Addis Ababa University, Ethiopian Journal of Business and Economics, EJBE Vol. 11, No 2,
DOI: https://dx.doi.org/10.4314/ejeb.v11i2.3, p-ISSN:2311-9772, e-ISSN: 2410-2393
Available online: https:/ejol.aau.edu.et/index.php/ejbs and https://www.ajol.info/index.php/ejbs

Households Willingness to pay for Water Hyacinth Control to Lake Tana, Ethiopia: An application of Contingent Valuation Method.

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Abstract

Currently, Water Hyacinth (WH) has become a growing problem in Lake Tana. Infestations of this weed have been, causing environmental, economic, and social problems to the riparian communities. This study uses a cross-sectional survey of 398 randomly selected households in Bahir Dar city, Ethiopia, to assess their willingness to pay (WTP) for its control to Lake Tana using contingent valuation approach by Considering hypothetical scenarios encircling different socio-economic variables. The Tobit regression model was used to analyze the socio-economic factors influencing of urban households' WTP decisions for WH control in Lake Tana. The results showed that households were on average willing to pay the amount of ETB 1011.436 with a total contribution of ETB 77,624,226.2 for a one-time payment to clean WH from Lake Tana. Results reveal that residents' WTP for control of WH is significantly related to income, member of household's having job and awareness of WH, among other factors. The mean WTP that found can be a guide for municipal officials in setting a more appropriate fee that can finance cleaning in WH, where both regional and federal governments have co-operated.

Key Words: *Contingent Valuation Method, Households', Tobit regression, Water hyacinth, Willingness to pay.*

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1. Introduction

Water hyacinth (Eichhornia crassipes [2]) is an invasive aquatic plant species which live, reproduce, and floating freely on the surface of fresh waters and can be anchored Stolon in mud in the bottom of the water body and spread throughout vital freshwater bodies (Cilliers et. al, 2003). The size of the plant spans from inches to a meter in height and its rate of propagation under a certain environment are extremely rapid and it can spread out and cover large areas of water bodies causing a variety of problems that affect flora and fauna. Reduce light and oxygen, thereby changing water chemistry. Moreover, the plant causes a significant increase in water loss due to evapotranspiration (Chatterjee et.al.2015; Patel, 2012).

The native origin of the plant is Amazon Basin and was spread to many parts of Latin America as an ornamental garden pond plant due to its beauty. WH is the most widespread and damaging aquatic weed in terms of its invasive potential and adverse impact on aquatic ecosystems as well as the cost of controlling it (Cilliers et. al, 2003). The plant is particularly suited to tropical and subtropical climates and has become a problem in several parts of Southern USA, Latin America, Eastern, Western and Southern Africa, South and South East Asia and Australia. (Vila et.al, 2011,and Cilliers et.al, 2003).

In Africa, the WH was first reported in Egypt between 1879 and 1893 (Osienala, 1990). According to (UN, 1997) WH is now an environmental disaster to the Central and Eastern region of Africa. The fast-spreading WH is introduced to some of the region's major inland waterways, threatening communities living on the shores of Tanzania, Uganda, and Kenya. Invasive alien species like WH are a major global problem that requires urgent action (Xu et al. 2012). These species put pressure on world's biodiversity as they alter ecosystem services and processes, reduce the prevalence of native species, and decrease genetic biodiversity of the ecosystem (Rands et. al, 2010; Vila et. al, 2011 & Hejda et.al, 2009).

WH has been identified by the International Union for Conservation of Nature (IUCN) as one of the 100 most aggressive invasive species (Téllez et al., 2008) and recognized as one of the top 10 worst weeds in the world (Shanab et al., 2010; Gichuki et al., 2012; Patel, 2012). In Africa, WH is listed by law as a poisonous weed in several countries (Theuria, 2013). The economic impacts of the weed in seven African countries Such as South Africa (1908) ,Zimbabwe(1937) ,Zaire(1957) ,Sudan(1957) ;Senegal (1964), Nigeria(1983) and Uganda (1987) have been estimated between USD 20-50 million every year (Osienala,1990). According to (UNEP, 2006) reported across African countries, the economic cost of the weed is as much as USD100 million annually.

In Ethiopia, around 35 invasive alien plant species exist including WH. Thus weed posing threat to economic, social and, the environmental livelihood of the riparian community and, ecosystem health of Lake Environment (Rezene .F& Taye, T. (2014). WH was first reported in south-central Ethiopia in1965 in Koka Lake and the Awash River (Fessehaie, 2012). Control of this undesirable plant through chemical, physical, biological management strategy is imperative for the conservation of recreational areas. Though the use of chemical pesticides is one of the plausible solutions, it is still questionable because it might create environmental hazards (Eichhornia et al., 2011).

[2] Eichhornia crassipes refers Scientific name of Water Hyacinth

Organization for Rehabilitation and Development in Amhara (ORDA), Bahir Dar University (BDU), Amhara Regional Bureau of Environmental Protection, Administration and Use (BoEPLAU), Global Coalition for Lake Tana, Debre Tabor University Research Unit (DTURU) ,Environment Forest and Climate Change Commission(EFCC), Regional Water Hyacinth Steering Committee (RWHSC), Environment ,forest and wildlife protection and development of Amhara national regional state(ANRSERWPD) Amhara Regional Bureau of Agriculture (BoA), Amhara Regional Bureau of Tourism (BoT), Amhara regional Bureau of Water (BoW), Amhara Regional Agricultural Research Institute (ARARI), Amhara Region Cooperative Promotion Agency (CPA), Zonal and Woreda administration of the Amhara Regional State, and University of Gondar(UOG) aim to control invasive species at local and national level. A team of researchers from the Global Coalition 2018 for Lake Tana Restoration (a US-registered not-forprofit initiative) and Geospatial Centre of Bahir Dar University spent a number of days and actively contributing to control and prevention of invasive species. Yet, these efforts have mostly been unsuccessful in eliminating the weed and restoring the health of the invaded part of the lake ecosystem. An expert committee has been formed to provide strategic policy guidance for mainstreaming wetland issues into national policy, planning frameworks, as well as ensuring coordination, cooperation and collaboration (Wassie et al., 2014).

The Existence of WH in lakes can result in lower tourism revenues from rowing and, other activities, an increase in malaria infestation and clogging hydropower generation activities. As a result, power interruption and financial losses act as an obstacle to positive economic change (Khatri et al., 2018). WH invasion in Lake Tana has a negative effect on fish production, and local irrigational system. The rampant growth of WH has a long term impact on the daily livelihood of the riparian community who are dependent on the lake and the neighboring businesses. WH invasion on Lake Tana directly affects fishermen and farmers and all the people that depend on the environmental services of the lake (Wassie et al., 2014).

An international study has already estimated that infestations of WH cause environmental, economic, agricultural and social problems that can amount to of billions of US dollars (Khatri et al., 2018). The adverse environmental, health and economic effects of WH are estimated at 120 billion USD (Pimentel et al., 2005; & Kettunen et al., 2009). Principally WH degrades ecology. It also causes economic losses and leads to biodiversity loss (Mironga et al., 2014). WH invasion on Lake Tana directly affects the riparian communities and all the people who depend on environmental services or production from the affected lake Despite the significant worldwide growth of research on invasive species, are not yet to be conducted that concerned with invasive species valuation in Lake Tana.

