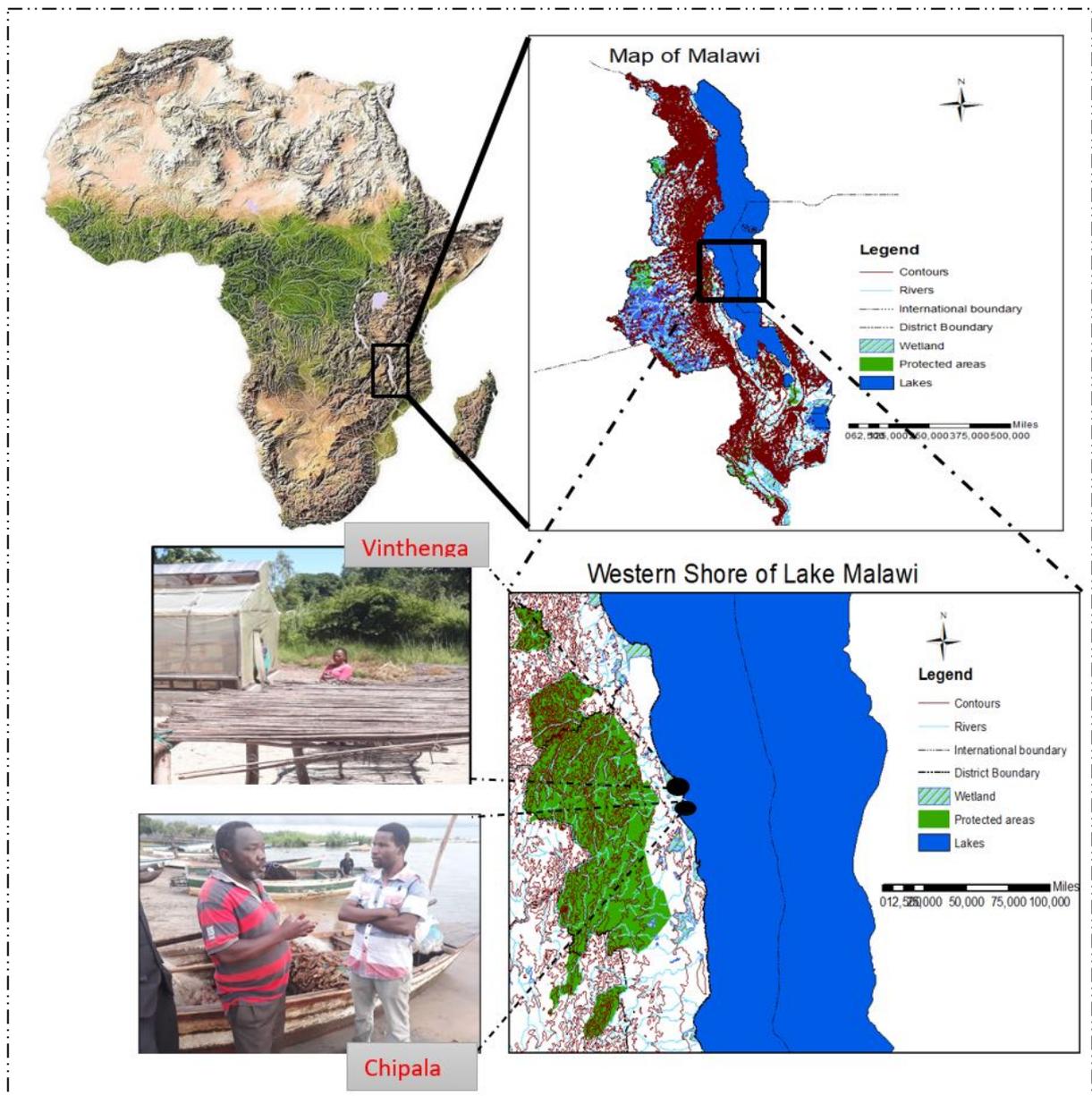


Figure 1: Map showing Western Shore of Lake Malawi

The WSLM is ranked second in terms of total annual fish contribution in Malawi. In 2015, the area contributed approximately 33,350 metric tonnages representing 21.2% of total annual landings in Malawi [26]. Small-scale traditional fishery contributes about 5% of the total landings in the area while 85%-90% of the total landings are contributed by artisanal fishery, which comprises modern fishing gears. On the other hand, large commercial fishing contributes less than 5% of the total landings.

Survey design

Four exploratory surveys, key informant interviews, focus group discussions and direct field observations were conducted in two fish landing sites (Vinthenga and Chipala) within the study area from March to April 2017. These two villages were selected

because they were primary beneficiaries of the technology. Fish processors, traders, fishers, local governance structures, men and women were interviewed separately to capture a general perception of the communities towards the FSD. These interviews were coordinated by asking communities to explain the changes they have experienced in terms of their level of income, their ability to adapt to climate change impact and livelihood since the introduction of the technology. The responses were used as a basis for framing the CV survey questionnaire, identify the bid levels, and ensure that items in the survey were practical and easy to understand. Participants were encouraged to share their views and attitude towards technology.

Sample and sampling design

The contingent valuation questionnaires targeting 200 households were framed, pre-tested, and checked for both internal validity and reliability. The households for the interviews were purposively sampled based on their proximity to FSD. The sample size was calculated based on the below formula [27]:

$$n_r = p(1 - p) \left(\frac{z}{\varepsilon}\right)^2 \quad (1)$$

Where n_r = sample size and z = value from the standard normal distribution reflecting the level of confidence ($z=1.96$ for 95% level of confidence) of unknown population proportion (p). The $P=0.5$ was used assuming maximum heterogeneity (50/50 split). The margin of error (ε) of 0.069 was used to calculate a statistically representative sample of 200. The households for interview were selected randomly using the directory obtained from the village head.

