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Households' Willingness to Pay for Water Hyacinth Control in Lake Tana, Ethiopia: A Contingent Valuation Method Application

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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 for the riparian communities. This study uses a cross-sectional survey of 398 randomly selected households in Bahir Dar, Ethiopia, to assess their willingness to pay (WTP) for its control over Lake Tana using a 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 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. The findings show that residents' WTP for WH control is significantly related to income, having a job, and being aware of WH, among other factors. The average WTP discovered can serve as a guide for municipal officials in establishing a more appropriate fee to fund cleaning in WH, where both regional and federal governments have collaborated.

Keywords: Contingent valuation method, households, tobit regression, water hyacinth

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Introduction

Water hyacinth is an invasive aquatic plant species that lives, reproduces, and floats freely on the surface of fresh waters. It can be anchored in mud at the bottom of the water body and spread throughout vital freshwater bodies (Cilliers et al., 2003). The plant's size ranges from inches to a metre in height, and its rate of propagation under certain conditions is extremely rapid, allowing it to spread out and cover large areas of water bodies, causing a variety of problems for 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 the Amazon Basin, and it was spread to many parts of Latin America as an ornamental garden pond plant due to its beauty. Water hyacinth (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 the 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 the UN (1997), there is now an environmental disaster in the central and eastern regions 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 the world’s biodiversity as they alter ecosystem services and processes, reduce the prevalence of native species, and decrease the 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 recognised 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), Sudan (1957) Senegal (1964), Nigeria (1983) and Uganda (1987) have been estimated at between USD 20 and 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. There are approximately 35 invasive alien plant species in Ethiopia, including WH. Thus, weed poses a threat to the economic, social, and environmental livelihood of the riparian community and the ecosystem health of Lake Environment (Rezene, F., and Taye, T. (2014). WH was first reported in south-central Ethiopia in 1965 at Koka Lake and the Awash River (Fessehaie, 2012). Control of this undesirable plant through chemical, physical, and biological management strategies 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).

Organisation 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 A team of researchers from the Global Coalition 2018 for Lake Tana Restoration (a US-registered not-for-profit initiative) and the Geospatial Centre of Bahir Dar University spent a number of days actively contributing to the 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 and planning frameworks, as well as ensure coordination, cooperation, and collaboration (Wassie et al., 2014).

The presence of WH in lakes can result in lower tourism revenues from rowing and other activities, an increase in malaria infestations, and clogged hydropower generation activities. As a result, power interruptions and financial losses act as an obstacle to positive economic change (Khatri et al., 2018). In Lake Tana, WH invasion has a negative impact on fish production and the local irrigation system. The rampant growth of WH has a long-term impact on the daily livelihood of the riparian community, which is dependent on the lake and the neighbouring businesses. The WH invasion on Lake Tana directly affects fishermen, farmers, and all the people who depend on the environmental services of the lake (Wassie et al., 2014). Infestations of WH have already been estimated to cause environmental, economic, agricultural, and social problems worth billions of dollars (Khatri et al., 2018). The adverse environmental, health, and economic effects of WH are estimated at 120 billion USD (Pimentel et al., 2005; and Kettunen et al., 2009). Principally, WH degrades ecology. It also causes economic losses and leads to biodiversity loss (Mironga et al., 2014). The 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, it has not yet been conducted in a way that is particularly 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 environmental goods characteristics and recreational costs concurrently to estimate the actual use value. However, in this particular study, the stated preference method seems a suitable tool for exploring household 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 can also capture the non-use or existence value of environmental goods and services.

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

Review of Related Literature

Contingent valuation surveys have been widely applicable methods for valuing the use and non-use values of environmental goods and services (like lake resources) (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 on 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) examined the willingness to pay for water hyacinth control by visitors and local people to Phewa Lake in Nepal using the stated preference contingent valuation method on 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 in the lake and derive a relatively inelastic demand curve for preserving environmental goods and services. They prepared three contingent valuation scenarios for the respondents by encircling different socioeconomic variables and introduced six impact categories to the valuation scenarios, such as weed impact on the scenic beauty of Lake Phewa, impact on aquatic life, impact on economics, 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 the 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[2] 920.51. Similarly, the mean willingness to pay for the second scenario to achieve the 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 expenditures of the households were negative signals and significant at the 5 percent level that determines the respondent's willingness to pay, but a number of visitors was a positive sign and significant at the 5 percent level that determines the respondent's willingness to pay for the removal of water hyacinth in Phewa Lake, Nepal.

[2] NPR refers to the Nepalese rupee, which is Nepal's currency.

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 a payment-cared elicitation format for a one-time payment or donation in the form of a neutral trust fund from 268 sampled Fisher Folks. He used a binary response Tobit model in order to analyse the socio-economic determinants of individuals' (fisher folk's) WTP decisions for the improved water hyacinth management in Lake Victoria. The findings of the study showed that fishermen were on average willing to pay an amount of Kshs[3] 175.11. With a total contribution of Kshs. 42,500, monthly to improve water hyacinth management in Lake Victoria. Among the used explanatory variables, age, experience, income, perception of fisher folks about water hyacinth infestation in the lake, fishing groups, and gender of fisher folks had a significant level at the 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. 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[4] 21.12 (R26.40 at 2008 price levels), R 25, 344.00(R 31, 680.00 at 2008 price levels) and R21.87 (R 27.34 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.