Given the non-existence of a market for valuing some environmental goods and services, non-market valuation methods are often employed. The two primary methods include revealed preference and stated preference. Economists have long used two popular revealed preference methods, hedonic price technique and travel cost technique, as proxy concepts that consider the characteristics of environmental goods and recreational costs simultaneously to estimate the actual use value However, in this particular study, the stated preference method seems suitable tool for exploring households preferences and measuring public support related to invasive plant species control. This method, belonging to the Contingent Valuation Method (CVM), is helpful for directly capturing the WTP .it is also capable of capturing the non-use value or existence value of environmental goods and services.

In this study therefore, an attempt was done to estimate the amounts of money households are willing to pay for WH control to Lake Tana. Besides, the study assessed the level of household's perception on problems of WH, and determined the factors affecting households. It is believed that the study plays a key role in formulation of a successful lake policy and aquatic environment protection to preserve resources and keep up their economic value.

2. Households' Demand for water hyacinth control : A Brief Review

Contingent valuation surveys have been widely applicable methods in valuing use and non use values of environmental goods and services (like lake resource) (Whittington 2012). In recent years, especially since 1940, the Contingent Valuation method has found expensive application in the valuation of environmental resources benefits. The above theoretical explanations of the method have been employed in many studies of valuing the environment in both developed and developing countries. Some of the CVM studies done in developing countries in general and in Ethiopia, in particular, are reviewed as follows.

A study by Khatri et al (2018) willingness to pay for Water hyacinth control of visitors and local people to Phewa Lake in Nepal using stated preference contingent valuation method was employed to 13 sample points to capture heterogeneity. The main objective of their studies was to elicit the non-marketed social value (benefit) of controlling Water hyacinth to the lake and derives a relatively inelastic demand curve for preserving the environmental goods and services. They prepared three contingent valuation scenarios to the respondents by encircling different socioeconomic variable and introduced six impact categories to the valuation scenarios such as weed impact on scenic beauty of the lake Phewa, impact on aquatic life, impact on economic, impact on ecosystem health and recreational impact. They used a binary response logit model to identify determinants that affected the donations of visitors and the local people to control water hyacinth from the lake and to derive elasticity of the demand curve. The finding of their journal article showed that from the first scenario the mean willingness to pay to remove water hyacinth for one year was NPR[3] 920.51. Similarly, the mean willingness to pay for the second scenario to minimum annual impact was NPR 717.38 and the final mean willingness to pay for the third scenario that keeps the impact at a low level in the lake for ten years was NPR 1848.17. Assistance and expenditure of the households were negative sings and significant at 5 percent level that determines willingness to pay of the respondent but a number of visitors were a positive sign and significant at 5 percent level that determines willingness to pay for removal of water hyacinth in Phewa Lake, Nepal.

Economic Analysis of Fisher folks' Willingness to Pay for Improved Management of Water Hyacinth in Lake Victoria, Kenya was conducted by Otieno et al, (2019) using a contingent valuation method with payment cared elicitation format for a one–time payment or donation in the form of the neutral trust fund from 268 sampled fisher folks. He used a binary response Tobit model in order to analyze the socio-economic determinants of individuals' (fisher folks') WTP decisions for the improved water hyacinth management in Lake Victoria. The finding of the study showed that fisher folks were on average willing to pay the amount of Kshs[4] 175.11. With a total contribution of Kshs. 42,500 monthly to improve water hyacinth management in Lake Victoria. Among used explanatory variables age, experience, income, perception of fisher folks about water hyacinth infestation to the lake, fishing groups and gender of fisher

[3] NPR refers Nepalese rupee which is Nepal currency
[4] Kshs refers to Kenyan shelling which is Kenyan currency

folks had a significant at (1 percent) level which has a strong influence on the fisher folks' WTP decisions for improved management of water hyacinth.

Preez et al (2010) conducted research on willingness to pay for restoring indigenous vegetation in Underberg, KwaZulu-Natal, and South Arica using contingent valuation method from 260 sam The results showed that fisher folks were on average willing to pay the amount of Kshs. 175.11 (USD1.75) with a total contribution of Kshs. 42,500 (USD 42.5) monthly to improve water hyacinth management in Lake Victoria. The variables age, experience, income, perception of fisher folks about water hyacinth infestation, fishing groups and gender of fisher folks had a significant influence on the fisher folks' WTP decisions for improved management of water hyacinth in Lake Victoria. The Lake Victoria management authorities should take the opportunity to raise funds for improved management of water hyacinth in Lake Victoria. The purpose of the study was to estimate the household's willingness to pay for indigenous vegetation over the alien's vegetation and to measure a household's willingness to pay using the Tobit model. the mean of willingness to pay for restoring of indigenous vegetation was found to be R[5]21.12 (R26.40 at 2008 price levels), R25, 344.00(R31, 680.00 at 2008 price levels) and R21.87 (R27.34 at 2008 price levels per hectare. the finding of this study showed that knowledge of the local working for water programs and income were important determinants of willingness to pay.

Rodriguez-Tapa et al (2017) also applied the contingent valuation method to household's perception of water quality and willingness to pay for clean water in Mexico City using censored econometric (Tobit) model. The average willingness to pay for better potable water quality is US$3.1 or 4.7 percent of the bimonthly water bill per family. The finding of the study was that the high cost of bottled water significantly influences willingness to pay.

Marbuah(2016)applied an ordered logistic regression model to a willingness to pay for environmental quality and social capital influence in Sweden .the study found that individuals are fair will contribute to environmental protection and elements of social capital (stock of social and institutional trust, incentives) were significantly influence individual willingness to pay for the environment protection.

A study on assessing of willingness to pay for lake conservation on North Pond and west pond in Waterville, Maine was conducted by Sarkar in 2011. He employed a contingent valuation survey on 100 shoreline residents through a web-based interview with mail and applied a nonparametric test (Mann-Whitney U-Test and Two samples T-Test) for estimation of the mean willingness to pay for lake conservation. The study found that the mean willingness to pay from the two ponds (North and west pond) was USD 5,652 per year for water shade conservation program. Age, income, lake association membership and water quality perception were the most significant determinants of willingness to pay for lake conservation.

A Study by Do et al (2007) employed the choice modeling approach of Multinomial Logit (MNL) to estimate willingness to pay for wetland improvement in Vietnams Mekong River Delta. They employed MNL and Random Parameters Logit (RPL) models using contingent valuation approach and they divided respondents into three subpopulations'; Cao Lanh, Ho Minh city, and Hanoi to 300 sample size personal interviews or face –to- face interviews were conducted. The finding of their articles showed that respondents in three locations have different marginal willingness' to pay for wetland attributes and the

[5] R refers rand which is South Africa currency

overall willingness to pay for the proposed wetland biodiversity conservation in the three sub-sample ranging from 2.5 USD per households in Hanoi to 0.9 USD in Ho Chi Minh city and zero in Cao Lanh. Age of the respondents (older), knowledge of the problem and geographical distance from the study site were positive factors which determines willingness to pay.

A study by Eugene et al.,(2015) preference and willingness to pay for close to home nature for out door recreation in Sweden, using the contingent valuation method. The data was originated from a mail survey that involves Swedish residents' with a random selection from the national register. They used Tobit and ordinary least square (OLS) model for estimation and to account factors influence willingness to pay. The finding of the articles showed that approximately 50 percent of the respondents spend their leisure time by visiting nature (consumption from the recreation of nature) and/ or establishing to nature areas close to their home and the average frequency of visit to this area was 74 times annually. The mean willingness to pay of the respondents was approximately 7200 SEK[6] (USD 1080) annually the respondents willing to pay for nature strongly influence by income , types of nature areas and distance to and time to spent at the recreational areas .Again the finding of the study showed that those respondents live nature the recreational areas (nature)and live in rural areas were more willing to pay for nature which is an average of 9044 SEK (USD1357) per year for outdoor recreation than the urban respondents were willing to pay an average of 6425 SEK (USD 964) . The coefficients of the variables were relatively the same except age and gender that the coefficients associated with distance, time and income had positive and statistically significant effects that determine willingness to pay of the respondents that support the theory of demand and supply.