Contingent valuation Conceptual Model Approach

A contingent valuation survey instrument was used to capture the values that cannot be captured through the economic market instrument. The pre-test survey was conducted in a different area to validate the bids used in the CV survey questionnaire and identify possible research shortfalls. An individual's attitude, perception, and preferences regarding FSD and its non-market values were elicited. The CV survey questionnaire had two sections. The first section contained warm-up questions to get the respondents thinking about the technology implemented in their area. The respondents were provided with a list of problems including increased in post-harvesting losses, depletion of fish stocks, increased in fish contamination by pests, loss of income, disease outbreaks, poor fish quality, poor hygiene and other ecological problems such as deforestation and others and were asked to rank the three critical problems in the area. The second section focused on respondents' attitudes towards technology and knowledge on how to use the technology to solve the above-mentioned problems [27]. In this section, money was used as a standard measure of a change in risks of being affected by various problems (increased fish post-harvest losses, disease outbreak due to fish contamination, loss of income and others) and was defined as either positive or negative payments, which, according to the principle of economics, holds expected utility constant under different risk levels. High risk implied high WTP amount which was categorically equated to high improvement of FSD and the reduction of risk of being affected by problems [28]. The risk of households being affected by increased problems of post-harvest losses was

categorized two-fold. Firstly, as exogenous, where factors were beyond individuals' control and secondly, as endogenous, where households could take action to reverse the situation and reduce the undesirable likelihood of events, such as high post-harvest losses, loss of income etc. The individual's risk reduction actions were assumed to be the function of WTP, which was linked to individual perception towards the technology. To determine the WTP amount across the primary beneficiaries of the technology, several influencing factors such as realizing the gravity of risk experienced in the absence of the technology determined as exogenous factors R, income (i), self-initiative to avoid post-harvest loss (S), risk aversion (P) were expressed using logistic regression model[27].

$$WTP_i = \beta_0 + \beta_S S_i + \beta_R R + \beta_P P_i + \dots \beta_y X_i + \varepsilon_i \quad (2)$$

where WTP_i is a dummy variable (where 0 = positive WTP and 1 = negative WTP), β_S is a corresponding vector of estimated coefficient and ε_i is a random error term assumed to be normally distributed with zero mean and variances δ^2 . Endogenous risk factors include protective measures that respondents are expected to take and it is controlled through the information collected in the CV survey. The main hypothesis in this study was that WTP for FSD would be consistent with variations in exogenous risk levels across households. However, realizing risk alone could not justify WTP. Other factors such as socio-economic, demographic, and institutional factors were also equally important and were considered.

Hypothetical model approach

Based on the CV questions on whether respondents are willing to pay for the improvement of the technology without mentioning any monetary value, a double-bound dichotomous choice (DBDC) WTP question was adopted to identify the possible protest responses. Respondents were asked to give a truthful answer considering their limited monetary income that can also be spent on other equally important items. The interviewers provided mental accounts to all respondents and no formal cheap talk scripts were used. The questions were made simple and easy to understand considering the high illiteracy level in the study area. Some questions encountered by the researchers in the field were '*why only the selected respondents were interviewed and not everyone in the study area?*'[28], and the probable explanation was that not all beneficiaries could be interviewed due to resource constraint and time, but all households who benefit from the technology would be asked to contribute. The WTP questions without mentioning any monetary value were framed as follows [28]:

Q1. Suppose a communal FSD was constructed close to your home to ensure that everyone has access to it, would you be willing to pay in principle for such a communal arrangement?

Yes/No (If No, go to question 5)

Q2. In case your family member is the one involved in fish processing activities, are you willing to pay on behalf of your household for the capital investment cost of the technology?

Yes/No (If No, go to question 5)



Q3 To operate and maintain the technology in your area, everyone in the village will also be asked to contribute to the operation and maintenance costs of the technology. In this case are you also willing to contribute to ensuring that the technology is sustainable and beneficial to everyone?

Yes/No (If No, go to question 5)

Q4: If you are willing to pay, can you give a probable explanation?

Q5. If you are not willing to pay, would you mind to explain why not?

Based on the responses obtained from the above questions, five bids capital costs (US\$ 0.5, US\$10, US\$20, US\$50, and US\$100/year) were presented to the respondents. Depending on the first ('yes' or 'no') responses, the respondents were asked for their WTP for a second follow up-bid to which they would again answer either 'yes' or 'no'. If the respondents answered 'no' or 'yes' to the first bid, the subsequent bid was a lower or higher amount. The bid levels were pretested before being used in the CV survey and were framed based on prior knowledge of the households for the investment cost of the technology. The double-bound dichotomous choice (DBDC) used in this study was an extended version of the single bound dichotomous choice (SBDC) format, where WTP depends on a variety of factors X_i , including bid price and unobservable factors that are captured in the error (ε_i) and can be expressed as.

$$WTP_i^1 = X_i'\beta + \varepsilon_i \tag{3}$$

$$WTP_i^2 = (1 - \gamma)WTP_i^1 + \gamma\beta_1 + \delta \tag{4}$$

Where γ is the parameter reflecting on the starting bid β_i and δ is a shifting parameter. If there is no starting point bias $\gamma = 0$. Likewise, incentive incompatibility means that $\delta = 0$. Based on the DBDC CV approach, information on WTP intervals was obtained. The respondents were again asked two questions for double intervals. 'Do you accept the first bid (B^1) or the second bid (B^2)?'. Based on these two questions, four possible intervals were constructed for WTP:

- $WTP \geq \beta^2$ accept both starting bid (B^1) and follow up a bid (β^2)
- $\beta^1 \geq WTP < \beta^2$ accept the starting bid (β^1) and reject the follow-up bid (β^2)
- $\beta^1 \leq WTP > \beta^2$ Reject the start bid (β^1) and accept the follow up (β^2)
- $WTP \leq \beta^2$ Reject both starts (B^1) and follow up a bid (B^2)

