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Farmer's Willingness to Accept Buffer Zone Land around Lake Tana: Evidence from Fogera and Libokemkem Districts, Ethiopia

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Abstract
The main objective of the study was to identify the determinants of rice farmers' willingness to accept for leaving the land around Lake Tana as a buffer zone. The study used the household survey collected from 189 respondents by using semi structured questionnaire. A significant difference in household's characteristics between who are WTA and not WTA was observed. Farmers were reported that water hyacinth appeared on rice farms since 2013. Majority of households were not willing to leave their land as a buffer zone. Based on binary logistic model estimation results, household rice farming experience, sex, residence from lake Tana, location and perception on the importance of conserving Lake Tana ecosystem were affected the decision of households' willingness to leave the land as buffer zone. The study suggested that the adoption of payment for ecosystem services as national conservation and livelihoods enhancement policy tool to conserve ecosystems.
Keywords: rice farmers; water hyacinth; willingness to accept; binary logistic model
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Introduction

In Ethiopia, invasive aquatic weeds are a major concern, posing challenges to aquatic biodiversity and fisheries, as well as agricultural land in the surrounding water bodies (Firehun et al., 2014). The presence of water hyacinth in Lake Tana was reported relatively recently, and it was officially recognized in September 2011 as an ecologically dangerous and worst invasive weed (Wasse et al., 2015; Dereje, 2015). According to Tana Lake and Other Aquatic Resources Conservation and Development Agency in 2020 the extent of the water hyacinth infestation has spread to 28 *kebele*s and seven districts, namely Dera, Fogera, LiboKemkem, G/Zuria, East Denbia, West Denbia, and Takusa.

Many factors contributed to the expansion of water hyacinth, for example, an intensification of agriculture, the overgrazing of pastures, and the expansion of farmland; the release of waste and effluent discharged from some of the homes, factories, and hotels in urban settlements; and fertilizers and pesticides used in agriculture that are washed into the lake, which contributed to the deterioration of lake ecosystem values. Water hyacinth has an impact on crop production by covering rice fields with mats; livestock rearing in lakeside villages by reducing the growth of grasses used for cattle feed; fish production; and fishing efficiency (Asmare *et al.,* 2016; Yitbarek *et al.,* 2019; Tewabe et al., 2017).

The proposed Lake Tana Biosphere Reserve is expected to help address these problems and provide a sustainable future for the area's environment and its local inhabitants. Previous studies showed that users of Lake Tana ecosystem services like fishers, water transport users, and the tourism sector, in general, are negatively affected by the spread of water hyacinth. There needs a scheme to ecosystem valuation and payment system, the beneficiaries, government and NGOs who demanding the ecosystem conservation are expected to pay for ecosystem services, rice farmers on the other hand need a minimum amount of compensation for leaving the land around the Lake Tana as a buffer zone that could be taken as a measure to control the expansion of water hyacinth.

For valuing the ecosystem services, willingness to accept has been assessed in natural resources economics studies at various areas in the globe(Nyongesa et al. 2016, Al-Assaf et al. 2021; Ahiale et al., 2019; Grutters et al., 2008; Wang et al., 2019; Xiong et al. 2019; Xiong and Kong, 2017), for developing the payment for ecosystem services to the environmental sustainability.

However, none of the existing researches in the study area particularly focuses on the factors affecting farmer's willingness to accept to leave the land around Lake Tana as a buffer zone. Identifying the factors affecting WTA by rice producer farmers will give better insight to the concerned bodies on the cost of ecosystem

services on mitigation and controlling strategies against the water hyacinth. The study will have a wide range of benefits and will help policy-making oriented toward conserving the ecosystem services of the Lake Tana against the spread of water hyacinth in the area, especially within the ecosystem payment system framework. As a result, to bring policy impact in the area, there is a need to assess and understanding the farmers' willingness to accept for Lake Tan as buffer zone.

This study, therefore, is assessing farmers' willingness to accept (WTA) for leaving farm land around Lake Tana as buffer zone with a main objective of identify the determinants of rice farmers WTA for leaving the land around Lake Tana as a buffer zone.