Willingness to pay as an economic instrument for coastal tourism management by Birdir et al (2013) in Mersin, Turkey using contingent valuation method from 432 respondents. A non- parametric one-way analysis of variance test with ANOVA was used to estimation of the model. The mean willingness to pay of the respondents was approximately €1.70 -2.30 can willingness to pay for the beaches as a fixed price per visit for maintenance and improvement of coastal tourism management. The finding of the study showed that local government should be ultimately focused on environmental policy, programs, and implementation. Using a discrete choice experiment method, Peng & Oleson (2017), the study on beach recreationalists' willingness to pay and economic implications of coastal water quality problem in Hawaii. Conditional logit model was used for estimation. Individuals were willing to pay $11.43 per day to reduce the bacterial exceedance in the beaches from 11 to 5 per year the respondents also willing to pay USD15.33 to improve coral reef cover from 10 percent to 25 percent. To increase fish species in the coastal areas the individual willing to pay was from USD 2.47 to USD 7.14. The finding of the study showed that consumer surplus (recreationalists 'welfare) was increased from USD20 million to USD550 million and USD120 million due to environmental improvements in coastal water quality. The study estimated benefits of environmental improvement by taking management actions targeting each of the areas relevant to the recreationalist government and other agency can effectively increase consumer surplus derived from improved coastal water quality.

The study by Wang &Jia (2012) on tourist's willingness to pay for biodiversity conservation and environment protection, DalaiLake protected areas implementation for the entrance fee and sustainable management in northern East China using contingent valuation method from 2000randomly selected

[6] SEK refers Swedish Krona which is the currency of Sweden.

respondents (tourist). Logit and Probit model was used for estimation and to establish the relationship between the variables and willingness to pay. The finding of the articles showed that majorities of the respondents (tourists) 73.6 percent were willing to pay. 26.4 percent of the respondents were unwilling to pay. Income level and awareness of being in protected areas were the most significant factors or predictors of the tourist willingness to pay which have positive sign and significant at 1 percent level but educational level and the institutional trust were also significant predictors' and having positive sign and significant at 5 percent levels the median willingness to pay was 71.08 RMB[7] (USD10.72).

A study by Bhandari&Heshmati (2010) willingness to pay for biodiversity conservation in Sikkim, India using cross-sectional surveys from 375 domestic and foreign tourists through personal interviews (face-to-face) interviews in verities of sites. Logit and Tobit model was used for estimation .the finding of the study showed that higher socioeconomic status of tourist was positively related to willingness to pay, higher age brackets might constitute an improvement revenues generators of biodiversity conservation, higher education and income of the respond ants have positive significant to determine willingness to pay.

MacLeod et al, (2010) study on Economic valuation of the influence of invasive alien species on the economy of the Seychelles islands Using contingent valuation method to obtain a willingness to pay (WTP) estimate for a policy to protect important biodiversity from IAS. Tourists indicated a mean WTP of USD52–USD58 on top of their usual expenditures to fund conservation policy. At present approximately USD 0.25 million per year is spent on IAS control while the economic damage associated with 4 key IAS is approximately USD 21 million per year. Comparing the benefits from eradication with the costs involved gives a benefit-cost ratio greater than unity, indicating that the policy of eradicating IASis economically justified. However, there is a long way to go before the resources devoted to the problem will be in proportion to the risks.

Coopera et al, (2004) conducted the study on the structure of motivation for contingent values: a case study of lake water quality improvement. This study examines the role of such motives by using measures of attitude and motive strength to interpret willingness-to-pay (WTP) values for a set of nested environmental goods with potential use and non-use benefits. Social motivations possibly associated with the benefit of contributing to a public good rather than the benefits of the good itself are potentially relevant to the WTP decision but do not give rise to separable values. The strength of perceived personal responsibility for the provision of the good is significantly associated with WTP but also with the theoretically desirable property of enhanced scope sensitivity. WTP is not found to be associated with the extent to which the individual feels under some general moral obligation to contribute to ''good causes''. Motives arising from ethical concerns for the environment and altruism are also potentially relevant to WTP but are closely related to underlying motives associated with existence and personal use values, respectively. The associations among motives found here also suggest that investigations of any particular motive should be conducted in context.

Halkos &Matsiori (2012) conducted a study on the point of assessing the economic value of protecting the artificial Lakes, by using CVM. The study was employed a logistic model followed by a Tobit and they apply the two hurdle model for analysis. The WTP was derived from a face-to-face survey of 564 residents and recreational users of the Plastira's lake, one of the most important constructed wetlands in Greece. The study found a higher WTP of individuals towards the lake's functions and their desire to

[7] RMB refers renminbi which is the official currency of Chinan

prevent possible diminutions of its total economic value and study show that the most important variable is pro-environmental behavior. They also found that respondents have different behavior for the lake's economic value according to mainly to their origin (residents or recreational users). Demographic variables (like income, age, gender) together with the extracted factors have a strong impact on the decision of individuals to pay as well as on the specific amounts stated. In conclusion, an important finding of the study is the influence of the lake's functions on people WTP for its protection.

Non-economic motives behind the willingness to pay for biodiversity conservation by Montes &Benayas in 2007 from 649 sample respondents. The annual mean willingness to pay ranged from €23.2 to €30.8 depending on the method applied in the estimation. The findings of the study were geographical distance; age and knowledge of the respondents were the most important determinants of willingness to pay for biodiversity conservation.

In Ethiopian experience reveals that limited CVM studies have been conducted to investigate factors affecting households' WTP for water hyacinth control in Lakes and other recreational sites but for improved water supply in rural and urban areas. There are also studies on improved lake quality.

All the above contingent valuation method (CVM) studies also identified that the variables like monthly income, level of education, age brackets (group) ,geographical distance , knowledge to invasive alien's spices Montes &Benayas ,(2007),recreational activities to the lake affected by water hyacinth, prior knowledge of the problem (Otieno, M. 2014);Household expenditures, assistance received and occasional presence of a household member who has visited the lake, and household's expenditure or size Khatri et al (2018) are the main determinant for positive Willingness to Pay. Besides, all the studies had concluded that the result from the CVM survey is theoretically and practically consistent and gives a reliable result. However, all the above studies failed to account the non-use value or passive value or existence value or the non-marketed social value (benefit) of environmental goods and services and I do not know of any such study for Lake Tana and it would be of timely of the title undertaking this study.

3. Analytical Framework

Protecting natural resource such as lakes from the infestation of invasive species like WH involves non-market valuation techniques. Since the market value and the" WTP price" is used to estimate the economic benefits of Lake Tana. This study focuses on the price that households are willing to pay to maintain the natural resources (Wu et al., 2007). The CVM framework was preferred over payment card elicitation format approaches since it yielded the aggregate (non-use and use) value of the proposed socio-economic aspect of water hyacinth control (Ndambiri et al., 2015).

An analytical framework was developed based on a study by (Otieno et al, 2019) and (Khatri et al, 2018) to analyze urban Households' preferences for WH control based on threshold decision-making theory to pick the maximum amount they are willing to donate for WH cleaning in future from the lake and elicit a specific monetary value for 'willing' responses.

Depending on the modified payment card (PC) survey, each selection represents the actual outcome of households' WTP. Respondents can select their minimum or maximum bids from the PC, as a result, the choice variable indicating the WTP is observed in actual amount. Standard Tobit model is consistent (Batte et al, 2007) to construct an exact WTP premium. Therefor, the study employed a Tobit model to

investigate the results of the open-ended question, surveyed in CVM questionnaire to model the actual household's WTP for WH control.