Deriving the probability of observing each of the sequences of the possible choices, the j th contribution to the likelihood function was specified as:



$$L_j \left(\frac{WTP_i}{\beta^i} \right) = P_r(WTP_1 + \varepsilon_{1j} > \beta^1, WTP_2 + \varepsilon_{2j} \geq \beta^2)^{YY} \\ \times P_r(WTP_1 + \varepsilon_{1j} \geq \beta^1, WTP_2 + \varepsilon_{2j} < \beta^2)^{YN} \\ \times P_r(WTP_1 + \varepsilon_{1j} < \beta^1, WTP_2 + \varepsilon_{2j} > \beta^2)^{NY} \\ \times P_r(WTP_1 + \varepsilon_{1j} < \beta^1, WTP_2 + \varepsilon_{2j} < \beta^2)^{NN} \quad (6)$$

Where WTP_i and WTP_2 are the means for the first and second bid response and YY =yes and YN=1 for yes-no answer, NY= for a no-yes answer, and NN= I for no-no answer. This likelihood function is estimated while using the probit model (cumulative distribution function with zero means (WTP), correlation coefficient p, the jth contributing to the univariate probit likelihood model) [27].

$$L_i \left(\frac{WTP_i}{\beta^i} \right) = \Phi \left(\frac{\varepsilon_1}{\varepsilon_2} \left(d_{1j} \left(\frac{\beta_1 - WTP_1}{\sigma^1} \right), d_{2j} \left(\frac{\beta^2 - WTP_2}{\sigma^2} \right), d_{1j} d_{2j} \rho \right) \right) \quad (7)$$

Where $WTP_{1j} = 1$ if the response to the first question is yes or otherwise, $WTP_{1j} = 1$ if the response to the second question is yes or otherwise, $WTP_{2j} = 1$ if the response to the second question is yes; or otherwise, $d_{1j} = 2WTP_{1j} - 1$ and $d_{2j} = 2WTP_{2j} - 1$. Mean and median WTP were derived, as follows:

$$\text{Mean WTP} = \exp \left(\frac{-\bar{x} \hat{\beta}'}{\hat{\beta}_0} + 0.5 \hat{\sigma}^2 \right) \quad (8)$$

$$\text{Median WTP} = \exp \left(\frac{-\bar{x} \hat{\beta}'}{\hat{\beta}_0} \right) \quad (9)$$

Where \bar{x} is a k+1 row vector of the mean value of the explanatory variable, including 1 for constant term, $\hat{\beta}'$ is ak-1 column vector of estimated coefficient and $\hat{\sigma}$ is the estimated variance [27]. Stata version 14 was used to calculate the specified confidence intervals around the mean and median.

RESULTS AND DISCUSSION

General characteristics of the respondents

Table 1 shows a summary of the descriptive statistics of the respondents interviewed. The average age of the total respondents was 36 with the maximum being 84 and minimum 20 suggesting that the fishing households in the study area were dominated by youthful population. Limuwa & Synnevåg [29] reported the mean age of men and women to be within the range of 39.8 and 39.4 respectively. On the other hand, the Malawi government report also acknowledged that approximately 73% of the population in Malawi is below the age of 35 years. It was noted that about 66.7% of the households interviewed were married. Limuwa & Synnevåg [29] in their studies on gender perspective on the fish value chain, livelihood patterns, and coping strategies under climate change in Malawi also reported a higher proportion of married men (89%) and women (60%) in Nkhotakota, Malawi. The study further recorded a higher percentage (74%) of male respondents than female. Researchers such as Limuwa & Synnevåg [29],



Kayamba-Phiri [30] and Kopa [31] had similar observations suggesting that men dominate fishing activities more than women [32]. A similar case was reported among Lake Chilwa riparian communities where fishing activities were predominately dominated by men [32]. The level of monthly income among the households interviewed was reported to be within the range of US\$ 5 to US\$300, respectively with an average of US\$92.4. The estimate of the human population within the radius of the 100km buffer zone shows that Lake Malawi catchment is highly populated with 10 million households. The average household size was 6 with a minimum of 2 and a maximum of 14. The majority (86.3%) of these households depend on fishing as the main source of livelihood. Researchers such as Makwinja & M'balaka [26] and Limuwa *et al.* [25] had a similar observation. Furthermore, about 45% of the respondents were involved in fish processing activities and knowledge of FSD was not new to the respondents. The majority (54.9%) of the respondents expressed that they knew the technology.

Analysis of the rate of households' willingness to pay amount

Table 2 shows the reasons for positive and negative WTP responses. Firstly, the household's satisfaction with services rendered by FSD was assessed. The responses from the sampled fishing households showed that about 20.6% were very satisfied and 42.3% were satisfied. In other words, a total of 62.9% of the respondents were satisfied with the services rendered by FSD. Rasch *et al.* [33] attributed this fact to the improved level of income among the fishing households involved in fish processing using FSD technology. Asking whether the respondents were willing to pay for the maintenance of the FSD, about 72.4% of the respondents were willing to pay for the FSD. The previous researcher reported a lower range of 25% to 30% rate of respondents WTP for FSD [33]. Chiwawula *et al.* [34] reported the average probability of about 74% in the Southern Part of Lake Malawi and Javan-Noughabi *et al.* [35] reported 88.8% WTP in Iran. It was noted that the rate of respondents WTP achieved in this study was higher than what was previously reported by other authors except Javan-Noughabi *et al.* [35] and Chiwawula *et al.* [34]. The rate of WTP presented in this study may depict the perceived value of FSD to the users.