[3] Kshs refers to Kenyan Shilling, which is Kenya's currency.
[4] R refers rand which is South Africa currency

Rodriguez-Tapa et al. (2017) also applied the contingent valuation method to households' perceptions of water quality and willingness to pay for clean water in Mexico City using a censored econometric (Tobit) model. The average willingness to pay for better potable water quality is US$3.1, or 4.7 percent of the family's bimonthly water bill. The study discovered that the high cost of bottled water has a significant impact on willingness to pay.

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

A study on assessing the 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-Sample 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 ponds) was USD 5,652 per year for the water shade conservation Programme. 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 modelling approach of multinomial logit (MNL) to estimate willingness to pay for wetland improvement in Vietnam's Mekong River Delta. They employed MNL and Random Parameters Logit (RPL) models using a contingent valuation approach and divided respondents into three subpopulations: Cao Lanh, Ho Minh City, and Hanoi, for a total of 300 personal interviews or face-to-face interviews. According to their findings, respondents in three locations have varying marginal willingness to pay for wetland attributes, with the overall willingness to pay for the proposed wetland biodiversity conservation ranging from 2.5 USD per household in Hanoi to 0.9 USD in Ho Chi Minh City and zero in Cao Lanh. The respondents' age (older), knowledge of the problem, and geographical distance from the study site were all positive factors influencing willingness to pay.

A study by Eugene et al. (2015) examined consumer preferences and willingness to pay for close-to-home nature for outdoor recreation in Sweden, using the contingent valuation method. The information came from a mail survey of Swedish residents drawn at random from the national register. They used the Tobit and ordinary least squares (OLS) models for estimation and to account for factors that influence willingness to pay. The findings of the articles showed that approximately 50 percent of the respondents spent their leisure time by visiting nature (consumption from the recreation of nature) and/or establishing nature areas close to their home, and the average frequency of visits to this area was 74 times annually. The mean willingness to pay of the respondents was approximately 7200 SEK[5] (USD 1080) annually. The respondent's willingness to pay for nature was strongly influenced by their income, the types of nature areas, and the distance to and time spent at the recreational areas. Again, the study's findings revealed that respondents who live in rural areas and live in nature were more willing to pay for nature, which is an average of 9044 SEK (USD1357) per year for outdoor recreation, than urban respondents who were willing to pay an average of 6425 SEK (USD 964).The coefficients of the variables were relatively the same except age and gender; the coefficients associated with distance, time, and income had positive and statistically significant effects that determined the willingness to pay of the respondents, supporting 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 the contingent valuation method from 432 respondents. The model was estimated using a non-parametric one-way analysis of variance test with ANOVA. The respondents' mean willingness to pay for beaches as a fixed price per visit for maintenance and improvement of coastal tourism management was approximately €1.70 -2.30. The findings of the study showed that local government should be ultimately focused on environmental policy, programmes, and implementation.

Using a discrete choice experiment method, Peng & Oleson (2017) made a study on beach recreationalists' willingness to pay and the economic implications of the coastal water quality problem in Hawaii. A conditional logit model was used for estimation. Individuals were willing to

[5] SEK refers to Swedish Krona, which is the currency of Sweden.

pay $11.43 per day to reduce the bacterial abundance on the beaches from 11 to 5 per year; the respondents were also willing to pay USD 15.33 to improve coral reef cover from 10 percent to 25 percent. Individuals were willing to pay between USD 2.47 and USD 7.14 to increase the number of fish species in coastal areas. The study found that environmental improvements in coastal water quality increased consumer surplus (recreationalists' welfare) from USD20 million to USD550 million and USD120 million. The study estimated that taking management actions targeting each of the areas relevant to recreationalists, the government, and other agencies can effectively increase consumer surplus derived from improved coastal water quality.

The study by Wang and Jia (2012) on tourists' willingness to pay for biodiversity conservation and environment protection, Dalai Lake protected areas implementation for the entrance fee, and sustainable management in northern East China using the contingent valuation method with 2000 randomly selected respondents (tourists), The Logit and Probit models were used for estimation and to establish the relationship between the variables and willingness to pay. The findings of the articles showed that majorities of the respondents (73.6 percent) were willing to pay. 26.4 percent of the respondents were unwilling to pay. The most significant factors or predictors of tourist willingness to pay were income level and awareness of being in protected areas, both of which had a positive sign and were significant at the 1% level, but educational level and institutional trust were also significant predictors, both of which had a positive sign and were significant at the 5% level. The median willingness to pay was 71.08 RMB[6] (USD10.72).

A study by Bhandari and Heshmati (2010) examined 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 a variety of sites. The Logit and Tobit models were used for estimation. The findings of the study showed that higher socioeconomic status of tourists was positively related to their willingness to pay; higher age brackets might constitute an improvement in the revenue generators of biodiversity conservation; higher education and income of the respondents have positive significance in determining their willingness to pay.