However, in Tobit model the dependent variable, or WTP, is partially observed and the dependent variable ($MWTP_i^*$) assumes zero values for a substantial part of the sample. That is, $MWTP_i^* > 0$ and is not observed if $MWTP_i^* \leq 0$. If $MWTP^*$ and x_i were observed for everyone in the population, there would be nothing new, and we could use standard regression methods (ordinary least squares (OLS)) (Maddala, 1992). However, in this study since we deal with maximum WTP for WH control which is partly observed, therefore, using OLS leads bias and hence, this study employed Tobit model. According to Maddala (1992) the equation for Tobit model is specified as:

$MWTP_i^* = \alpha + \beta x_i + \varepsilon_i$

$MWTP_i$=$MWTP_i^*$ if $MWTP_i^* > 0$

$MWTP_i = 0 \quad if MWTP_i^* \leq 0$ …….. (1)

With ($\varepsilon \sim N(0, \delta^2)$

Where $MWTP_i^* =$ unobserved maximum willingness to pay for WH control $MWTP_{i=}$ Household's actual maximum willingness to pay for water hyacinth control $X_i =$ A vector of theoretically important independent or explanatory variables; $\beta =$ A vector of the coefficients or parameter vector common to all households; $\delta =$ The intercept; and $\varepsilon_x =$ The stochastic term. Assuming that censoring point is zero, then

$$mwtp_i^* = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \varepsilon_i \quad if\ MWTP_i^* > 0$$

$$= 0 \quad \text{otherwise (if} MWTP_i^* \leq 0) \text{ ……. (2)}$$

Where: mwtp stands for one time maximum WTP, X1 = Age of the respondents (Age), X2 = Number of visit (NVST), X3 = Water hyacinth awareness of the respondents (WHAR), X4 = income (y), X5 = Household size (HHS) , X6 = distance of the respondent from the lake (DIST) , X7 = education level of the respondent (EDUC), X8= Number of household Members having a job (NHHMHJ) , x9 = Gender of household Head (GENDER) ,x10=Value attached to the lake by respondents (users) (VATL) X11= marital status (MRST) and ε= Error term.

4. Empirical Strategy

The main purposes of this study are to assess the residents' willingness to pay for WH control, analyze the determinants of WTP and suggest mechanisms for cost recovery. In this regard, the main objectives of the WTP survey are to calculate mean WTP and estimate a parametric model that includes respondents' socioeconomic factors in the WTP function.

Using the PC valuation value elicitation format, to source information regarding households WTP for WH control to Lake Tana Moreover, for the results of the open ended question format, because the dependent

variable, or WTP, is not fully observed (it is censored at zero), the study used a Tobit model in the analysis of determinants of WTP.

In this format, households are given a card containing different ranges of WTP values. The use of PC format provides households' a chance to scan through all the WTP values and then settled on their suitable or highest WTP value. Data obtained from this format was less scattered thus minimum samples required to yield robust estimates. PC format does not also suffer from starting point bias unlike other valuation formats commonly used in literature today (Otieno et al, 2019). However, it has a weakness of giving a very low proportion of zero responses as compared to other formats even though it has the possibility of generating protest zero responses (Alberini, 2000).

5. RESEARCH METHODOLOGY

5.1. Description of the Study Area

Lake Tana is a natural lake situated in the North of Bahir Dar city. The lake maintains high water levels throughout the year. Since the rain water from the neighboring areas is drained into the lake, including several tributary streams such as Megech River. The geographical location of the Lake is 10°58`–12°47`N latitude and l36°45`-38°14`E longitude. The lake catchment covers an area of 16,500 square kilometers and surface area of 3,200 square kilometers, a mean depth of 8 meters and a maximum depth of 14 meters with fluctuations due to increased siltation levels. It is the largest freshwater body in the country, contributing about 50 percent of the water resource of the nation.

The lake lies at higher altitude in the range of 1,840 meters above sea level compared to Lake Victoria at 1,134 meters above sea level and is considered the highest lake in Africa. Due to its altitude, it is characterized by cold waters with a mean temperature of 21.7°C.Accoreding to International Fund for Agricultural Development (IFAD, 2007). The Lake Tana watershed consists of 347 Keble's[8] and 21 Woredas[9] in four administrative zones.

Geographically, Bahir Dar city is found in the northwestern part of Ethiopia and is faster growing city and a global position of the city is located between 15°37' north latitude and 37°25' east longitude, and enjoys tropical type of climate with 19.6°C mean annual temperature and the average elevation of the city is estimated 1801 meters above sea level UNEP (2006). The city is strategically located at the side of the country's largest lake-Tana and the world's longest River Abay. It has a total population of 96,140 in 1994 and 230,344 in 2007 CSA (2007) an estimated 297,749 in 2014 Form for environmental assessment, FFE (2010) population of the city is increasing with high growth rate (287,756) in 2014 and it is 301,425 in 2015 CSA (2007). The current population of the city is estimated to be 313,997and the total number of households in the City is 63,916 (Kassahun, 2018). Currently, the city is serving as a regional capital city of Amhara National Regional State (ANRS) in Ethiopia. It has become one of the major tourist destinations of the country with a variety of attractions in the nearby Lake Tana (FFE 2010). The decision to select Bahir Dar city for our study is informed by (i) its status as the most popular tourist destination in Ethiopia, (ii) its nearness to Lake Tana and (iii) its current infestation of WH to the Lake.

[8] Keble refers to the lowest administrative unit in the Federal and Democratic Republic of Ethiopia
[9] Woreda refers to a group of Keble's in the Federal and Democratic Republic of Ethiopia

