AN ECONOMIC VALUATION OF INVASIVE SPECIES

(A CASE STUDY OF WATER HYACINTH IN PHEWA LAKE, POKHARA, NEPAL)

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Submitted By

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LETTER of RECOMMENDATION

This thesis entitled **"AN ECONOMIC VALUATION OF INVASIVE SPECIES, A CASE STUDY OF WATER HYACINTH IN PHEWA LAKE ,POKHARA, NEPAL**" has been prepared by **Mr. Umesh Khatri** under my supervision. I hereby recommend this thesis for examination by the Thesis Committee as a partial fulfilment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS.

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APPROVAL SHEET

We certify that this thesis entitled **"AN ECONOMIC VALUATION OF INVASIVE SPECIES, A CASE STUDY OF WATER HYACINTH IN PHEWA LAKE, POKHARA, NEPAL"** submitted by **Mr. Umesh Khatri** to the Central Department of Economics, Faculty of Humanities and Social Sciences, Tribhuvan University, in partial fulfilment of the requirements for the Degree of MASTER of ARTS in ECONOMICS has been found satisfactory in scope and quality. Therefore, we accepted this thesis as a part of the said degree.

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Umesh Khatri

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LIST OF ABBREVATIONS

BZCFUG =Buffer Zone Community Forest User Group

CBA = Cost Benefit Analysis

CE = Choice Experiment

CVM = Contingent Valuation Method

FAO = Food and Agriculture Organization

FBA =Fhewa Boat Association

FFA = Fhewa Fish Association

IAS = Invasive Alien Species

IDRC =International Development Research Centre

IUCN = International Union for Conservation of Nature and Natural Resources

K = Potassium

N = Nitrogen

NOAA =National Oceanic and Atmospheric Administration

NTB =Nepal Tourism Board

NTS = Nepal Tourism Statistics

NGO = Non Government Organization

P =Phosphorus

POMDP =Partially Observable Markov Decision Process

PH = Hydrogen Ion Concentration

USD = US Dollar

VDC =Village Development Committee

WH = Water Hyacinth

CHAPTER I
INTRODUCTION

1.1Background of the Study

Water Hyacinth (WH), *Eichhornia Crassipes* is originated from the Amazon and has spread very quickly in various continents like Latin America and Caribbean, Africa, Southeast Asia and Pacific where tropical and subtropical climate exist. Weed is growing rapidly where the plant has recently introduced. The extensive growth rate of weed is due to rain water bodies. In addition, the rapid growths of species have been seen in lake since absence of natural enemies (FAO, 1996). Control is possible using several management strategies like chemical, physical, biological etc. though; chemical pesticides should be avoided because of environmental hazards (Baral and Shrestha, 2011).It is observed that water hyacinth invasion can have detrimental impacts at economical as well as ecological level (Moyo et al., 2013).Wherever WH found there is completely a complete lack dissolved oxygen that leads to the deaths of a great number of aquatic lives (Tellez et al., 2008). In Nepal, WH was first reported in 1972 in the western part (Nepalgunj district) of the country before spreading eastward (Tiwari et al., 2005).

It seems that WH decreases the potential tourism revenues. Boating activities also decreases and swimming becomes more hazardous. People may get easily malaria with increasing WH. Moreover, hydropower generation activities are obstructed to clear the WH time to time. As a result power interruptions and financial losses may occur (Mbendo et al., 1988). The different bioclimatic zones of Nepal favour the introduction of several alien species. Nepal has a long list of alien species introduced for various purposes e.g. cereals (maize), vegetables (potato, tomato, sweet potato), fruits (papaya, guava) and ornamentals (marigold, mirabilis, bougainvillea). These species are cultivated. They never out competes native species and hence, their control is manageable (Potato, tomato, maize, etc.) and pose little or no threat to biodiversity, natural ecosystem or economy (Tiwari et al., 2005).

Regarding the benefit of WH, (Godfredo et al.,1980) has stated in their book that "Nearly every natural thing has some value, and suggests that we should find ways of

using the water hyacinth, rather than trying to destroy it." Numerous studies have revealed that this exotic has some positive advantage. It is used to make furniture for our home and offices, mushroom farming, wastewater treatment and nutritious food for cattle. Production of biogas and organic fertilizer is also possible but the small amount of available WH is not enough for the economical operation gas generating plant. Therefore higher quantity of production is required with higher cost to set up plants to operate at initial stage.