[6] RMB stands for renminbi, China's official currency.

Mwebaze et al. (2010) study on the economic valuation of the influence of invasive alien species on the economy of the Seychelles islands Using the 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 USD 52–USD 58 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 four key IAS is approximately USD 21 million per year. Comparing the benefits of eradication with the costs involved gives a benefit-cost ratio greater than unity, indicating that the policy of eradicating IAS is 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 into any particular motive should be conducted in context.

Halkos and Matsiori (2012) conducted a study on the point of assessing the economic value of protecting the artificial lakes by using CVM. The study employed a logistic model followed by a Tobit, and they applied 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 prevent possible diminutions of its total economic value, and the study shows that the most important variable is pro-environmental behaviour. They also found that respondents have different behaviour for the lake’s economic value according mainly to their origin (residents or recreational users). Demographic variables (like income, age, and 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 the people who seek its protection.

Non-economic motivations for willingness to pay for biodiversity conservation were studied by Montes and Benayas (2007) using 649 sample respondents. The annual mean willingness to pay ranged from €23.2 to €30.8 depending on the method applied in the estimation. According to the study's findings, geographical distance, age, and respondents' knowledge were the most important determinants of willingness to pay for biodiversity conservation. Limited CVM studies have been conducted in Ethiopia 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 improving lake quality.

All the above contingent valuation method (CVM) studies also identified that the variables like monthly income, level of education, age brackets (groups), geographical distance, and knowledge of invasive alien 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, the occasional presence of a household member who has visited the lake, and the household’s expenditure or size (Khari et al. (2018)) are the main determinants for positive will 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 for the non-use value, passive value, existence value, or non-marketed social value (benefit) of environmental goods and services, and I do not know of any such study for Lake Tana. It would be timely to undertake this study.

Analytical Framework

Protecting natural resources such as lakes from the infestation of invasive species like weeds involves non-market valuation techniques. Since the market value and the "WTP price" are used to estimate Lake Tana's economic benefits. This study focuses on the price that households are willing to pay to maintain 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 the 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. To construct an exact WTP premium, the standard Tobit model is consistent (Batte et al, 2007). Therefore, the study employed a Tobit model to investigate the results of the open-ended question surveyed in the CVM questionnaire and 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:

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

$$MWTP_i = MWTP_i^* \text{ if } MWTP_i^* > 0$$

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

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

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

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

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.

Empirical Strategy

The primary goals of this study are to assess residents' willingness to pay for WH control, analyse the determinants of WTP, and propose cost recovery mechanisms. 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, 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 the PC format provides households with a chance to scan through all the WTP values and then settle on their suitable or highest WTP value. Because the data obtained in this format was less scattered, fewer samples were required to produce robust estimates. The 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 the weakness of having 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).

Research Methodology

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 has fallen, water from the neighbouring areas has been drained into the lake, including several tributary streams such as the Megech River. The geographical location of the lake is 10°58`–12°47`N latitude and 36°45'–38°14`E longitude. The lake catchment covers an area of 16,500 square kilometres and a surface area of 3,200 square kilometres, with a mean depth of 8 metres and a maximum depth of 14 metres, with fluctuations due to increased siltation levels. It is the largest freshwater body in the country, contributing about 50 percent of the nation's water resources.

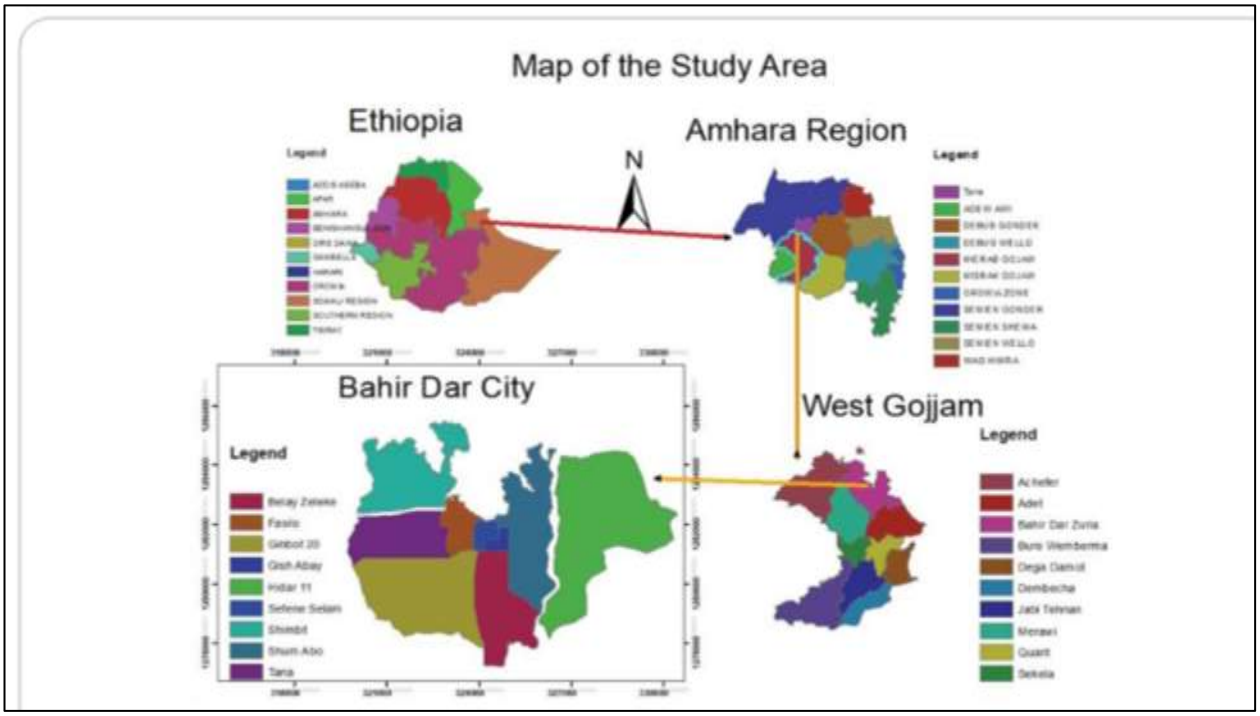
The lake lies at a higher altitude in the range of 1,840 metres above sea level compared to Lake Victoria at 1,134 metres above sea level and is considered the highest lake in Africa. Due to its altitude, it is characterised by cold waters with a mean temperature of 21.7°C. International Fund for Agricultural Development (IFAD), 2007.The Lake Tana watershed consists of 347 Kebles[7] and 21 Woredas[8] in four administrative zones. The average elevation of the Bahir Dar city is estimated at 1801 metres above sea level by UNEP (2006).