Reasons for consumers' willingness to pay

An attempt was made to probe the reasons for those respondents (56 respondents) who were not willing to pay and their negative responses were categorized as protest and genuine zero. Protests were separated from genuine zero by asking respondents the reason for not willing to pay for the proposed program. The respondents who honestly said that they had a low level of income and could not afford to pay for the proposed program were categorized as genuine zero. As seen in Table 2, about 31.4% suggested that they could not afford to pay due to a low level of income. Other respondents who did not agree with the proposed program were categorized as a protest. For example, about 35.3% of the respondents protested against the program while 20.8% explained that they could not see any value of the technology. In other words, the technology had no impact on their livelihood. It was noted that 13.7% suggested that it was the responsibility of the government to pay for the FSD and about 8.8% had their local political reasons. Based on economic theory, any technology is desired because of its ability to satisfy human wants. This implies that those individuals who protested the WTP program might probably not be satisfied with the services rendered by the



technology. An attempt was further made to probe the reasons for those respondents (144 WTP respondents) who were willing to pay for the technology. As seen in Table 2, about 43.3% of the respondents believed that technology is capable of mitigating the impact of climate change. On the other hand, 17.6% suggested that they experienced a tremendous positive change in terms of their level of income since the technology was introduced. As seen in Table 1, about 92.2% of the respondents explained that they have been experiencing post-harvest losses over the past years. However, 17% of the respondents believed that technology would help to solve such problem, 19.6% believed that technology would consequently improve fish quality while 7.8% had their reasons.

Economic value of the Fish Solar Dryer

Because there is no market price for public facilities such as FSD (the commodity or service that is provided without profit to all members of a society either by government, private individual or organization) [36], based on the theory of demand and supply, the economic value of FSD as a public facility was conceptualized by determining the monetary value which a household was willing to pay to exchange for the service of the facility if it were possible to make such an exchange in the real market [34]. The WTP amount was quantified into monetary terms and the results are presented in Table 3. The lowest WTP value recorded from the study was US\$0.5 per year and the maximum was US\$54.42. The median was recorded with the assumption that there may be extreme values in the data set which in this case median could be more useful than mean. On the other hand, the mode was recorded to display the most frequent number in the data set. The median recorded from the study was US\$2.72 while the mean was US\$7.9 and the mode US\$2.72. The total annual WTP ranged from US\$0.5 to US\$54.42. Chiwawula *et al.* [34] also reported the average WTP amount of US\$29.45 (US\$26.46 for females and US\$33.51 for males) in the Southern Part of Lake Malawi. According to Chiwawula *et al.* [12], FSD with a life span of five years can be constructed at an estimated cost of MK120, 000 (about US\$160) to MK1, 200, 000 (US\$1700). There were two FSD constructed in the two fishing landing sites (Chipala and Vinthenga). The total capital investments of two FSD with a capacity to serve approximately 500 households per year ranged from 240,000 (US\$ 320) to 2,400,000 (US\$3,200). However, the annual household mean WTP amount was US\$ 7.93. Assuming a total of 500 households were willing to pay US\$7.93/individual household, it implied that about MK3,648,750 (US\$4,865) could be recovered annually suggesting that the capital investment of the two FSD could be recovered within a year with a profit of about MK1,248,750 (US\$1,665). The amount of money recovered can be used to construct additional FSD as well as maintaining the existing ones. However, if the cost is to be spread throughout the FSD life span, it implies that the mean annual WTP value could be lower than US\$ 7.93.

Analysis of factors influencing consumers' willingness to pay

The study also theorized the potential influencing factors for the respondents WTP. Communal technology such as FSD is socio-economic and ecological systems that include human sociological, economic and ecological components. Understanding and managing such public facilities requires a multidisciplinary approach which includes economics, sociology, and ecology. In a public facility such as FSD, the WTP of a household depends on several factors amongst being socio-economic, demographic, economic, and psychological factors. In this study, these WTP influencing factors were



first tested for multi-collinearity before being introduced into the logistic regression model. The existence of a high multi-collinearity problem makes the regression model deficiency [37]. Multi-collinearity problem seriously affects least-squares parameter estimates and in extreme cases can cause the least-squares parameter estimates to be far from the true values of the parameters leading to incorrect conclusions about the relationships between responsive and explanatory variables. The results presented in Table 4 show that multicollinearity was not a problem and none of the explanatory variables overlapped, which suggests that the explanatory variables were fit to be presented in the logistic regression model. Table 5, presents the results of logistic regression of the probability of the WTP respondents. The results showed a -2log likelihood of 31.2 suggesting that the model classification was clear and correct. In this study, Cox and Snell [38] were used to assess the model's power of prediction. Table 5 shows Cox & Snell R squared of 0.53, Nagelkerke R square of 0.71, Hosmer and Lemeshow Chi-Square of 6.60 and Sig of 0.58 suggesting that the logistic regression model explained a considerable amount of variance in the choice of the respondents' WTP. Hosmer and Lemeshow Chi-Square were greater than 0.05 and non-significant indicating that the models were a reasonably good fit for the data and therefore good overall model fit.

The logistic regression results in Table 5 demonstrated a significant ($p < 0.05$) relationship between Age of the household (AGH), Gender of household head (GHH), Household literacy level (HLL), Household involved in fish processing (HIVFP), Household-level of income (HLI) (US\$), Household social trust (HST), Household institutional trust (HIT), Household has experience fish post-harvest losses (HEFPL), Household has access to extension services (HAE), Household has access to a social network (HST) and WTP. As seen from Table 5, the regression coefficients of AGH and GHH were negative while HLL, HIVFP, HLI, HST, HIT, HEFPL, HAE, HSN, and HST were positive. The regression coefficient of AGH was -6.02 and Wald of 5.34, and statistically significant at 0.05 level of confidence suggesting that young people were more willing to pay as compared to the old. Previous studies have shown that older people have huge responsibilities ranging from high expenditures on food and associated family expenses and hence not able to contribute as much as young people [39]. Monthly income is the most significant factor affecting WTP. The study conducted by Javan-Noughabi [35] in Iran indicated that the monthly income of respondents significantly influenced altruistic WTP in all different states of health. The study further showed that the increase of 1% of monthly income resulted in US\$ 251 increase in the altruistic WTP. Similar findings were reported in the present study. For example, it was noted that HLI had a positive regression coefficient of 2.06, Wald 9.02, and significant at 0.05 suggesting that a decrease in the level of income is strongly linked to the low rate of respondents WTP.