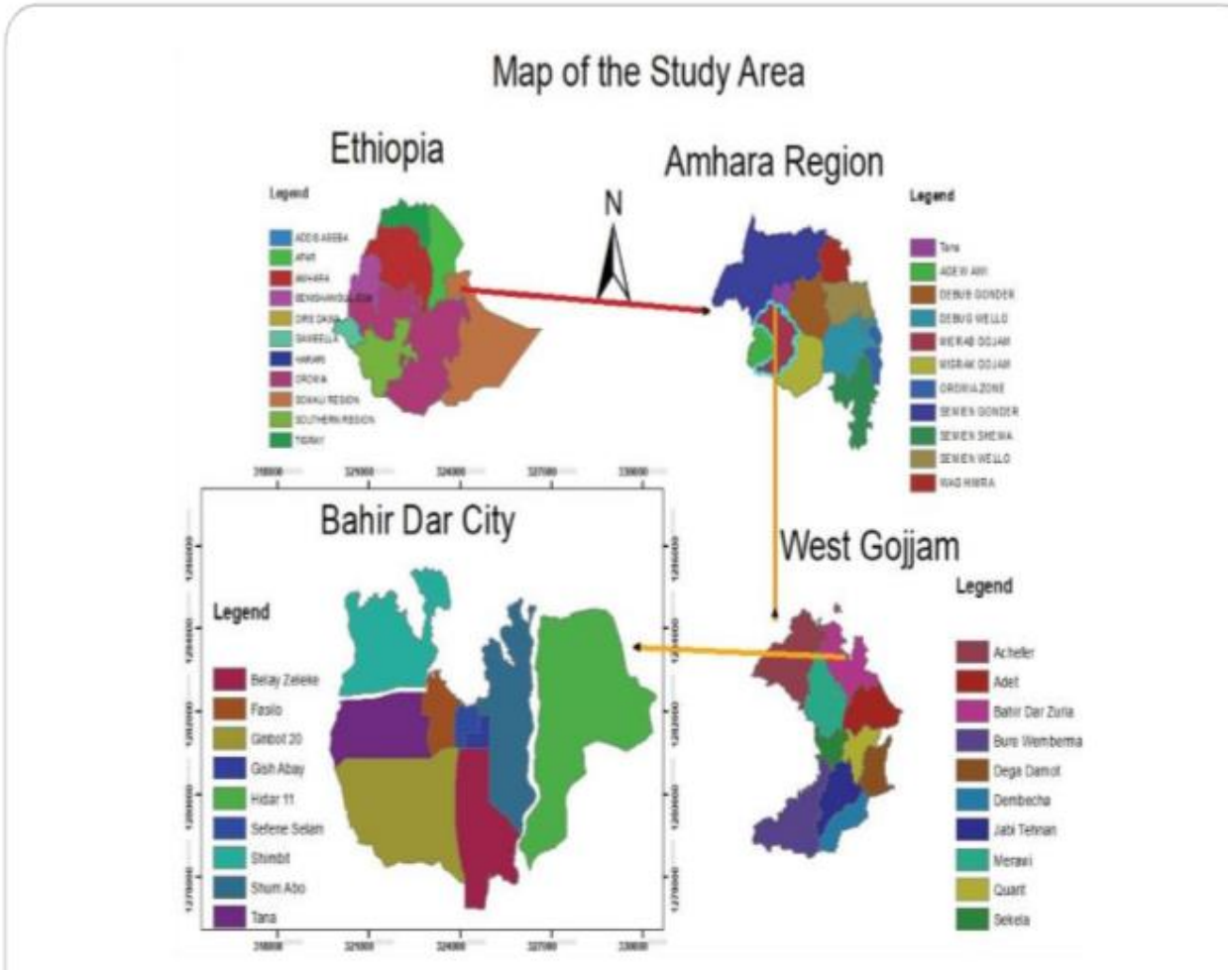

Figure 1: Map of the case study area

5.2 Survey Design

Cross-sectional analytical economic evaluation design was employed using only primary information owing to the absence of secondary data. Sample households for the study were drawn from a list of household heads residing in fifty two local administrations in Bhair Dar City, who had been a legal residence of households in the City. With stratified and proportionate random sampling, 398 households were selected and 390 questionnaires were completed. A contingent valuation survey was used to assess the economic value of environmental damage due to rampant WH in the lake. Based on the design of a survey to elicit the WTP for the control of damages from invasive species (WH); we shared information about WH.

Interview participants are informed that WH is an invasive species that is not native to Lake Tana and it harms the environment, and the economy. Based on the severity of the effect, we classify the impact categories into four and then, introduced to the respondents. The impact categories include: (I) low productivity of fish, (II) hampering navigation due to encroaching of the weed, (III) increasing human

diseases in the Lake; (IV) reduce the income of the riparian community due to impact on Ecology or ecosystem health of the lake. We informed the respondents about the future possibility of total infestation of the Lake by WH. We explain to the respondents that a technological intervention (mechanical removal of WH currently in Lake Tana) exists to get rid of such problem. Appropriate use of such technology can delay or control the invasion for a given amount of time from today to the future. The technology for clean-up is not free. We also explain to the respondents that a one-time donation within neutral trust fund will use to form a "trusted public or private environment organization in your region" to use only for the protection of lake from the hyacinth. This introductory section will create to inform the respondents of the terminology used in the valuation questions. Contingent valuation method (CVM) of eliciting demand for control of WH for Urban household's WTP for WH control to Lake Tana was used. To make the main survey less time consuming and more attractive to the respondent, a pilot survey was done. But the major aim of the pilot survey was to collect direct open-ended 'information about how much respondents were willing to pay for the control of WH.

5.3. Population and sampling

According to Kassahun, (2018) there were approximately 313,997 and 63,916 total number of population and households in Bahir Dar City respectively. In this study, all 63,916 households were targeted. Stratified and simple random sampling techniques were used to determine the number of households, in order to collect primary data from these samples to obtain a reasonable and reliable result. The city is divided into 17 administrative kebeles and after the 2007 reforms; these kebeles are rearranged into 52 Zones (smallest legal administrative units). All zones in the city are classified into three main groups i.e. nearest, middle and Outer based on the distance of the respondent's house to the Lake in a kilometer, respondent's geographical location and socioeconomic activities to make homogenous for primary data collection from sample units. Six zones from all zones were selected randomly by using lottery method for data survey. To make the sample zone more representatives, 2 zones from the nearest, outer and middle zones were selected. Before Zone selection, a stratum of Zones into three groups that helps to reduce heterogeneous characteristics of households in different zones is made. Table 1 shows the details about making stratum and proportional sample households' selection. About 0.61 percent of sampling units were selected from the total households in the selected zones by using a random sampling method by applying a lottery selection mechanism with the help of the sample frame developed before. From all sample zones [10]selected randomly, a total of 398 households are selected as a sample for the study.

5.4. Sample size determination

In each zone of the city, a list of households was generated from Kebelle administrations to form the sampling frame. A critical component of sample size formulas is the estimation of variance in the primary variables of interest in the study Israel et.al (2003). To determine sample size of households those to participate in the study, a sample size determination formula used which was Israel (2003). The formula that we used for determining sample size is the following:

[10] Zone refers group of woredas/ disetrcts for adminstration purpose in the Federal democratic republic of Ethiopia

$$n = \frac{N}{1+N(e)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where n= is the required sample size. N= is a number of large household size

e= is the desired level of precision.

Therefore, $n = \frac{63{,}916}{1+ 63{,}916(0.5)^2} = 398$ households.

Table 1; Sample Households determination across sample zones

The stratum of an area	Sample Zones	Total households	Sampled households	Percentage (%)
Nearest	A & B	15839	183	1.16
Middle	C & E	39381	131	0.33
Outer	B& D	8696	84	0.96
Total	6 Zones	63,916	398	0.62

Source: Total population data as per the census of 2007 & current Bahir Dar population growth rate.

5.5. Survey technique

This study used questionnaire guided survey technique. The researcher with the help of two trained enumerators administered the research questionnaires to the households in Lake Tana. The survey was administered from March 23 to April 27, 2019, for consecutive days, through a face-to-face interview by the researcher and two enumerators. This technique was chosen since it helped interviewers to clearly explain to respondents all the variables required for the study, assist respondents who do not know how to read and write to fill research questionnaires, enabled researcher to obtain first-hand information and also to motivate them to participate in the data collection exercise.

5.6. Survey implementation

A pilot study was conducted to enhance the reliability and validity of data in this study. Information sourced from this pilot study aided in the determination of Bid values upon which mean WTP was anchored. Additionally, results from this study were used as a chief arsenal for improving the structure of the final research questionnaire to capture all the relevant components and anomalies of the study. Given all these adjustments, the final questionnaire was prepared and administered to 398 respondents by a researcher with the help of two trained enumerators.

5.7. Payment Vehicle

This study used a special trust fund which was a neutral payment vehicle to help in minimizing objections and protest responses by households. Based on this payment vehicle, Households were going to make a one-time donation to help in the management of WH infestation to Lake Tana. This special trust fund

method was highly recommended due to its credibility and ability to improve the hypothetical scenario. It was thus, superior over other payment vehicles such as; fees, tax and amenity bills (Otieno et al, 2019).