MIcontosh et al., (2010) revealed that trade and trade routes amongst regions are known to be a primary vector in the spread of invasive species. As we all know that the Nepal rains source is Bay of Bengal. This may be a major route of entering many invasive species in Nepal. It is assumed that, WH might get habitant in Phewa Lake one of the tourist destinations that lie in Pokhara, when pilgrimage pouring a holy water of Ganga, food feeding to fish, offering a flower to the Tal Barahi Temple. In addition, water that is flowing from canals for irrigation purpose and others lake boat using without sterilization in Phewa. We can claim that swiftly growing WH has long term impact on tourism, the daily livelihood of people those are concerned with lake and business of Pokhara. So it is necessary to apply some controlling as well as eradication step for already existing aquatic invasive plants.

1.2 Statement of the Problem

Water hyacinth has become a growing problem across Africa, the Middle East and Asia. Infestations of this weed are reaching crisis proportions in important freshwater bodies of the region. This is causing environmental, economic, and social problems and accumulated damage that can easily be valued in the order of billions of dollars. It directly affects not only the riparian communities but also all those people who in one way or another depend on environmental services or production of the affected water bodies. Therefore, this added constraint on development (IDRC, 2000).

Despite the significant growth of research on invasive species in the world, there are considerable gaps in research that is concerned with invasive species valuation in a region like Nepal. Although, some published research is based on perennial invasive valuation. In Nepalese case, no any research study has been done on aquatic invasive

plant valuation. Therefore this research tries to answer the following research questions.

i. How much people are ready to pay to prevent or eradicate the aquatic invasive species like WH?
ii. Is there any relationship exist between willingness to pay (WTP) for the control of WH in study area?
iii. Is there any relationship exist between price paid and the environmental goods?

1.3 Objectives of the Research

The general objective of this research is to determine the WTP for the WH of Lake Phewa. The specific objective are

i. To estimate the relationship between WTP for the control of WH in the study area.
ii. To derive a demand curve of environmental goods that is WH.

1.4 Significance of the Study

According to the article published in Himalayan times on 28th august, 2010 Local people said that aquatic alien was colonized in a lake since a decade ago. Phewa environment development committee, Phewa fish entrepreneurs committee and Phewa boat entrepreneurs have worked to clean the Phewa Lake with financial help from the tourism board of Nepal but the activities are in vain. It seems that tourism board of Nepal spent some portion of budget for clearing the WH.

As we know that Nepal has many lakes in tourism destinations which generate the income and revenue to both local people and government but invasive species are hampering the economic generating activities thus this research is helpful for policy makers and government of Nepal to make adequate policy to manage invasive species. Additionally, economic valuation of aquatic invasive plant has not done yet about a wetland of Nepal. Therefore, this study may be helpful in upcoming generation and concerned researcher.

1.5 Limitation of the Study

All the research work has its own limitation and purpose: no study can make beyond the limitation. So, in this study

(i) Institutional household is not covered in our study and

(ii) Evaluation of total social benefit is left.

1.6 Organization of the Study

This study will be divided into five chapters. The first chapter will introduce the subject matter of the study. It will describe the statement of problems, objectives, significance of study and limitations of the study. The second chapter will show review of the literature on economics of invasive species, aquatic species and economic loss and contingent valuation method.

The third chapter will be related to the research methodology. It provides a theoretical framework; define the method to attain the objectives and the nature, types of variables. The fourth chapter will provide detailed analysis and result. Chapter five will be concentrated on summary of finding, recommendation and conclusions.

CHAPTER II
LITERATRUE REVIEW

Since a long decade invasive species are discussed in many forums. Therefore, several research papers, surveys, articles and books on invasive species and its impact on agriculture, environment, society and ecosystem at international, regional and even local levels are available. At existed papers different conclusions had been drawn by researchers about the impact of invasive species on agriculture, environment, human life etc at location wise. This study has particularly focus on calculation of willingness to pay for the control of water hyacinth in Lake Phewa. Therefore, this chapter reviews the literature related to economics of invasive species on the first section. Similarly, the second section deals with aquatic invasive species and economic loss and final section deals with economic valuation of invasive species.