The city is strategically located on the banks of Tana, the country's largest lake, and Abay, the world's longest river. It had a total population of 96,140 in 1994, 230,344 in the 2007 CSA (2007), and an estimated 297,749 in 2014. According to the Form for Environmental Assessment (FFE) (2010), the population of the city is increasing at a high rate (287,756) in 2014, and it is 301,425 in the 2015 CSA (2007). The current population of the city is estimated to be 313,997, and the total number of households in the city is 63,916 (Kassahun, 2018). Currently, the city serves as the regional capital of Ethiopia's Amhara National Regional State (ANRS). 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 city of Bahir Dar was chosen for our study because of (i) its popularity as a tourist destination in Ethiopia, (ii) its proximity to Lake Tana, and (iii) its current WH infestation in the lake.

[7] Keble refers to the lowest administrative unit in the Federal and Democratic Republics of Ethiopia.
[8] Woreda refers to a group of Kebeles in the Federal and Democratic Republic of Ethiopia.

Figure 1

Map of the case study area



Source: http://www.maplandia.com/ethiopia/amhara/west-gojam/bahir-dar/

Survey Design

Due to the lack of secondary data, a cross-sectional analytical economic evaluation design was used with only primary information. The study's sample households were drawn from a list of household heads residing in fifty-two local administrations in Bahir Dar City who had a legal residence 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 damage 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 that it harms the environment and the economy. Based on the severity of the effect, we classify the impact categories into four and then introduce them to the respondents. The impact categories include: (I) low productivity of fish; (II) hampering navigation due to encroachment of the weed;

(III) increasing human diseases in the lake; and (IV) reducing the income of the riparian community due to the 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 a problem. Appropriate use of such technology can delay or control the invasion for a given amount of time, from today into the future. The technology for clean-up is not free. We also explain to the respondents that a one-time donation within the neutral trust fund will be used to form a "trusted public or private environment organisation in your region" to be used only for the protection of the lake from the hyacinth. This introductory section will inform the respondents of the terminology used in the valuation questions. A contingent valuation method (CVM) of eliciting demand for control of WH for urban households' 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.

Population and sampling

According to Kassahun (2018), there were approximately 313,997 and 63,916 total population and household numbers in Bahir Dar City, respectively. In this study, all 63,916 households were targeted. To determine the number of households, stratified and simple random sampling techniques were used, and primary data was collected 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 were rearranged into 52 zones (the smallest legal administrative units). To make primary data collection from sample units more homogeneous, all zones in the city are classified into three main groups: nearest, middle, and outer, based on the distance of the respondent's house to the Lake in a kilometre, the respondent's geographical location, and socioeconomic activities. Six zones from all zones were selected randomly by using the lottery method for the data survey. To make the sample zone more representative, 2 zones from the nearest, outer, and middle zones were selected. Prior to Zone selection, a stratum of Zones is formed into three groups, which aids in reducing heterogeneous characteristics of households in different zones. Table 1 shows the details about making stratum and proportional sample household selections. 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. A total of 398 households are chosen at random from all sample zones[9] as a sample for the study.

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:

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

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 2007 & current Bahir Dar population growth rate.

[9] Zone refers to a group of woredas or districts for administrative purposes in the Federal Democratic Republic of Ethiopia.