6. RESULTS AND DISCUSSION

6.1. Socio-demographic characteristics of respondents

Table 2 showed the socio-demographic characteristics of households. Most of the households (323) representing 82.8 % were male, and (67) representing 17.08% were female. The average age of respondents is 48 and the minimum and maximum are 25 and 79 years old, respectively. All of them were decision makers since the

Study mainly focused on the interviewers' decision-making ability rather an aged member of the family. The minimum and a maximum number of household size or family members are 1 and 9, respectively while the average is 4.76. The minimum and the maximum number of household's member or family having job per family within the household's is 1 and 3, respectively while the average is 1.17. The mean educational attainment of respondents is 13.69 years. When the minimum education is zero (illiterate), the maximum educational achievement is 20 years (Ph.D. level). Most of the time people do not provide accurate information about their income. For this reason, respondents were presented different questions that are proxy to income for a number of workers in the household that generate income or family member having a within the family, and monthly income of the household before tax. Accordingly, based on the survey the average monthly income of the sample households was ETB 4873.5, with a minimum monthly income of ETB 1000 and a maximum of ETB 16,451.

Table 2: Socio demographic characteristics of respondents

Characteristics	Frequency (f)	Percentage (%)
Gender		
Male	323	82.8
Female	67	17.2
Marital status		
Married	321	82.3
Singles	69	17.7
Education Level		
Illiterate	28	7.17
Primary school	189	48.46
Secondary school	101	28.9
College Diploma	35	8.97
University	17	4.35
Importance of giving value for the lake		
Recreational value	122	31.28
Future generation	75	19.23
Source of income	193	49.48

Variables	N	Mean	Ste.dv	Min	Max
Mwtp	390	1011.436	877.0138	0	3500
Age	390	48.11538	11.28434	25	79
Nvst	390	1.294872	0.8347987	0	3
Arwh	390	0.9589744	0.1986043	0	1
Y	390	4873.5	3178.206	1000	16451
Hhs	390	4.766667	1.83354	1	9
Dist	390	2.719	0.849422	0.5	3.75
Educ	390	13.697	2.87096	0	20
Nhhmhj	390	1.176923	0.4081191	1	3
Gender	390	0.8282051	0.3776866	0	1
Mrs	390	0.8923	0.3103896	0	1
vatl -1	390	0.4846154	0.50040	0	1
vatl-2	390	0.325641	0.4692158	0	1
vatl-3	390	0.1794872	0.3842527	0	1

6.2. Households' Willingness to Pay for Water hyacinth control

In the questionnaire, households were asked whether they are willing to pay for WH control for Lake Tana. Consequently, among the sample household heads, about 96 percent are willing to pay if the donated money is correctly used for weed cleaning. This indicates that the implementation of the project is supported by about 96 percent of households from the entire sampled respondents in general. Only 4 percent of respondents were not agreed to pay for conservation of the lake. 8 respondents were unwilling to respond for interviews while another 8 respondents are willing to donate money but they are unable to pay due to low monthly income.

Table 3: Willingness to pay of sampled respondents

Willingness to pay	Frequency	Percent (%
Number of respondents Willing to donate	374	96
Number of respondents unwilling to donate	16	4
Total	390	100

Source; Survey data, 2019

6.3. The Results of Tobit regression model

Table 4; Maximum Likelihood Estimates of the Tobit model

Mwtp	Coef	Std.Err.	T	P>|t|	[95% Conf.	Interval]
Age	-3.1344	3.41747	-0.92	0.36	-9.8541	3.58525
Nvst	31.8195	41.6899	0.76	0.446	-50.154	113.793
Y	0.03416	0.01362	2.51	0.013**	0.00737	0.06095
Hhs	49.0528	20.7849	2.36	0.019**	8.18397	89.9216
Dist	20.7419	41.5271	0.5	0.618	-60.912	102.396
Educ	93.6635	16.371	5.72	0.000***	61.4736	125.853
Nhhmhj	925.206	89.1752	10.38	0.000***	749.863	1100.55
1.arwh	451.841	179.634	2.52	0.012**	98.6303	805.052
1.gender	67.188	91.9828	0.73	0.466	-113.68	248.052
1.mrs	35.2937	112.604	0.31	0.754	-186.12	256.703
1.vatl$_1$	240.898	237.001	1.02	0.31	-225.11	706.906
1.vatl$_2$	228.999	238.054	0.96	0.337	-239.08	697.078
1.vatl$_3$	153.823	247.533	0.62	0.535	-332.9	640.541
_cons	-2463.3	398.502	-6.18	0.000	-3246.9	-1679.8
/sigma /	652.92	24.0194	--	--	605.691	700.149

Number of obs = 390 ; LR chi2 (13) = 248.74

Prob > chi2 = 0.0000 ; Log likelihood = -2970. 4

Pseudo R2 = 0.0402;

** Significant at 5 percent *** significant at 1 percent

Using continuous CVM, respondents were asked to give the maximum amount of money they are willing to pay for WH control. Since the dependent variable (MWTP) cannot be fully observed (it is censored at zero) and that an OLS (ordinary least squares) estimator cannot be applied, a Tobit model for the observed MWTP value was employed. The Tobit regression results of factors influencing MWTP value for WH cleaning showing the coefficients, standard errors, significance levels, and the constant together with the log-likelihood value, Chi-square, Pseudo R-square and the overall significance of the model is presented in **Table 4.** In order to test for the goodness of fit, the Pseudo R-squared was used. The Tobit regression gave a Pseudo R-squared of 0.0402. The explanatory

power of the model increases by 0.0402, suggesting that approximately 4 percent of the variation in MWTP value is explained by the explanatory variables. But, the pseudo R2 of 0.0402 is not surprising, given that the conventional measure of goodness of fit of it is not particularly meaningful in binary regressed models. The likelihood ratio chi-square of 248.74 degrees of freedom (DF=13) with a p-value of 0.0000 means that the joint significance test of all variables in the model is significant at 1% level as P<0.05, implying that the variables correctly predict the model.

From the above **Table 4** Tobit regression result we have 5 statistically significant , positive effect on WTP and met the priory decision for the sign of the coefficients from 11 explanatory variables such as awareness of water hyacinth , income levels of the household's ,household size ,educational level of households ,and number of household's member having job. Awareness of WH was positive and statistically significant at 5 percent which has a positive effect on the household's WTP for its control. Since knowledge of the problem associated with the invasion of WH did have a positive effect on WTP i.e households had more information about the problem they conveyed or concern for the environment that they live it. Incomes of household's head were another significant variable at 5 percent and a positive relationship with the maximum WTP amount. This showed that an increased head of household income resulted in an increase in the maximum amount of money a household head would be WTP for control of water hyacinth. It was therefore evidenced that wealthy households were more WTP for its control than the poor household's.

This is consistent with expectation depend on theoretical literature weather household were more willing to pay for environmental protection. This is also an indication that people were making "real decisions". The study by Otieno et al, (2019), & Mironga, (2015) were found the same result. Household size also significantly and positively at 5 percent influences the household willingness to pay. ChuenKhee & Othman (2002) pointed out that the more the number of people in the household, the more willing the household will appreciate a clean environment. The number of household's member having job found to be significant (1 perecent) and positive effect on WTP as the income of the household member increase that they were live in any place and do anything was more willing to pay for clearing of the lake from WH. Educational level was positive and statistically significant at 1 percent level, suggesting that highly educated household heads had a higher willingness to pay for WH control program. This is true because education is believed to increase individuals' ability to obtain, analyze and assimilate information that helps to make prudent decisions related to the management of their environment. In this instance, educated people will have a better understanding of the negative impacts of WH and working in infested areas of WH is the risk of catching water born disease and lack of clean water possibility. The variables number of visit to the lake, marital status, and value attached to the lake and gender were insignificant but, met the priory decision for the sign of the coefficients except for the variable age.