2.1 Literature Related to Economics of Invasive Species

Pimentel *et al,* (2001) calculated the damage cause by over 1, 20,000 non native species of plants, animals and microbes in the developed country: United States, United Kingdom and Australia and underdeveloped country: South Africa, India and Brazil especially on agriculture, forestry and ecology. The approach applied in this investigation is to assemble all the published data on available invasive species in the US, UK, Australia, South Africa, India, and Brazil regarding number of species, environmental losses, control-cost and economic impacts of invasive species on crops, pastures, forests, public and livestock health, and natural ecosystem. Hence, it is recorded that exotic species invasion damage in six nations is around US$ 314 billion per year. This method is not as strong as our study however secondary data collection method is usble in our study as well.

Sinden *et al,* (2004) performed a study to estimate the economic effect of weeds on agricultural land, national parks, public land and indigenous land for the year 2001-002 in Australia using top down approach. The total estimated cost of impact is ranged from $3554 million to $4532 million due to production losses and expenditure on weed control. This Top down approach is concerned with estimating impact of weeds at industry level rather than at the farm level. In another way, the cost of control and weed impact are not always obtainable to individual weeds. Therefore

estimation is carried out in a top - down approach that is by each agriculture industry, by natural environments, by public lands and by indigenous land. This approach is not found relevant to our study because we are going to estimate impact of single weeds, water hyacinth of Lake Phewa rather than industry of water hyacinth. However, in our observation this study estimated value is unable to capture the impacts of weeds on the output of the natural environment, urban area and any health impact. Moreover estimation is obtained from preferences revealed in the market rather than preferences that are elicited from survey.

Buhle *et al,* (2005) argued that invasive management depends on life history traits of the species, for most of the species. This study analysed the cost-effective control in two- or three-stage matrix population models, using population elasticity analysis. For the two-stage matrix, fecundity and juvenile survival always have identical population elasticity because they affect a single pathway of the life cycle. This analysis is basically based on two stage matrix, where analysis explored relative contributions of reproduction, juvenile survival and adult survival to population growth of invading species which shows at which stage intervention should provide to prevent the population growth. For an invasive species stage wise growth, control by removing adults would likely only be effective if adult survival is naturally high. Control by removing juveniles would be particularly effective when pre-reproductive periods are long. Likewise, this model suggests that intervention in adult survival is optimal except during periods of peak reproduction .If similar analysis is done for three stage life cycles, population elasticity gives similar result of the two-stage case. A current limitation of this analysis is that it does not effectively incorporate the costs of damage due to the invader self. Our analysis is concerned with damage caused by invasive aquatic plants rather than intervening the life cycles of the weeds for control. Consequently, this model is irrelevant in our case.

In our opinion, knowledge regarding organism's proper life cycle and its dynamics, as well as information on the relative costs of controlling at different stage is required for cost-effective decisions about controlling invasive species via elasticity analysis.

Pimentel *et al,* (2005) evaluated control cost and environmental damage cause by approximately 50,000 invasive species like plant group, Mammals group, bird group,

reptiles and amphibian group, mollusk group, fish group, arthropoda, microbes, livestock, diseases, human diseases in United States employing secondary sources of data collection method in which all published data regarding control cost and environmental damage is collected and assembled. Researcher estimated the total monetary loss is $ 120,105 billion per year in USA, which value may be higher if lack of data is available in some of the subgroup and it is found that monetary loss per year value excludes the invasive species impact that is originated in the United States or its periphery. Even the method is weak but it is applicable in our study because some secondary sources data are required to complete the valuation.

Ceddia *et al,* (2009) conducted a research on invasive insect pest management employing an ecological- economic model, based on simple optimal control theory when both professional and hobby farmers co-exist in the landscape. An ecological-economic model conceptually similar to the one developed by Eiswerth and Johnson [Eiswerth, M.E. and Johnson, W.S., 2002. Managing non indigenous invasive species: insights from dynamic analysis. Environmental and Resource Economics 23, 319–342.]. For this study, some addition has been made in this model. Firstly; researchers make explicitly relationship between the invaded state carrying capacity and farmers' planting decisions. Secondly, they add another producer type into the framework and hence account for the existence of both professional and hobby farmers. Thirdly, they provide a theoretical contribution by discussing two alternative types of equilibrium. Then empirical study is carried out in the Finland potato field employing same model and found that obtained outcome is difference between the value of damage caused in Nash and the social optimum at base case stood at 84, 00 Euro per year for 1200 Hector. Extending to whole commercial potato field (30,000 Hector) of Finland, the damage value would be around 2 million Euros per year. Furthermore, when pest controls costs are reduced, the difference between the profits at the Nash and Social optimum exceeds 430,000 Euro per year, which would be over 10 million Euros per year if extended to whole Finland. The result seems that hobby farmer utility is reduced and the benefits achieved through social optimum for professional are always observable. The sample area taken in this study is comparatively low according to population of potato field in Finland. Thus there is a high chance of not true representation of sample statistics to population parameter.