Survey technique

This study used a questionnaire-guided survey technique. The research questionnaires were distributed to Lake Tana households by the researcher and two trained enumerators. 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 clearly explain to respondents all the variables required for the study, assist respondents who do not know how to read and write to fill out research questionnaires, enable researchers to obtain first-hand information, and also motivate them to participate in the data collection exercise.

Survey implementation

A pilot study was conducted to enhance the reliability and validity of the data in this study. Information sourced from this pilot study aided in the determination of bid values upon which the 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.

Payment Vehicle

This study used a special trust fund, which was a neutral payment vehicle, to help minimise 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 the WH infestation in 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, taxes, and amenity bills (Otieno et al., 2019).

Results and Discussion

Socio-demographic characteristics of respondents

Table 2 shows the socio-demographic characteristics of households. Most of the households (323), representing 82.8 percent, were male, and t of the households (323), representing 82.8 percent, 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 than an aged member of the family. The minimum and maximum number of household members are 1 and 9, respectively, while the average is 4.76. The minimum and maximum number of household members or families having jobs per family within the household are 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). As a result, respondents were asked a series of questions that proxies income for a number of workers in the household who generate income or a family member who has a within the family, as well as the household's monthly income before taxes. 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

Gender	Frequency (f)	Percentage (%)
Male	323	82.8
Female	67	17.2
Marital Status		
Married	321	82.3
Single	68	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

Source; Survey data, 2019

Table 2

Summary of Descriptive Statistics

Variables	N	Mean	Sd.	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

Source; Survey data, 2019

Households' Willingness to Pay for Water hyacinth control

In the questionnaire, households were asked whether they were willing to pay for WH control in 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 population in general. Only 4 percent of respondents agreed to pay for the conservation of the lake. 8 respondents were unwilling to respond to interviews, while another 8 respondents were willing to donate money but were unable to do so 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

The Results of Tobit regression model

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 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 the 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, are presented in Table. 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 the MWTP value is explained by the explanatory variables. But, the pseudo-R2 of 0.0402 is not surprising, given that the conventional measure of its goodness of fit 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.

We have 5 statistically significant, positive effects on WTP from the above Table. Tobit regression results and met the priory decision for the sign of the coefficients from 11 explanatory variables such as awareness of water hyacinth, household income levels, household size, educational level of households, and number of household members working. 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 WH invasion had a positive effect on WTP, i.e., households had more information about the problem they conveyed or concern for the environment in which they live. Incomes of the household's head were another significant variable at 5 percent and had a positive relationship with the maximum WTP amount. This demonstrated that an increase in household income resulted in an increase in the maximum amount of money a household head would be willing to pay for water hyacinth control. It was therefore evidenced that wealthy households were more WTP for their control than the poor household's.

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

Source: Own Computation

This is consistent with expectations based on theoretical literature about whether households were more willing to pay for environmental protection. This is also an indication that people were making "real decisions". The studies by Otieno et al. (2019) and Mironga et al. (2015) 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 larger the household, the more willing the household will be to appreciate a clean environment. The number of household members with jobs was found to have a significant (1%) and positive effect on WTP as the income of the household member increased that they were willing to pay for clearing of the lake from WH. Educational level was positive and statistically significant at the 1 percent level, suggesting that highly educated household heads had a higher willingness to pay for the WH control programme. This is true because education is believed to increase individuals' ability to obtain, analyse, and assimilate information that helps them make prudent decisions related to the management of their environment. In this case, educated people will have a better understanding of the negative effects of WH, and working in WH-infested areas increases the risk of contracting water-borne disease and the possibility of a lack of clean water. The variables number of visits 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.

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. Each explanatory variable's sign, magnitude, statistical tests, marginal effects, and significance level are shown in Table. 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 include a household's educational level, awareness of WH, and the number of household members who work. The other 6 explanatory variables had an insignificant effect on the amount of WTP for the 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 by the estimated coefficients of the Tobit model (see Table below). Therefore, for the interpretation of the Tobit model, the researcher reports 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 household's WTP for WH control. That is, when the income of the household increases by one birr, it increases the probability of the household's willingness to pay for WH control by about 0.00065 percent. Besides, when the income of the household increases by one birr, their willingness to pay increases, on average, by about 0.032 ETB[10] for all observations and 0.0266 ETB for willing respondents ', ceteris paribus. This shows that the conservation of Lake Michigan 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 that says that income and quantity demanded for a particular commodity are positively related in 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 (an 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 number of households WTP.

In terms of awareness of water hyacinth, when 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 results show that when a unit changes from 0 (not aware) to 1 (aware), the willingness to pay increases by 398.3 ETB and 311.5 ETB for the whole and willing respondents, respectively, ceteris paribus. Respondents with more knowledge or information about the problems associated with water hyacinth will be able to make a more accurate valuation assessment. The estimated coefficients for household size and the number of working household members were also found to be statistically significant, indicating that a positive value on the amount of WTP is expected. Indicating the probability of WTP to support the control of the water hyacinth project increases as the household size increases. Holding constant the influence of other factors, an increase in 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, the expected WTP value increases by 45.93 ET for the entire population and 38.21 ET for observations with positive WTP respondents. This is due to the households' confidence in

[10] ETB refers to Ethiopian Birr, which is the Ethiopian currency.

their ability to use the Lake resource following control. The number of household members with jobs was another variable found to have a significant and positive effect on WTP. Members of a household can work anywhere that pays; an increase of one Birr increases the likelihood of a household's willingness to pay for water hyacinth control by approximately 17.7 percent. Furthermore, when the income of a household member increases by one birr, their willingness to pay increases by about 866.20 ETB for all observations and 720.60 ETB for willing respondents, ceteris paribus.