The GHH on the other hand had negative regression coefficients of -0.92, Wald of 2.01, and significant at 0.05 suggesting that more men were willing to pay than women. The study findings were in line with Javan-Noughabi *et al.* [35] who reported a significant level of 0.01 in GHH. Javan-Noughabi *et al.* [35] explained that low WTP in female respondents is because male participants had higher income levels as compared to females and according to the principle of economics, a decrease in income level is strongly linked to a low rate of respondents WTP. They further noted that the level of



education was higher among male respondents than females which were also linked to higher WTP in males than females. Similar findings were reported in the present study. It was noted that HLL had a positive regression coefficient of 2.97, Wald of 7.11, and significant at 0.05 level of confidence suggesting that education positively influenced the household's WTP. Researchers such as Halkos and Matsior [39] earlier reported that education has a positive influence on WTP and is strongly linked to the perception of the communities towards the technology. Theoretically, it can be suggested that households who were literate could understand the technology much better than their counterpart [40,41]. The HIVFP had a positive regression coefficient of 6.37 and Wald of 5.41 suggesting that those respondents who were involved in fish processing were much more willing to pay than their counterparts. The HST and HIT had both positive regression coefficient 3.03 and 0.91, Wald of 6 and 11.2, respectively suggesting that when the communities have much trust in the local governance structures, government institutions and NGOs, they are more WTP towards the proposed program. The HEFPL had also positive regression coefficient 2.42, Wald of 8, and significant at 0.05 suggesting that the higher the post-harvest losses experienced by the individual households, the higher the WTP amount. The influence of HAE and HSN were assessed and the model demonstrates positive regression coefficient 0.93, Wald of 4,81 and 2.50, Wald 2.10, and both were significant at 0.05 suggesting that HAE and HSN had a positive influence on the household WTP towards the proposed program.

CONCLUSION

The findings from this study revealed that the mean annual WTP value (US\$ 7.93) could generate enough capital return (MK3,648,750 (US\$4,865) with a profit of about MK1,248,750 (US\$1,665) at total capital investments cost of MK2,400,000 (US\$3,200)) within a year, which could be used to reinvest into the technology in the two sites at the end of their lifespan. The mean WTP value could be applied as a fixed price for maintenance, and reinvestment in the FSD to ensure sustainability. The regression coefficients of age and gender of household head (GHH) were negative ($\beta = -6.02$ and Wald of 5.34, $\beta = -6.92$, Wald of 2.01) and significant ($p < 0.05$) suggesting that young people were more WTP than their counterpart. Males also coded as (0) were more willing to pay than females. On the other hand, household literacy level (HLL), household involved in fish processing (HIVFP), household social trust (HST), household institutional trust (HIT), household level of income (HLI), household experienced fish post-harvest losses (HEFPL), household access to extension services (HAE) and household social network (HSN) were positive ($\beta = 2.97$, Wald of 7.11, $\beta = 6.37$ and Wald of 5.41, $\beta = 3.03$ and Wald of 6, $\beta = 11.2$, Wald 9.02, $\beta = 2.42$, Wald of 8, $\beta = 0.93$, Wald of 4,81 and $\beta = 2.50$, Wald 2.10) and significant ($p < 0.05$) suggesting that those HIVFP, had high HLL, HLI, HST, HIT, HSN and HEFPL were more willing to pay than their counterparts. The findings from this study have local policy implications, particularly for local government. Strategies that aimed to improve communities' climate change resilience, improve communities' income, and livelihood while reducing postharvest losses in the fisheries sector need to consider this kind of study for effective implementation and sustainability.



ACKNOWLEDGEMENTS

The FSD was part of the SEEDFISH project implemented in the Western Shore of Lake Malawi under Capacity Building for Managing Climate Change Programme (CABMACC) funded by the Norwegian Ministry of Foreign Affairs [grant number MWI – 2011-11/0007] to the Malawi Government, which the authors acknowledge. Further acknowledgement is extended to Nkhotakota District Council in particular Nkhotakota fisheries office. Individuals such as Mayamiko Chaweza, Catherine Joshua, Judith Chulu, Charles Mandala, German Winter, and Macfillard Ching'ani from Nkhotakota Fisheries office, Mzuzu University students (Monica Longwe and Anthony Ghambi) and friends (Enock Rhino and Edward Danisa) are further acknowledged for their support during the data collection. The authors further extend gratitude to communities of Vinthenga and Chipala fish landing sites for their lively participation during the data collection process.

FUNDING SOURCES

This study received no external funding.