Research Methodology

Area description

Lake Tana is located in Northwestern Ethiopia. The Lake Tana Biosphere Reserve is located in the Amhara National Regional State; it is one of Africa's most unique wetland ecosystems and the source of 50% of the freshwater of the country. The average altitude of Lake Tana is approximately 1800m, and the area of the basin (including water surface area) is 15,096 km^2. The Lake has a surface area of 3111 km^2 and 284 km^3volume. Gilgel Abay, Ribb, Gumera, and Megech are the most important rivers feeding into Lake Tana and contribute over 90% of the total water inflow(Song et al., 2018). The only out-flowing river is the Abay (Blue Nile) and it covers 20% of the surface area of the Lake Tana sub-basin.

The study was conducted in the Eastern part of Lake Tana in which rice crop is produced and invaded by Water hyacinth. The study was conducted in *Fogera* and *Libokemkem* districts which are two of the ten districts bordering Lake Tana and found in South Gondar Administrative Zone. *Fogera* district has 33 kebles, two of its kebles (Nabega and Wagetera) bordered by Lake Tana in the west and heavily affected by water hyacinth whereas *Libokemkem* district comprises of 34 *kebeles*[1]. Out of these *kebeles*, four of them namely Tezamba, Kab, Agid&Kirgna are bordered by Lake Tana.