Table 5

The Tobit Model Estimation Results of Households WTP

				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				

Source: Own Estimation

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 Bahir Dar 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).

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.

Table 6

Household's Contribution to Water Hyacinth Control and Estimation of Mean Willingness to Pay

WTP∗(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	Min	Max	Mean	SD
The highest number of households	390	0	3500	1011.436	877.0138

MWTP for water hyacinth control

∗ Willingness to pay.

∗∗ETB= Ethiopian Birr.

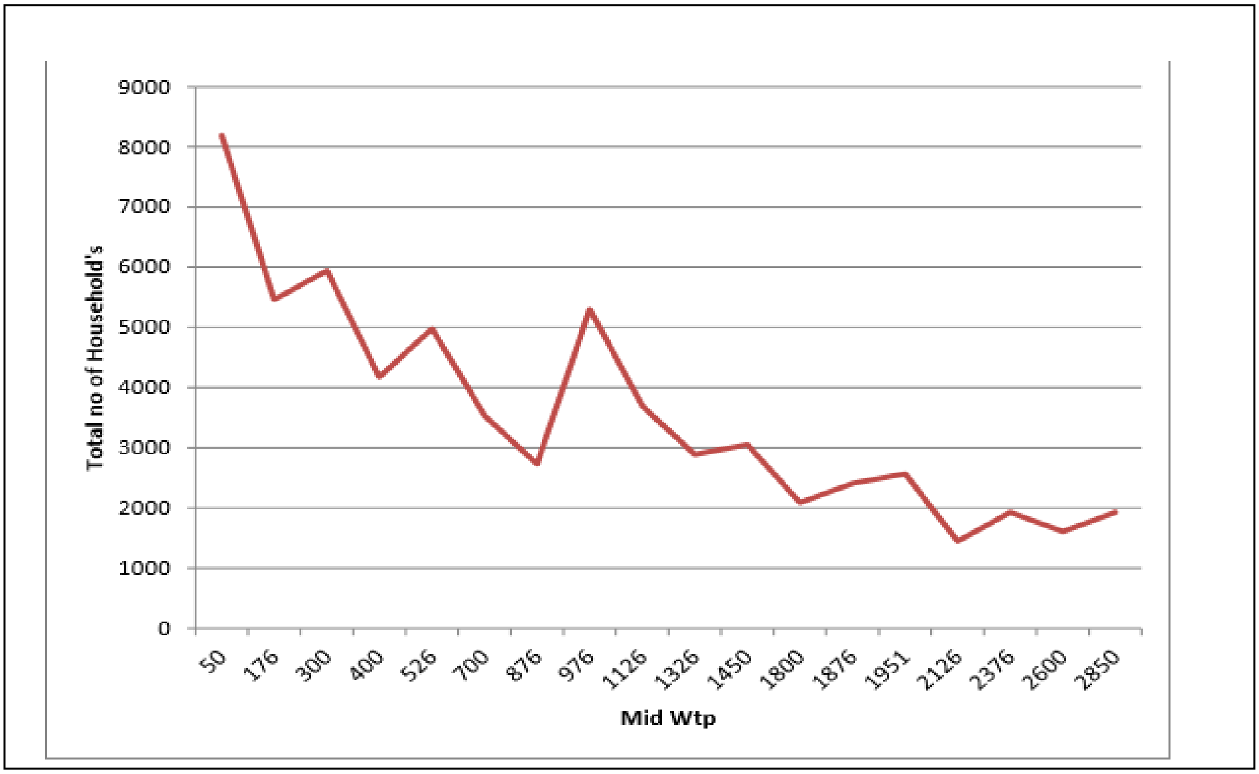
Source: Author calculations.

Aggregate Demand for Water Hyacinth control

The demand for WH control at different price level is shown graphically in figure 4.1 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



Source: Estimation based on Survey data

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.

Conclusion and Recommendations

The purpose of this study is to assess urban households in Bahir Dar city's Lake Tana cleaning 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 analyse 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 sewage from the lake, with varying degrees of amount, while some protested and some were outliers.

In terms of WTP estimation, 96 percent (374) of the households were willing to pay an average of ETB 1011.436, while 4 percent (16) were not. The mean WTP for WH control for a one-time 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 income, awareness of WH, and household size; these were significant at 5 percent; the number of household members having jobs and the educational level of the household were also significant at the 1 percent level that met the priory decision for the sign of the coefficients. On the other hand, while gender of household head, value attached to the lake, number of visits, and marital status of the household met the priory decision for the sign of the coefficients, the variables age and distance of the household's home to the lake did not.