Table 1: Descriptive statistics of the characteristics of the respondents

Variables	Definition of variables	Description of variables	Frequency	Valid percent	Mean± STD error	Min-Max
AGH	Age of the household	continuous			36±0.14	20-84
MS	Marital status	Dummy variable where married = 0 and single = 1	133	66.7	0.33±0.01	0-1
GHH	Gender of the household head	Dummy variable where male = 0 and female = 1	148	74	0.13±0.00	0-1
HFS	Household Family size	Continuous			6.00±0.32	2-14
HLL	Household literacy level	Dummy variable where 0= literate 1=illiterate	152	29.4	0.07±0.06	0-1
HDFML	Household depends on fishing as the main source of livelihood	Dummy variable where positive = 0 and 1 = otherwise	172	86.3	0.02±0.03	0-1
HIVFP	Household involved fish processing	Dummy variable positive = 0 and 1 = otherwise	90.2	45.1	0.61±0.00	0-1
HUSTPF	Household uses the technology for processing fish	Dummy variable where 0 = positive and 1 = otherwise	161	80.4	0.01±0.00	0-1
HBTLI	Household believe that technology can improve their income	Dummy variable where 0 = positive and 1 = otherwise	180	90.2	0.01±0.00	0-1
HBTMC	Household believe that technology can mitigate the impact of climate change	Dummy variable where 0 = positive and 1 = otherwise	145	72.4	0.02±0.00	0-1
HKSTD	Household know the use of technology	Dummy variable where 0 = positive and 1 = otherwise	109	54.9	0.03±0.00	0-1
HLI	Household-level of income (US\$/month)	Continuous			92.4±0.00	5-300
HSP	Household social position	Dummy variable where 0 = positive and 1 = otherwise	27	13.7	0-1	0-1
HST	Household social trust	Dummy variable where 0 = positive and 1 = otherwise	43	21.6	0.51±0.00	0-1
HIT	Household institutional trust	Dummy variable where 0 = positive and 1 = otherwise	129	64.5	0.04±0.00	0-1
HEFPL	A household has to experience fish post-harvest losses	Dummy variable where 0 = positive and 1 = otherwise	184	92.2	0.01±0.00	0-1
AES	The household has access to extension services	Dummy variable where 0 = positive and 1 = otherwise	156	78.4	0.02±0.00	0-1



HIFP	Household Involved in fish processing	Dummy variable where 0 = positive and 1 = otherwise	108	54.2	0.03±0.00	0-1
HKLF	Household has knowledge on the fisheries legal framework	Dummy variable where 0 = positive and 1 = otherwise	51	25.4	0.04±0.00	0-1
THSA	Time household has stayed in the area	Continuous			21±0.00	3-77
HDBLS	The household does business at the landing site	Dummy variable where 0 = positive and 1 = otherwise	36	17.6	0.83±0.00	
HMO	Household Main occupation	Dummy variable where 0 = Fishing, 1 = Farming, 2 = Traders, 3 = Formal employment, 4 = no occupation	148	74	0.06±0.00	1-4
HDTL	Household distance to the facility	continuous			0.31±0.00	0.2-4
HSN	A household has access to social network	Dummy variable where 0 = positive and 1 = otherwise	132	66.2	0.5	0-1
HHP	A household has ever heard about the FSTDT	Dummy variable where 0 = positive and 1 = otherwise	66	33.1	0.01±0.00	0-1



Table 2: Reasons for consumers' positive and negative willingness to pay responses

Factors	Categories	values	Percent	Mean± S. E	Min-Max
Ranking household satisfaction with the services rendered by FSTDT	Very satisfied	52	20.6		0-4
	Satisfied	85	42.3	1.07±0.13	
	Less satisfied	29	14.6		
	Not satisfied	24	11.9		
	Not very satisfied	20	10		
Total		200	100		
WTP	WTP	144	72.4		
	Not WTP	56	27.6	0.27±0.06	0-1
Total		200	100		
Reasons for not WTP	The household does not have money	18	31.4		
	Disagree with the program	20	35.3		
	FSTDT has no impact on the livelihood of the household	6	10.8	1.35±0.19	0-4
	It is the government responsibility	8	13.7		
	Other reasons	4	8.8		
Total		56	100		
Reasons for WTP	Mitigate climate change impact	62	43.3		
	Improve household income	25	17.6	1.39±0.23	0-4
	Improve fish quality	28	19.6		
	Reduce post-harvest losses	17	11.8		
	Other reasons	12	7.8		
Total		144	100		

Table 3: Analysis of willingness to pay amount (US\$) (N=144)

Parameter	Number	Mean	Median	Mode	minimum	Maximum	Sum
Amount/year	144	7.9	2.72	2.72	0.04	54.42	214.32

Table 4: Correlation matrix of explanatory variables

	AGH	MS	GHH	HFS	HLL	HDFML	HIVFP	HBTILI	HBTMCI	HKSTD	HLI	HSP	HST
AGH	1												
MS	-0.26	1											
GHH	-0.23	0.07	1										
HFS	0.05	0.02	-0.04	1									
HLL	-0.34	0.01	0.22	0.11	1								
HDFML	0.49	0.12	0.18	0.17	0.05	1							
HIVFP	0.05	0.13	0.06	0.01	0.01	0.39	1						
HBTILI	0.28	0.08	0.00	0.20	0.04	0.01	0.00	1					
HBTMCI	0.00	0.47	-0.01	0.39	0.05	0.21	-0.03	-0.28	1				
HKSTD	-0.16	0.12	0.00	0.18	-0.03	-0.09	0.09	0.06	0.06	1			
HLI	0.26	0.06	-0.26	0.00	0.02	0.05	0.03	-0.02	0.43	-0.21	1		
HSP	0.04	0.22	0.32	0.25	-0.04	0.03	0.45	0.03	0.23	0.04	0.03	1	
HST	0.32	0.02	0.05	0.34	0.08	0.21	0.34	0.027	-0.10	-0.03	0.13	-0.2	1

Table 5: The effects of the best fitted logistic regression model of exogenous, endogenous, socio-demographic and institutional variables