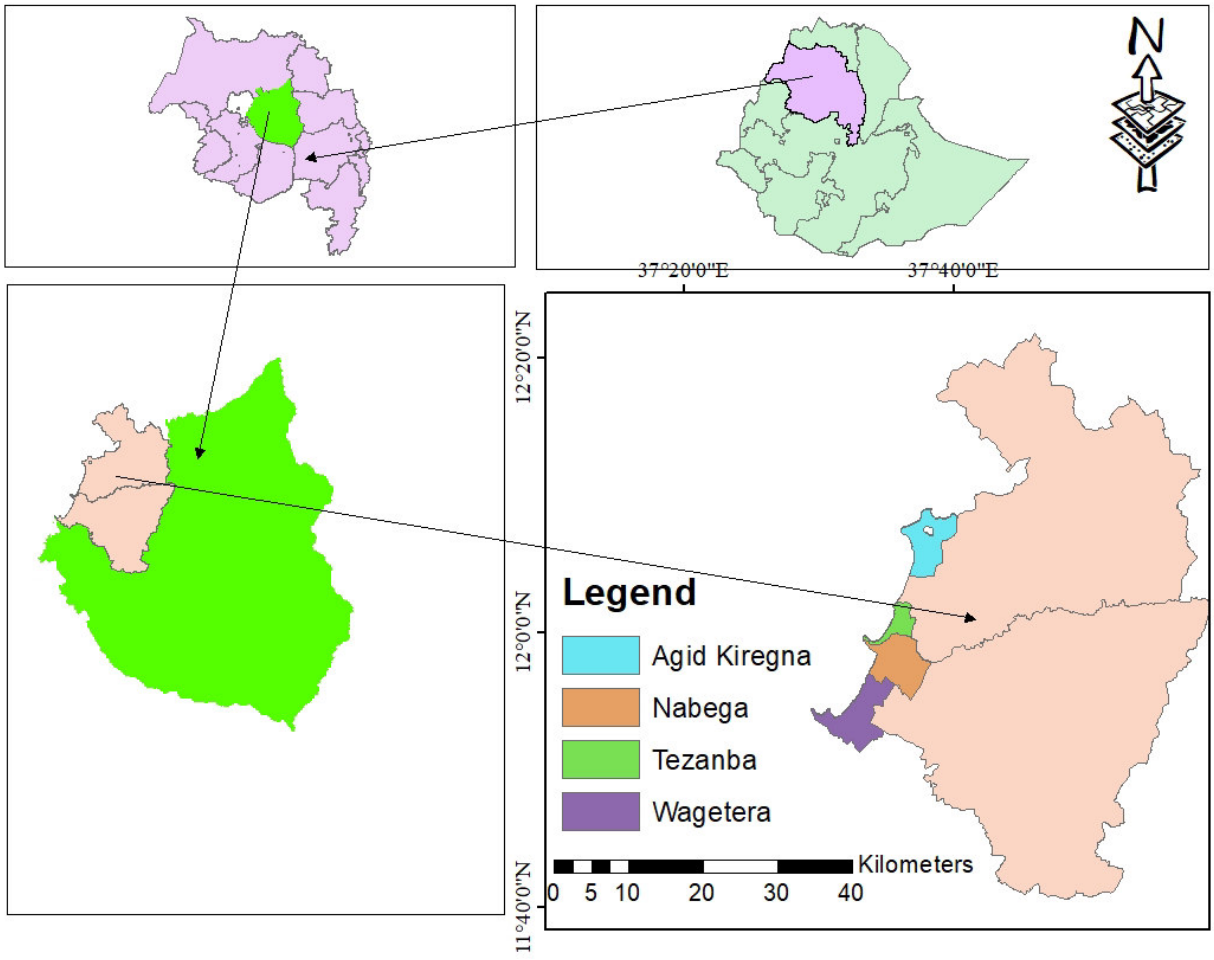

Figure 1. Map of the study areas

[1] Kebele: *a small administrative unit in Ethiopia*

Data Sources and collection methods

Both primary and secondary data sources were employed for this study. Data were collected by interviewing from randomly selected rice-producing farm households in the study area at the household level through semi-structured questionnaires. Additionally, information was gathered from secondary sources such as journals, reports, and internet sites. The study used purposive sampling techniques to select the districts, as a result *Fogera* and *Libokemkem* districts were selected based on the water hyacinth's rate of expansion. The numbers of rice producing *kebele*s in each district which are affected by water hyacinth were then evaluated, and two *kebele*s in each district were selected. Finally, 189 respondents were selected using systematic sampling techniques.

In this study, WTA was assessed using the contingent valuation (CV) method to estimate rice farmer's willingness to accept for leaving their land around Lake Tana as a buffer zone. It is a survey-based value elicitation approach which queries responders in systematic ways to state their willingness to pay (WTP) or willing to accept (WTA) hypothetical changes in some marketed and non-marketed goods or services (Cao *et al*., 2010). An open-ended WTA questionnaire was used so that respondents would not be restricted by defined values as in binary choice or close ended questions. Contingent valuation method is the most widely used method for estimating non-use values, it is based on asking people questions. After focus groups with community members in the study area have been conducted, and it has been reached a point where an idea of how to provide background information, describe the hypothetical scenario, and ask the subsequent valuation question and related, pre-testing the survey was conducted. *To do the actual survey, pre-test is usually conducted prior to the final contingent valuation (CV) studies. Pre-test surveys are used in CV studies to test the survey questionnaire's reliability and validity as well as to determine start up bids for the actual survey.* For this purpose, eight households were selected at random for the pre-test survey. Accordingly, a draft questionnaire was modified based on the pre-test survey and minimum amount of compensation was settled. Finally, well trained and experienced enumerators were employed to administer the actual survey and farmers were asked their willingness to leave the land as a buffer zone with a minimum amount of compensation. Accordingly, the following issue/scenario as survey questionnaire was used to get minimum WTA for leaving the land around Lake Tana as a buffer zone.

> *Lake Tana is the major source of livelihood for majority of communities live in the around the lake, it is important for fishers, farmers, livestock risers. Since 2011 the official declaration of Lake Tana invaded by water hyacinth, the lake is under serious problem. Many factors contributed for the widespread of water hyacinth, the release of waste from homes, factories and hotels in urban settlements discharge of fertilizers and pesticides used in agriculture and expansion of farmland. This change in quality will have consequences for crops production and as well as a decrease in the income of local farmers. These calls up the need to conserve the Lake Tana ecosystem, one way to conserving the ecosystem are leaving the farmlands as buffer zone around the Lake Tana.*
>
> *Assume that you were offered compensation as an annual payment specified per hectare leaving your land around the lake as buffer zone. Indicate the annual payment you at least would like to accept a minimum compensation per hectare. If the stated WTA by farmers is significantly larger than the annual land rate value, respondents were asked to state the reason.*

Methods of Data Analysis

To examine quantitative data, the study used econometric model and descriptive statistics. There are a number of studies on the evaluation of factors that affect farmers' willingness to accept (WTA).It was mainly applied in ecosystem conservation (Ahiale et al., 2019; Christensen et al., 2011; *Nyongesa*, 2018; Xiong & Kong, 2017). Based on the goals of the study and the type of the dependent variable being used, a variety of econometric models were used to identify the determinants of WTA, including the tobit model (Xu, 2012), binary logistic model (Wang & Ling, 2013), interval regression model (Ahiale et al. 2019), Heckman two-stage model (Xiong et al. 2019), multinomial logistic regression (De Steur et al. 2010), etc.