6.4. Determinants of Households Willingness to Pay

Eleven explanatory variables were included in the Tobit model to predict its influence on households' willingness to pay for WH control. **Table 5** shows the sign, magnitude, statistical tests, marginal effects and a significance level of each explanatory variable. Out of the 11 variables hypothesized to influence households' willingness to pay, 5 explanatory variables were found to be statistically significant at less than 1 percent and 5 percent significant levels. These variables are an educational

level of household's, awareness of WH, number of household's member having a job. The other 6 explanatory variables were the insignificant effect on the amount of WTP for WH control. These significant variables have a positive effect on the amount of WTP. However, the interpretation of the censored regression model is not straightforward. That is, the marginal effects cannot be adequately explained from the estimated coefficients of the Tobit model (see **Table 5** below). Therefore, for interpretation of the Tobit model the researcher report three sets of marginal effects: the effect on the probability of a positive WTP, the effect on conditional WTP, and the effect on unconditional WTP.

To be more specific, household's monthly incomes have a positive and significant association with the households WTP for WH control. That is, when the income of the household increase by one Birr, it would increase the probability of willingness of a household to pay for WH control by about 0.00065 percent. Besides, when the income of the household increase by one birr their willingness to pay would increase, on average, by about 0.032 ETB[11] for all observation and 0.0266 ETB for willing respondents', ceteris paribus. This shows that conservation of Lake from water hyacinth infestation is a normal economic good whose demand changes or increases in the direction of income change which confirms the economic theory which says that income and quantity demanded to a particular commodity are positively related for the case of normal goods. Respondents with higher education levels were more likely to state positive WTP, and on average, they actually stated higher conditional and unconditional WTP than respondents with lower educational levels (illiterate one).

This result suggests that investing in the education of people might help to control or restore lake resource in a degraded environment. The marginal effect of the result shows that the respondent being educated, the probability of willingness to pay for water hyacinth control increases by 1.8 percent. Also, as the years of education increases by one year, the amount of cash the household is willing to pay for water hyacinth control increase by 87.69 ETB for the whole sample of the study, and 72.95 Birrs for the willing respondents, Ceteris paribus. The variables awareness of water hyacinth also has a positive and significant effect at 5 percent level which has a positive effect on the amount of households WTP.

In terms of awareness to water hyacinth, a unit changes from 0 (not aware) to 1 (aware) the probability of being willing to pay increases by 13.5 percent. That is, the marginal effect result shows that a unit changes from 0 (not aware) to 1 (aware), the willingness to pay increased by 398.3 ETB and 311.5 ETB for the whole and willing respondents respectively, ceteris paribus. When respondents have better knowledge or information about the problems associated water hyacinth would be able to make a better valuation assessment. The estimated coefficients household size and a number of the household member having a job was also found to be statistically significant with expected have positive value on the amount of WTP. Indicating the probability of WTP to support the control of water hyacinth project increases as the household size increase, holding, the influence of other factors, constant an increase household size by one member within the household, increased the probability of WTP by about 0.938 percent.

According to marginal effects, as the household size increases by one person within the household's, the expected WTP value increased by 45.93 ETB for the entire population and 38.21 ETB for observations with positive WTP respondents. This is because the households may feel secure of their

[11] ETB refers Ethiopian Birr which is the Ethiopian Currency

right to use the Lake resource after control. Numbers of household's member having a job were another variable found to be a significant and positive effect on WTP. Members of household work in any place that generates income increase by one Birr; it would increase the probability of willingness of a household to pay for water hyacinth control by about 17.7 percent. Besides, when the income of the household member within the household increase by one birr their willingness to pay would increase, on average, by about 866.20 ETB for all observation and 720.60 ETB for willing respondents', ceteris paribus.

Table 5: The Tobit Model estimation results of households WTP; Dependent variable; Maximum willingness to pay, 390 observations

				Marginal effects (dy/dx) 1, 2, & 3.		
Variables	Coef	std.err	t-value	prob(1)	truncated(2)	censored(3)
Age	-3.1344	3.41747	-0.92	-0.0006	-2.441	-2.935
Nvst	31.8195	41.6899	0.76	0.00609	24.78	29.79
Y	0.03416	0.01362	2.51 **	6.5E-06	0.0266	0.032
Hhs	49.0528	20.7849	2.36**	0.00938	38.21	45.93
Dist	20.7419	41.5271	0.50	0.00397	16.16	19.42
Educ	93.6635	16.371	5.72 ***	0.0179	72.95	87.69
Nhhmhj	925.206	89.1752	10.38***	0.177	720.6	866.2
1.arwh	451.841	179.634	2.52 **	0.135	311.5	398.3
1.gender	67.188	91.9828	0.73	0.0135	51.73	62.61
1.mrs	35.2937	112.604	0.31	0.00697	27.29	32.95
1.vatl-1	240.898	237.001	1.02	0.046	187.8	225.4
1.vatl-2	228.999	238.054	0.96	0.0401	181.8	215.9
1.vatl-3	153.823	247.533	0.62	0.0262	122.2	145.3
/sigma /	652.92	24.0194				
N	390	390	390	390	390	390

(dy/dx) for discrete change of dummy variables from 0 to 1

.esttab coef prob, truncated, censored, p star(0.1 ** 0.05 *** 0.01) margin mtitles nostar b(% 9.5g)*

[1] *Marginal effects on the probability of being censored.*

[2] Marginal effects on the truncated expected value (Observations with positive WtP)

[3] Marginal effects on the censored expected value (the total observations)

Source; survey result (2019)

6.5. Estimating Aggregate Willingness to Pay

Table 6 below shows aggregate willingness to pay of WH control for urban residents living in Bahir Dar city. We find that the mean WTP for WH control per household for a one-time donation is ETB 1011.435 (Table 6). The survey was designed and intended to elicit households WTP and the aggregate value based on the urban population in the city. Given the current population of BahirDar city 313,997 with an average family size of 4.76 (in the sample), the number of households is about 63,916 CSA, (2007) and our survey data. Hence, we can calculate total WTP for a one-time donation by multiplying the mid WTP value by the total number of households in the city. The total one –time donation WTP of the households in the city, using the mid WTP, is estimated at ETB 77, 624,226.2 ETB (**Table 6**).[12]

The true willingness-to-pay value (with protest responses eliminated from the sample in advance) was used as the average individual value of willingness-to-pay for aggregation purposes. The results can serve as a starting point for cost-benefit analysis of degraded lake resources rehabilitation related policies. These results, which are shown in **Table 6**, suggest that if a policy aiming at promoting rehabilitation of degraded lake resource and use requires charging a price within the above range, households would be willing to pay for it. The information obtained from the household maximum willingness to pay result can also be used to draw the demand curve and to make aggregation for the willingness to pay for recovering of degraded lake resource activities. The demand curve for willingness to pay for control of water hyacinth is derived to see the extent of cost recovery. The demand curve can be derived in terms of the total number of households and their associated mid-WTP.

[12] Note that the total one-time WTP of the households in the City can be calculated using the open-ended elicitation formate,i.e., the maximum WTP of the respondents as follows using one of the aggregation methods of WTP. First i.e., prior to the aggregation of benefits class boundaries for the results of open-ended questions are set. Then, mid WTP or class mark is determind. That is, mid WTP or class mark is the average of the WTP interval or class boundaries. Total WTP for the class is derived multiplying mid WTP or class mark by the totaol number of households in the class.
Then this is aggregated across all classes.