Explanatory Variables	Definition of variables	Description of variables	β	S. E	Wald	Sig
AGH	Age of the household	continuous	-6.02	0.03	5.34	0.04*
MS	Marital status	Dummy variable where married = 0 and single = 1	5.23	0.71	0.12	0.20 ^{ns}
GHH	Gender of the household head	Dummy variable where male = 0 and female = 1	-6.92	0.61	2.01	0.02*
HFS	Household Family size	Continuous	0.455	0.13	0.01	0.95 ^{ns}
HLL	Household literacy level	Dummy variable where 0=literate 1=illiterate	2.97	0.94	7.11	0.03*
HDFML	Household depends on fishing as the main source of livelihood	Dummy variable where positive = 0 and 1 = otherwise	-2.63	0.39	0.21	0.12 ^{ns}
HIVFP	Household involved fish processing	Dummy variable positive = 0 and 1 = otherwise	6.37	0.66	5.41	0.04*
HBTILI	Household believe that technology can improve their income	Dummy variable where 0 = positive and 1 = otherwise	-2.97	0.03	0.00	0.99 ^{ns}
HBTMCI	Household believe that technology can mitigate impact of climate change	Dummy variable where 0 = positive and 1 = otherwise	2.37	0.03	0.03	0.08 ^{ns}
HKSTD	Household know the use of technology	Dummy variable where 0 = positive and 1 = otherwise	-0.75	0.89	0.407	0.24*
HLI	Household-level of income (US\$)	Continuous	2.06	0.04	9.02	0.01**
HSP	Household social position	Dummy variable where 0 = positive and 1 = otherwise	-2.21	0.32	2.79	0.09 ^{ns}

HST	Household social trust	Dummy variable where 0 = positive and 1 = otherwise	3.03	0.00	6.00	0.03*
HIT	Household institutional trust	Dummy variable where 0 = positive and 1 = otherwise	0.91	0.82	11.21	0.01**
HEFPL	A household has to experience fish post-harvest losses	Dummy variable where 0 = positive and 1 = otherwise	2.42	0.92	8.00	0.02*
AES	A household has access to extension services	Dummy variable where 0 = positive and 1 = otherwise	0.93	0.04	4.81	0.03*
HKLF	Household has knowledge on the fishery's legal framework	Dummy variable where 0 = positive and 1 = otherwise	-0.86	0.26	0.46	0.50 ^{ns}
THSA	Time household has stayed in the area	Continuous	1.09	0.03	0.74	0.21 ^{ns}
HDBLS	The household does business at the landing site	Dummy variable where 0 = positive and 1 = otherwise	7.18	0.43	1.32	0.14 ^{ns}
HDTL	Household distance to the facility	continuous	1.06	0.57	3.41	0.06 ^{ns}
HSN	A household has access to social network	Dummy variable where 0 = positive and 1 = otherwise	2.50	0.72	2.10	0.03**
HHP	A household has ever heard about the FSTDT	Dummy variable where 0 = positive and 1 = otherwise	0.60	0.02	0.35	0.55 ^{ns}
Constant			5.414	0.54	4.84	0.03*

-2log likelihood = 310.92, Cox & Snell R squared = 0.53, Nagelkerke R square = 0.71, Hosmer and Lemeshow Chi-Square = 6.60, Sig = 0.58
*Note ns indicates not significant while ** and * indicate significance at 0.01 and 0.05 level of confidence*

REFERENCES

1. **Government of Malawi** National Fisheries and Aquaculture Policy, Second Ed. Department of Fisheries, Ministry of Agriculture, Irrigation and Water Development. Lilongwe, 2016.
2. **Phiri L, Dzanja J, Kakota T and M Hara** Value chain analysis of Lake Malawi fish: A case study of *Oreochromis spp* (Chambo). *International Journal of Business and Social Science*, 2013; **4(2)**: 170-181.
3. **Fisheries Department.** Annual Economic Report 2017 Fisheries Sector Contribution. Department of Fisheries, Ministry of Agriculture, Irrigation and Water Development. Lilongwe, 2017.
4. **Mumba P and M Jose** Nutrient composition of selected fresh and processed fish species from Lake Malawi: A nutritional possibility for people living with HIV/AIDS. *International Journal of Consumer Studies*, 2005; **29(1)**: 72-77.
5. **Makwinja R, Singini W, Kaunda E, Kapute F and M M'balaka** Stochastic modeling of Lake Malawi *Engraulicypris sardella* (Gunther, 1868) catch fluctuation. *International Journal of Fisheries and Aquaculture*, 2018; **10(4)**: 34-43.
6. **Banda J, Chigwechokha P, Singini W, Kamanula J, Msiska O and J Simbeye** The Shelf life of Solar Tent Dried and Open Sun-Dried *Diplotaxodon limnothrissa* (Ndunduma)-Pisces; Cichlidae. *International Journal of Fisheries and Aquatic Studies*, 2017; **5(5)**: 212-218.
7. **Katola A and F Kapute** Nutrient composition of solar-dried and traditionally smoked *Oreochromis mosambicus* (Peters, 1852). *International Food Research Journal*, 2017; **24(5)**: 1986-1990.
8. **Wolff R and S Resnick** Contending Economic Theories: Neoclassical, Keynesian, Cambridge, Massachusetts: The MIT Press, 2012.
9. **Sewall H** The Theory of Value before Adam Smith. *Publications of the American Economic Association*, 1901; **2(3)**: 1-128.
10. **Awomew A and O Ogundele** The importance of the payback method in capital budgeting decisions. Blekinge Institute of Technology: Blekinge, **2008**.
11. **Jehle GA and PJ Reny** Advanced Microeconomic Theory, Third Ed. Prentice-Hall: London, 2011.
12. **Aristotle** *Nichomachean Ethics*. Retrieved from <http://classics.mit.edu/Aristotle/nicoma-chaen.html>, 350 BCE (Accessed 3rd September 2018).