Meanwhile, for this study the binary logistic regression model was used to analyse the factors of farmers' WTA for leaving the land around Lake Tana as a buffer zone, since it estimates the relationship between a categorical outcome variable which is usually dichotomous (WTA and not WTA) and a set of predictor variables(Archer and Lemeshow, 2006).

Willingness to accept is the amount of money that must be given to an individual experiencing deterioration in environmental quality to keep his utility constant. It is the minimum amount of income a person will accept in an exchange for a decline in circumstances(Haab & McConnell, 2013)

The WTA decision by farmers is specified as.

$$Z_i = \beta_0 \sum_{i=1}^{n} \beta_i + \beta_i X_i, \ldots\ldots (1)$$

β_0 Where is a constant and Zi is equal to one (1) when a choice is made to WTA and zero (0) otherwise; this means: The equation represents a binary choice model involving the estimation of the probability of WTA for leaving the land around Lake Tana as a buffer zone (Z) as a function of independent variables (X_i). Mathematically, this is represented as:

$$\text{Prob}(Z = 1) = F(\beta' X_i) \qquad (2)$$

$$\text{Prob}(Z = 0) = F(1 - \beta' X_i) \qquad (3)$$

Where, Zi is the observed response for the i^{th} observation of the response variable. This means that Zi=1 for positive WTA (i.e. farmers who are WTA a minimum compensation for leaving their land around Lake Tana as a buffer zone) and Zi= 0 for zero-WTA (i.e. farmers who are not WTA leaving their land around Lake Tana as a buffer zone with minimum amount of compensation). Xi is a set of independent variables (see Table 1) associated with the i^{th} individual, which determines the probability of adoption, (P). The logit model uses a logistic cumulative distributive function to estimate, P given z by,

$$\mathbf{Pr}\left(\mathbf{Y} = \frac{\mathbf{1}}{\mathbf{X}}\right) = \frac{\mathbf{e^z}}{\mathbf{1 + e^z}} \qquad (\mathbf{4})$$

$$\mathbf{Pr}\left(\mathbf{Y} = \frac{\mathbf{0}}{\mathbf{X}}\right) = \mathbf{1} - \frac{\mathbf{e^z}}{\mathbf{1 + e^z}} \qquad (\mathbf{5})$$

Since the model is non-linear, the parameters are not necessarily the marginal effects of the various independent variables. The maximum likelihood method was used to estimate the parameters. The empirical model for the logit model estimation is specified as follows:

$$\mathbf{Z_i} = \mathbf{ln}\left(\frac{\mathbf{P}}{\mathbf{1 - P}}\right) = \mathbf{a} + \boldsymbol{\beta_i}\mathbf{X_i} + \boldsymbol{\delta_i} \qquad (\mathbf{6})$$

Where the above formula is called log of odds ratio and X_i is the combined effects of X explanatory variables that would affect farmers‟ decision to WTA or not". In other words the model in the $\ln\left(\frac{P}{1-P}\right)$ formula represents log-odds in favor of farm households‟ decision to WTA or not to WTA. It is the logarithm of the ratio of probability of WTA (p) to probability of not WTA (1-p). The odds, logs of odds ratios are not straight forward to interpret the coefficients, so that marginal effects were computed and used for interpreting the coefficients of estimated model.

In this model, the following variables were used: The independent variables included in the model are listed in Table 1 below. The dependent variable is willingness to accept for leaving the land around Lake Tana as a buffer zone which is a dummy variable with values of 0 and 1.