Therefore, the study recommends that environmental protection agencies such as the environment, forest, and wildlife protection and development authority of Amhara, the Nile Basin Authority, and other responsible agencies at the national and regional levels should adequately sensitise the public on the long-term implications of the WH control strategy on the aesthetic value of the lake and the socio-economic wellbeing of households in the concerned communities. There is a need for building upper catchment areas and the protection of wetlands that reduce erosion.

References

Alberini, A., & Cooper, J. (2000) Applications of the contingent valuation method in developing countries: A survey. Rome:

Batte, I.J., M.A. Cole, S. Georgiou and D.J. Hadley (2007), “Comparing Contingent Valuation and Contingent Ranking: A Case Study Considering the Benefits of Urban River Water Quality Improvements”, Journal of Environmental Management, Vol. 79, No. 3, pp. 221-31.

Bhandari, A.K. & Heshmati, A. (2010). Willingness to pay for biodiversity conservation. Journal of Travel & Tourism Marketing 27, 612-623.

BirdirS. ÖzlemÜ, Kemal, B. &Allan T.W (2013) Willingness to pay as an economic instrument for coastal tourism management: Cases from Mersin, Turkey. Tourism Management, 36, 279-283.

Chatterjee PK. B.A. & H.S, (2015) Geographical distribution and physiology of water hyacinth (Eichhorniacrassipses) the invasive hygrophyte and biomass for producing. IntJ ChemTech Res, 7: 1849-1861.

Chuen-khee, P. & Othman, J. (2002) Household demand for solid waste disposal options in Malasia. World Academy of Science, Engineering and Technology, Vol. 66, 1153-58.

Cilliers, J.Carina, Hill, P. Martin, Ogwang, A.James, (2003) Aquatic Weeds in Africa and their Control. pp. 161-178.

Coopera et al, (2004) Economic valuation of the influence of invasive alien species on the economy of the Seychelles islands.

CSA (2007) Central Statistical Authority of Ethiopia Summary and statistical report of the population and housing census result of Ethiopia.

Do, T.N & Bennett, J (2007) ‘Willingness to pay for wet land improvement in Vietnam's Mekong River Delta. Australian Agricultural and Resource Economics Society 51st Annual Conference.

Eichhornia, H., C. Mart & Lake, S., (2011) Biological and chemical assessment of water

EugeneE.E, O,Mattias Boman,Leif, M.,A., L. & Werner, M.(2015).Preferences and willingness to pay for close to home nature for outdoor recreation in Sweden Journal of Environmental Planning and management, 58(2) 283-296. DOI: 10.10.

FFE (2010) Forum for Environment Assessment of the solid waste management system of Bahir Dar city, for the development of an ISWM Plan

Gichuki, J.Omondi, R.Boera, P.Okorut, T.Matano, A, S.Jembe, T. &Ofulla, A. (2012) Water Hyacinth Eichhornia crassipes (Mart.) Solms-Laubach Dynamics and Succession in the Nyanza Gulf ofLake Victoria (East Africa): Implications for Water Quality and Biodiversity Conservation.

Hejda, M.Pyßek, P. & V. Jaroßík, (2009) Impact of invasive plants on the species richness, diversity, and composition of invaded communities. Journal of Ecology, 97, 393- 403.doi: 10.1111/j.1365-2745.2009.01480.

IFAD (2007): Community-Based Integrated Natural Resources Management Project in Lake.

Israel, T. Borokini, & Dapo, F. Babalola. (2003) Management of invasive plant species in Nigeria through economic exploitation: lessons from other countries. Management of Biological Invasions, 3(1) 45–55.

Kassahun (2018) Household Behavior and Demand for Better Solid Waste Management Services: A Case of Bahir Dar City, Amhara National Regional State, Ethiopia. J Waste Recycl Vol.3 No.1:1

Kettunen, M., Genovesi, P., Gollasch, S., Pagad, S., Starfinger, U. ten Brink, P. &Shine,C. (2009) Assessment of the impacts of IAS in Europe and the EU (final module report for the European Commission). Institute for European Environmental Policy (IEEP, 070307/2007/483544/ MAR/B2, 44.

Khatri, U. Bahadur, R. Thapa-Parajuli .and Uttam, P (2018) Willingness to Pay for Water Hyacinth Control in Nepal.American Journal of Environmental Sciences, DOI:10.3844/ajessp.

Maddala, (1992) Introduction to Econometrics, 3rd edition, John Wiley and Sons Ltd Singapore

Marbuah, G. (2016) Willingness to pay for environmental quality and social capital influence in Sweden. FAIRE Working Paper, 1-23.

Mironga, M. J, Mathooko, M.J, &Onywere, M.S., (2014) Effects of spreading patterns of water hyacinth (Eichhornia crassipes) on zooplankton population in Lake Naivasha, Kenya. International Journal of Development and Sustainability 3(10) IJDS 14041401.

Mironga, M.J, Mathooko, M.J, & Onywere, M.S., (2014) Effects of spreading patterns of water hyacinth (Eichhornia crassipes) on zooplankton population in Lake Naivasha, Kenya. International Journal of Development and Sustainability,3(10) IJDS14041401.