13. **Hanemann W** The economic conception of water. In P. Rogers, M. Llama, & L. Martinex-Cortina, *Water Crises: Myth or Reality* (pp. 61-93). Leiden, Netherland: Tylor and Francis Group, 2012.
14. **Pearce D** Do we really care about biodiversity? *Environmental and Resource Economics*, (2007) **37(1)**: 313–333.
15. **Smith V and S Pattanayak** A Meta-Analysis a Noah' s Ark for Non-Market Valuation? *Environmental and Resource Economics*, (2002); **22(2002)**: 271–296 <https://doi.org/10.1023/A:101567316109>
16. **Makwinja R and V Chipofya** Impacts of Social-Cultural Factors on the Management of Deep Pools of Likangala River, Malawi. *Current Journal of Applied Science and Technology*, (2019); **34(4)**: 1-5.
17. **Bockstael N and M Freeman** Welfare Theory and Evaluation. In K. Mäler & J Vincent, *Handbook of Environmental Economics* (pp. 518-369). Elsevier B.V: 2005.
18. **Hoyos D and P Mariel** Contingent Valuation: Past, Present, and Future. Country, Lehendakari Agirre 83, 48015 Bilbao, University of the Basque: Spain, 2007.
19. **Buckley C, Howley P, O'donoghue C and P Kilgarrif** Willingness to Pay For Achieving Good Status Across Rivers in the Republic of Ireland. *The Economic and Social Review*, (2016); **47(3)**: 425-445.
20. **Hynes S, Campbell D and P Howley** A Holistic vs. an Attribute-based Approach to Agri -Environmental Policy Valuation: Do Welfare Estimates Differ? *Journal of Agricultural Economics*, (2011); **62(2)**: 305–329.
21. **Taylor J, Stewart T and M Downton** Perceptions of drought in the Ogallala Aquifer region. *Environment and Behavior*, 1988; **20(1988)**: 150–17.
22. **Grillia G, Landgrafa G, Curt J and S Hynes** A travel cost evaluation of the benefits of two destination salmon rivers in Ireland. *Journal of Outdoor Recreation and Tourism*. 2018; **23(2018)**: 1–7.
23. **Pearce D and R Turner** *Economics of Natural Resources and the Environment*. The John Hopkins University Press: Baltimore, Maryland, USA, 1990.
24. **Ingold T** *The Perception of the Environment: Essays on Livelihood, Dwelling, and Skill*. Routledge: New York, 2000.
25. **Limuwa M, Sitaula B, Njaya F and T Storebakken** "Evaluation of Small-Scale Fishers' Perceptions on Climate Change and Their Coping Strategies Insights from Lake Malawi. *Clime*. 2018; **6**: 34; doi:10.3390/cli6020034

26. **Makwinja R and M M'balaka** Potential Impact of Climate Change on Lake Malawi Chambo (*Oreochromis* spp.) *Journal of Ecosystem & Ecograph*, 2017); **7(2017)**: 227. doi:10.4172/2157-7625. 100 0227
27. **Makwinja R, Kosamu I and C Kaonga** Determinants and Values of Willingness to Pay for Water Quality Improvement: Insights from Chia Lagoon, Malawi. *Sustainability*, (2019); **11**: 4690; doi:10.3390/su11174690.
28. **Johansson P** *Evaluating Health Risks: An Economic Approach*. Cambridge: Cambridge University Press 1995.
29. **Limuwa M and G Synnevåg** A gendered perspective on the fish value chain, livelihood patterns, and coping strategies under climate change - insights from Malawi's small-scale fisheries. *African Journal of Food, Agriculture, Nutrition, and Development*, (2018); **18(2)**: 13525-13544.
30. **Kayamba-Phiri F** Between the sun and fish are people: A socio-economic study of solar dryers for fish processing in Malawi: MSc thesis. Norwegian University of Life Sciences: Oslo, 2018.
31. **Kopa T** Irrigation Livelihoods Heterogeneity and Water Resource Management: A Study of Bua Watershed in Nkhotakota, Central Malawi. Master's Thesis, Norwegian University of Life Sciences, Oslo, Norway, 2007.
32. **Nagoli J and L Chiwona-Karltun** Uncovering human social networks in coping with Lake Chilwa recessions in Malawi. *Journal of Environmental Management*, 2017; **192 (2017)**: 134-141.
33. **Rasch A, Hodek J, Runge C and W Greiner** Determinants of willingness to pay for a new therapy in a sample of menopausal-aged women. *Pharmacoeconomics*, (2009); **27(8)**: 693-704.
34. **Chiwawula L, Nagoli J and G Kanyerere** Improved Processing and Marketing of Healthy Fish Products in Inland Fisheries in Malawi. University of Malawi: Zomba, 2017.
35. **Javan-Noughabi J, Kavosi Z, Faramarzi A and M Khammarnia** Identification determinant factors on willingness to pay for health services in Iran, *Health Economics Review*, (2017); **7(40)**: 1-6.
36. **Fujita Y, Fujii A, Furukawa S and T Ogawa** Estimation of Willingness-to-Pay (WTP) for Water and Sanitation Services through Contingent Valuation Method (CVM): A Case Study in Iquitos City, The Republic of Peru. *JBICI Review*, (2015); **11(2015)**: 59–87.
37. **Krinsky I and A Robb** On approximating the statistical properties of elasticities. *Economics Statistics*, (1986); **68(4)**: 715–719.

38. **Cox DR and EJ Snell** Analysis of Binary Data. 2nd Edition, Chapman and Hall/CRC, London, 1989.
39. **Halkos G and S Matsiori** Determinants of willingness to pay for coastal zone quality improvement. *Journal of Socio-Economics*, 2012; **41(2012)**: 391–399.
40. **Lane R** Market and the satisfaction of human wants. *Journal of Economic Issues*, (1978); **12(4)**: 799-827.
41. **Makwinja R** Economic Valuation of Water Resources at Chia Lagoon in Nkhotakota District, Malawi, MSc thesis, University of Malawi, The Polytechnic: Blantyre, 2017.