Table 6: Household's contribution to water hyacinth control and Estimation of Mean willingness to pay

WTP ∗ (in ETB ∗∗ for a one-time donation)	Frequency of sample distribution		Mid Wtp	Total no. of households	Total WTP (in ETB
	Number	Percent (%			
0	16	4.10	0	0	0
100-250	71	18.21	176	11635.9896	2047934.17
251-350	37	9.49	301	6063.82533	1825211.42
351-450	31	7.95	401	5080.5026	2037281.54
451-600	32	8.21	526	5244.38961	2758548.93
601-800	21	5.38	701	3441.63052	2412582.99
801-950	13	3.33	876	2130.53312	1866347.01
951-1000	28	7.18	976	4588.84091	4478708.73
1001-1250	14	3.59	1126	2294.42078	2583517.8
1251-1400	9	2.31	1326	1474.98442	1955829.34
1401-1500	17	4.34	1451	2786.08182	4042604.72
1501-1600	5	1.28	1551	819.435717	1270944.8
1601-1750	6	1.54	1676	983.323372	1648049.97
1751-1850	8	2.05	1801	1311.0974	2361286.42
1851-1900	10	2.56	1876	1638.87207	3074524
1901-2000	19	4.87	1951	3113.85649	6075134.01
2001-2250	11	2.82	2126	1802.75909	3832665.83
2251-2500	15	3.85	2376	2458.30779	5840939.31
2501-2700	8	2.05	2601	1311.0974	3410164.34
2701-300	13	3.33	2851	2130.53312	6074149.93
3001-3500	6	1.54	3250	983.323372	3195800.96
Total	390	100		63,919	77,624,226.20

	N	Mim	Max	Mean	Sta.devation
The highest amount of households MWTP for water hyacinth control	390	0	3500	1011.436	877.0138

∗ Willingness to pay.

∗∗ETB= Ethiopian Birr.

Source: Author calculations.

6.6. Aggregate Demand for Water Hyacinth control

The demand for WH control at different price level is shown graphically in **figure 2** below. The demand curve is derived with a mid point value of the maximum willingness to pay on the horizontal axis and a total number of willing urban households on the vertical axis.

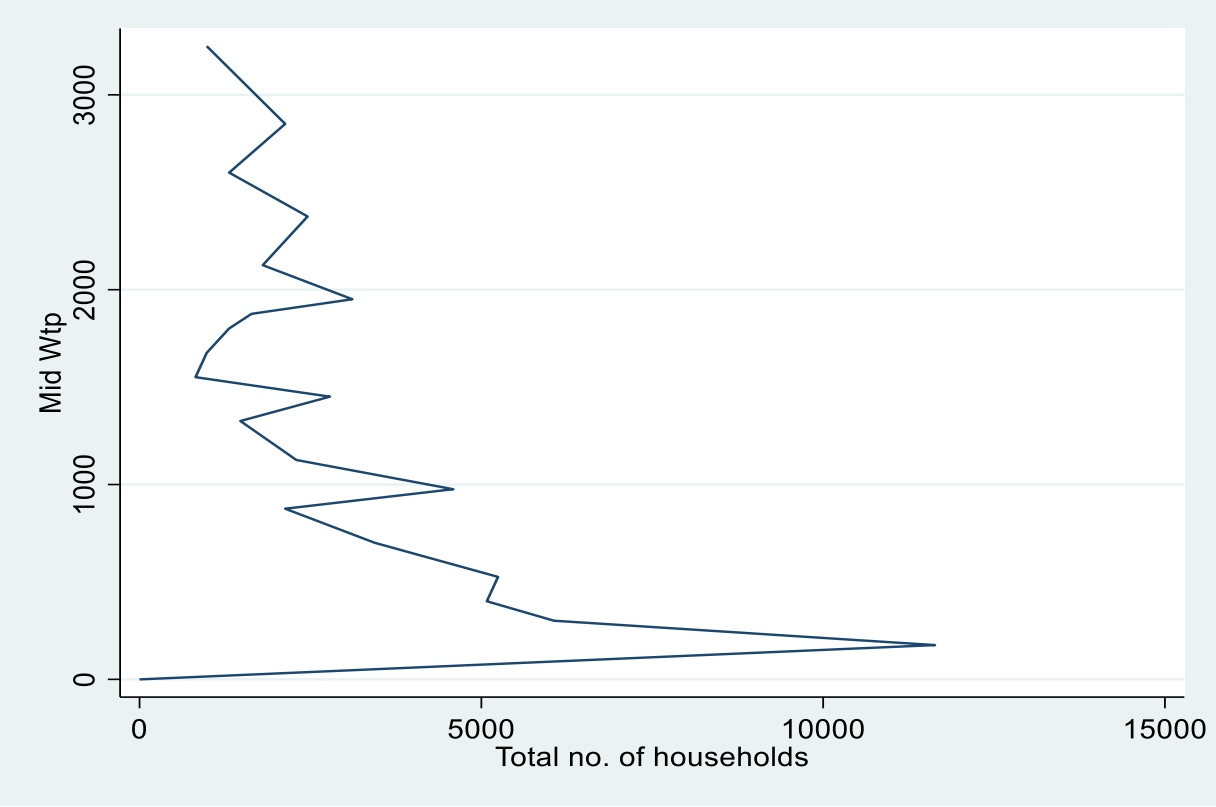

Figure 2: Aggregate Demand Curve for water hyacinth control

We note from the above figure, the demand curve is the zigzag line (slightly negative slope), indicating that demand for WH control project was decline as the bid amounts (prices in the proposed payment card) increases for control or recovery of degraded Lake resources, like most other economic goods, ceteris paribus. If Lake is considered as a free resource to the society, the consumers' surplus would be the total area under the demand curve. The area under the demand curve represents the gross value of consumers' surplus if they are not paying anything for the recovery of a lake infested by WH.

7. Conclusion and Recommendations

The aim of this study is to assess urban households of Bahir Dar city Cleaning of the Lake Tana and their willingness to pay (WTP) for WH control. We used a contingent valuation approach with a PC elicitation format followed by open-ended questions. We administered our survey via in-person interviews with 398 sampled household heads and used 11 explanatory variables in the regression models based on the degree of theoretical importance and their impact on WTP. Tobit models were used to identify factors influencing households' WTP for WH control and to analyze the mean WTP of households.

From the study, it is apparent that the majority of the urban households were willing to pay for the cleaning of WH from the Lake with varying degrees of amount while some protested and some were outliers. On the estimation of WTP, 96 percent (374) of the households were willing to pay with an average amount of ETB 1011.436 while 4 percent (16) of the households were not. The mean WTP for WH control for a onetime donation per household from the Tobit analysis (using PC elicitation format) is ETB 1011.436, with a total contribution of ETB 77,624,226.2 per household for a one-time donation. The

other objective was to examine socio-economic factors influencing households' WTP decisions for the control of WH in Lake Tana. From the Tobit regression result, factors that positively affected WTP for the control of WH include: household's income, awareness of WH and household size, were significant at 5 percent and number of household's member having job and educational level of household's, were also significant at 1 percent level that met the priory decision for the sign of the coefficients while gender of household head, value attached to the lake, number of visits, and marital status of the household aware met the priory decision for the sign of the coefficients except for the variable age and distance of household's home to the lake.

Therefore, the study recommends that environmental protection agency such as environment, forest, and wildlife protection and development authority of Amhara national regional state and Nile basin authority and other responsible agencies in federal and national level should adequately sensitize the public on the long-term implications of WH control strategy on aesthetic value of the lake and socio-economic wellbeing of households in the concerned communities, and also on the need for building upper catchment areas and protection of wetlands that reduce running of erosion.

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