Montes & Benayas (2007) Motives behind Willingness to pay for Biodiversity Conservation, European Commission, DG ENV

Mwebaze, P., MacLeod, A., Tomlinson, D., Barois, H., & Rijpma, J. (2010). Economic valuation of the influence of invasive alien species on the economy of the Seychelles islands. Ecological Economics, 69(12), 2614-2623.

Ndambiri, H.E. M. (2015) Stated Preferences for Improved Air Quality Management in the City of Nairobi, Kenya. European Journal of Applied Economics, 2(12), 16-26.

Osienala. (1990) (Friends of Lake Victoria), Dying Lake. PP, 96.

Otieno, M., (2014) Influence of water hyacinth on livelihoods of the riparian community of south west seme location, Kisumu Country, Kenya

Otieno,S.J; Kiprotic,W,B & Ndambiri ,H ,K. ,2019.Economic Analysis of Fisherfolks' Willingness to Pay for Improved Management of Water Hyacinth in Lake Victoria, Kenya. Quest Journals Journal of Research in Business and Management, vol. 07, no. 02, pp 01-0

Patel (2012) Threats, management and envisaged utilizations of aquatic weed Eichhornia crassipes: Environmental Science and Bio/Technology, 11(3)249–259.

Peng, M. &OlesonK.L.L., (2012) Beach Recreationalists 'Willingness to Pay and Economic Implications of Coastal Water Quality Problems in Hawa. Ecological Economics, l 136, 41–52.

Pimentel, D.Zuniga, R. &Morrison, D. (2005).Update on the environmental and economic cost associated with alien-invasive species in the United States.

Preez, M .D Tessendorf S. &Hosking SG, (2010). Application of the contingent valuation method to estimate the willingness-to-pay for restoring indigenous vegetation in Underberg, Kwazulu-Natal, South Africa Department of Economics, Nelson Mandela Metro.

Rezene, F. & Taye, T. (2014) Alien Plant Species Invasions in Ethiopia Challenges and Responses, Ethiopian Institute of Agricultural research

Rodríguez-Tapia, L., Revollo-Fernández, D. A., & Morales-Novelo, J. A. (2017). Household's perception of water quality and willingness to pay for clean water in Mexico City. Economies, 5(2), 12.

Sarkar, S. D. (2011). "Buffernomics: Assessing Willingness to Pay for Lake Conservation on North Pondand EastPond" .HonorsTheses. Retrieved

Shanab SMM, Shalaby EA, Lightfoot DA, El-Shemy HA, (2010). Allelopathic Effects of Water Hyacinth [Eichhorniacrassipes].PLoSONE, 5(10

Téllez, R.T.López, M.E.Granado, L.G. Pérez, A.E.López, M.R. & Guzmán, J.M.S (2008) The Water Hyacinth, Eichhornia crassipes an invasive plant in the Guadiana River Basin (Spain). Journal of Aquatic Invasions, 3(1) 42-53.DOI: 10.3391/ai.2008.3.1.8.

Theuria, M. (2013) Water hyacinth: can its aggressive invasion be controlled?

UN (1997) Water Hyacinth. Nairobi, University of Pennsylvania African studies centre.

Vilà, M. Espinar, J.L.Hejda, M.Hulme, H.E.Jarosˇı´k, V.Maron, L .J. Perg, J .Schaffner, U. Sun.Y. & Pysˇek, P. (2011) Ecological impacts of invasive alien plants: a Meta-analysis of their effects on species, communities and ecosystems. Ecology Letters, 14, 702– 708.

Vilà, M., Espinar, J. L., Hejda, M., Hulme, P. E., Jarošík, V., Maron, J. L. & Pyšek, P. (2011). Ecological impacts of invasive alien plants: a meta-analysis of their effects on species, communities and ecosystems. Ecology letters, 14(7), 702-708.

Wang, P.W. & Jia, J-B. (2012) Tourist's willingness to pay for biodiversity conservation and environment protection, Dalai Lake Protected Area: Implications for the entrance fee and sustainable management. Ocean& Coastal Management, 62:24–DOI: 10.1016/j.oce.

Wassie, A,Dereje, T, Addisalem, A. Abebaw, Z, Bafta, T. &Yitayew, W, (2014) Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2. Bahir Dar.

Whittington. 2012. “Giving Stated Preference Respondents ‘Time to Think’: Results from Four Countries.” Environmental and Resource Economics 51: 473–496.doi:10.1007/s10640-0119508-4.

Wu, PI, Wu, .SK, Yang.SL, (2007). The theoretical interpretation and empirical examination of discrete type of contingent valuation data: some implication for the benefits measurement of outdoor recreational studies in Taiwan. Journal of Outdoor Recreation Study 20(2): 1–37.

Xu H, Qiang S, Genovesi P, Ding H, Wu J, Meng L, Han Z, Miao J, Hu B, Guo J, Sun H, Huang C,& Lei J,(2012) An inventory of invasive alien species in China, Neo Biota, 15, 1–26.doi: 10.3897/neobiota.15.3575.