Table 1. Summary of independent variables used in the model

Variables	Variable description	Hypothesis
Sex of HH head	Male = 1, Female = 0	+ve
Rice farming experience	Years	+ve
Education level of HH head	Years	+ve
Number of family members	Persons	-ve
Annual household income	Ethiopian Birr (Birr)	+ve
Residential location from Lake Tana	Km	-ve
Household perception on the importance of conserving Lake Tana	Yes =important, No = not importance	+ve
Size of total own land	Ha	+ve
Size of WH infested farm land	Ha	+ve
Frequency Extension contact	Number /year	+ve
Years of infestation by water hyacinth	Years	+ve

Results and Discussion

Characteristics of the Households

The mean age of sampled household head was 44 years and there was a weaker statistical significance difference between those of who are WTA and not WTA for leaving their land around Lake Tana as buffer zone. The proportions of male headed households for those whom are WTA (98%) were relatively higher than who do not WTA (90%). The family size was 5.6 per household**.** Regarding rice farming experience, the result showed that the average households' experience of rice farming was 14 years and it showed a statistical significance between

the two groups, the more experienced farmers were more WTA as compared with their Counterparts. There was a significance difference in terms of level of education between WTA and non WTA; households headed by literate were less willing to accept to leave their land around Lake Tana as a buffer zone (Table2).

Table 2. Household characteristics

Variables	Mean value			Chi2/t-value
	Non WTA	WTA	Over all	
Age of the household head(years)	43.69	44.92	44.01	-.55
Sex of the household head(male)	.9	.98	0.92	-1.8*
Family size(number)	5.66	5.47	5.6	.55
Education (read & write)	0.53	0.388	0.49	2.88*
Farm experience (years)	23.71	24	23.78	-.15
Rice farming experience (years)	13.71	16	14.30	-2.05**
Distance to nereast cooperatives(kms)	3.22	3.54	3.31	-.65
Distance to reast extension office(Kms)	3.16	3.01	3.12	.35
Distance to nearest Allweather roads(kms)	11.12	18.63	13.07	-2.45**
The nearest distance to Lake tana(kms)	2.48	3.27	2.68	-1.9755**
TLU	4.31	3.8	4.16	1.2
Total land owned(ha)	.88	.91	0.88	-.35
Income from crop sales(ETB)	13069.86	13466.74	13172.76	-.2
Income from livestock sales(ETB)	11171.89	8563.18	10495.55	1.1
Off/non-farm income(ETB)	4105.43	3478.57	10422.71	.3
Total income (ETB)	28347.18	25508.49	9719.61	.7
Since when WH appeared on farm(years)	3.77	3.41	3.68	1.4
Area of rice farm infested by WA(ha)	0.52	0.48	0.51	0.61
Total area infested by WA(ha)	0.39	0.36	0.39	0.707
Accessed to advice on water hyacinth(yes=1)	0.807	0.92	1.16	3.2747*
Accessed to training on WH(yes=1)	0.48	0.39	1.55	1.2072
Adopted a strategy to resist the water hyacinth (yes=1)	0.92	0.94	1.07	0.1592

Note: Note; ** *p<.05,* * *p<.1*

Access to roads and service providing sources are critical for many rural development processes. As observed in Table 2, households were far about 11.3 kms on average from all-weather roads, those of whom residence far from all-weather roads was found to be more WTA. The respondents located in the nearest distance to Lake Tana were found more WTA as compared with those of who located far distance. Over all, the average distance of household's residence from Lake Tana was 2.68kms. The study result further showed that farmers who have received advice on the effect of water hyacinth were more WTA than non WTA.

Land utilization in the study area, the average own landholding size estimated at 0.88 ha (Table 2). Crop production through irrigation is common in the study area; 47% of the farm land was produced through irrigation system, mainly used Lake Tana water source. Moreover, farmers also cultivated crops through rain fed (40%), and residual moisture production system (11.79%) and the rest devoted for grazing land.

Water hyacinth invasiveness

The time of the water hyacinth invasion on farmers' land and common grazing land varies from *kebele* to *kebele*. Respondents reported that the first time they saw where rice farms damaged by water hyacinth at Nabega *kebele* of *Fogera* district were in 2013 (Figure 2). It has been observed and damaged since then. As stated by farmers, however, water hyacinth was able to spread to the farmers filed surrounding the lake about one/two years later, when it was observed on the water body.

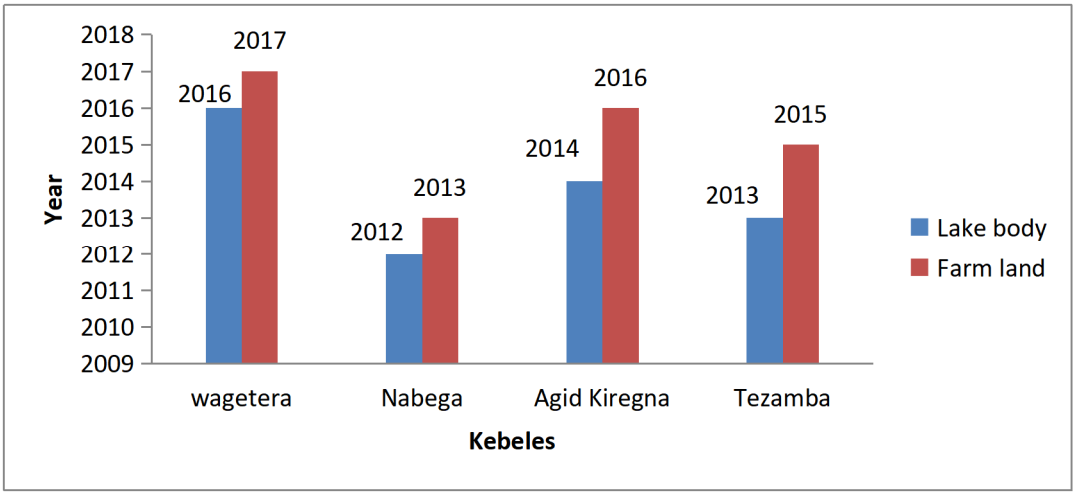

Figure 2. History of water hyacinth observed in different kebeles

Willingness to Accept and its determinants

As proposed by (Hoyos & Mariel, 2010) farmers were asked to answer yes or no to the WTA question (are you willing to Accept for leaving the land around lake Tana as buffer zone with a minimum birr). According to the result in Table 3, only 25.93% of the interviewed households have positive WTA, while 74.07% of them do not. A majority of households were not willing to leave their farm land located around Lake Tana as buffer zone even though that could be minimum amount of compensation provided, the main reason for a majority of farmers who are not WTA perceived that most of them prefer struggling with water hyacinth and continue cultivating the land, assumed that the rental value of land increasing in the future.

Table 3. Farmers WTA to leave the land located around the lake as buffer zone

WTA Status and its value	Freq	Percent
WTA	49	25.93
Not WTA	140	74.07

Variable		Mean	Std. Dev.	Min	Max
Minimum WTA value (ETB)		56432.65	51698.86	5000	320000

As shown in Table 3, the mean WTA values for leaving the land around Lake Tana as buffer zone was estimated at 56, 432.65 birr/ha/year (1,931.8US dollar)[1] for those who were willing to accept leave their land as a buffer zone.

For estimating the factors affecting farmers' WTA, binary logistic regression model was used and household demographics, socio economics and location variables were included in the model.

Given the coefficients in Table 4, among the explanatory variables included in the model five of them were found to the factors affect the decision of household to WTA for leaving land as buffer zone. These variables are household rice farming experience, sex of household head, household residence to Lake Tana, location of the households(district) and household's perception on the importance of conserving Lake Tana ecosystem. Unlike the ordinary least square estimate (OLS), the coefficients in this binary choice model are not easy to interpret directly. One way to interpret the parameters is to consider the partial derivative of the probability that the dependent variable equals one with respect to a continuous explanatory variable, calculating marginal effects (Verbeek, 2004: Wooldridge, 2000).

[1]Average exchange rate in 2019: 1USD=29.2123 ETB

Table 4. Estimated results of logit model

Variables	Coef.	Marginal effects (dy/dx)	Std. Err.
Rice farming experience	0.063	0.01068**	0.005
Sex of the household head	1.904	0.3240*	0.1822
Family Size	-0.105	-0.0179	0.0186
Education level of the household head	0.099	0.0168	0.0140
Distance of the house from lake	0.183	0.0312**	0.0132
District	0.676	0.1150*	0.0692
Land infested by water hyacinth	-0.59	-0.1004	0.1204
Total Land owned	0.223	0.0379	0.0656
Years of water hyacinth infestation	-0.127	-0.0216	0.02243
Frequency of rice extension visit	0.09	0.0153	0.0097
Total income	0	-1.32E-06	1.52E-06
Perception of households to Conserve the lake	1.35	0.2297**	0.1077
Number of observation		189	
LR chi2(12)		27.9	
Prob> chi2		0.0057	
Pseudo R2		0.129	
Log likelihood =		-94.2128	
Percent of correctly predicted		76.72%	

Note; *** *p<.01,* ** *p<.05,* * *p<.1*

Since the likelihood function is a measure of how well β explains the given sample dependent variables, it was done to test the hypothesis that the variable in the model have no effect upon the value of the dependent variable. This is denoted by:

Ho = β1 = β2 = βk = 0

Ha: some βi ≠ 0 with a likelihood ratio chi2 (21) of 27.9 and a p-value of 0.0057, the null hypothesis rejected that all independent variables of the logit model are zero. This implies that the expected value estimating the probability of the household to participate was explained by the significant explanatory variables under the condition of rejecting the null hypothesis. One goodness-of-fit measure that is usually reported is percent correctly predicted; the percentage of times the predicted value matches the actual value of the outcome variable. The value percept correctly predicted of logit model result indicates that the model predicts 76.72% of the outcomes correctly. The Analysis and interpretation of the significant variables presented as follows:

Rice farming experience of the household (years) was positively associated with farmers' willingness to leave the land around Lake Tana as buffer zone and statistically significant at the 5% level. The result implies that an increase of rice farming experience in one year increases the willingness to accept probability by 1.06%. The reason could be, water hyacinth has imposed a bigger impact on rice production, those of whom stayed longer periods of time in rice production understands its effect and needs to control the expansion of the water hyacinth, willing to accept a minimum compensation to conserve the ecosystem.

As compared with female headed households being male headed household significantly has less probability of willingness to accept leaving their land around Lake Tanas a buffer zone by 32.4%.and statistically significant at 10% level. The difference between the genders may be associated with awareness of the effort required as conservation of the ecosystem in the study area, consideration of conserving the environment as a personal benefit or financial rewards and perception of payment for ecosystem services funding as more helpful. Supported evidence had been found by Wang et al. (2019), females have higher WTA than males in valuing environmental conservation, but contradict with the findings of Ahiale et al., (2019), confirmed that households headed by females were willing to accept less than male household heads for compensation for soil conservation technologies in Northern Ghana.

The effect of household residence distance to the Lake Tana on the probability of farmers' willingness to accept for leaving the farm land around Lake Tana was positive and statistically significant at the 5% level. The

probability to leave the land as buffer zone will increase by 3.12% as the distance to Lake Tana increases by one km.

The location where the respondent lives also correlates with households' willingness to leave the land around Lake Tana as buffer zone at 10% statistical significance level. Farmers living in *Fogera* district were more willing to leave their farm land around LakeTana as a buffer zone than farmers in *Libokemkem* comparatively. The difference might come from the understanding of conserving the ecosystem with compensation, and the effect of the weed on the farming communities.

Households' perception on importance of conserving Lake Tana ecosystem showed significant impact on farmers' willingness to leave the land as buffer zone at 5% level of significance. The coefficient was positive and those households who perceived the importance conservation of the Lake Tana ecosystem were found to have higher probability of WTA. The positive relationship indicated that those of the households perceived the importance of conserving Lake Tana were more likely willing to accept a minimum of compensation to conserve the ecosystem by leaving the land around lake as a buffer zone. Having awareness and understanding on the importance of ecosystem services could be an important tool in environmental conservation (Børresen et al. 2022). But the result contradict with the findings in lake Naivasha watershed, Kenya where interest to conserve environmental ecosystem had a negative association with WTA(Nyongesa, 2018).

Conclusion and Recommendation

In the study area, the average own landholding size was very small, less that 1 ha. More than 46% of the land was devoted for an irrigation production system; mainly they used Lake Tana water sources. A majority of the households were not willing to accept to leave the land around Lake Tana as a buffer zone. The econometric result implies that, more experienced rice farmers, male headed households, households located far distance to Lake Tana, households live in Fogera and households who perceived the importance of conserving the ecosystem were found more likely for willing to accept leaving the land around Lake Tana as buffer zone.

Based on the results of the study it recommended that the adoption of payment for ecosystem service practices needs to be enhanced through sensitization and training of farmers as sellers of ecosystem services and institutionalizing payment for ecosystem services as national conservation and livelihoods enhancement policy tool to conserve ecosystems.

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