Haight *et al,* (2010) conducted a study applying the partially observable markov decision process (POMDP) for controlling an invasive species with imperfect information about the level of infestation with simple application that involves with three possible states: no infestation, moderate infestation and high infestation and four potentials management choices: no action, only monitoring, treatment alone and both monitoring and treatment jointly. The decision-maker then chooses a management action to minimize expected costs based on beliefs about the level of infestation. Here researchers model the problem of controlling an invasive species as a POMDP in which the decision-maker receives an imperfect signal about the level of infestation. Generally this approach allows us to find optimal management solutions when information about the degree of infestation is imperfect and allows us to address issues of updating beliefs about the state of the infestation and the value of improved information through monitoring. Researcher found in this study that optimal policy involves choosing no action when there is a sufficiently large probability of no infestation, monitoring alone with intermediate probability values and treatment alone when the probability of moderate or high infestation is large.

Hester *et al,* (2012) developed a spatially-explicit simulation model to show the hypothetical invasive species probability of eradication increment and total costs of invasion management reduction in the presence of passive surveillance or active surveillance and pest control agencies. Landscape attributes dispersal, surveillance and control and cost are the key component of model, where landscape is represented as a matrix of cells with dimension (r x c) row and column. Active surveillance is calculated based on the search theory. The total cost depends on the number of reports by the public, cost of treatment and search undertaken by the pest control agencies. Therefore total cost is calculated in terms of present value. For this, all simulations including of 500 Monte Carlo Iteration are applied for each strategy with ten years planning. On a same paper, a genetic algorithm is applied to find the better search strategies in terms of search effort per unit area; search radius and repeat visits for given rates of passive detection to minimize the cost of management of the pest while maximizing the likelihood of eradication. For this, 20 Monte Carlo Simulations for ten years are used. This study suggests that the cost of pest control via public is relatively cheap and a chance of invasion in outside area is high where pest control program is not implemented.

This model is strong in nature but not applicable in our study because this simulation is concerned with cost minimization for control of biological invasion on certain area and follows same as (Cacho et al., 2010) and study is based on hypothetically. Therefore it should be compared with others optimization and empirical study should conduct for the validity of the model.

2.2 Literature Related to Aquatic Invasive Species and Economic Loss

Mara, (1979) did a study in Florida`s hypothetical lake as an application of dynamic cost- minimization using linear programming. Basically this model has used to analyse the costs involved in mechanically harvesting hyacinths. The model allows one to investigate costs under different levels or hyacinth infestation, different levels or control, and with different types of harvesting equipment. For this, objective function is set. Here, the objective function is a mathematical statement of mechanical harvesting costs. Harvesting costs are part of control costs and have variable and fixed components. The constraints for the model are of three types: biological, harvesting, and non- negativity. Under this two situation, the report states that the annual minimum cost of controlling of water hyacinth through machine per acre is 33.75$ and further for a 400 acre lake, the annual costs of controlling is estimated around 13,500$. Additionally, 1.54$ is estimated to control per ton water hyacinth. In our view, the mechanical cost of controlling in future will be increased as the geometric growth occurs and size of the water bodies increases. This method is mathematically found strong but while performing maximization and minimization of issues like cost and profits etc difficult to insert slack variables.

Groote *et al* , (2003) did a study in the Southern Benin in 1999 taking 192 households' as a sample from 24 villages households where both man and women as a household owner are participated in the survey employing participatory and quantitative method after implementation of biological control program for water hyacinth between 1991 and 1993. The sample is withdrawn using simple random sampling method from population. For an information collection purpose both open ended and closed ended questionnaire are implemented then estimation has done using statistical analysis method. Researchers has estimated that the annual economic loss due to water hyacinth at the peak of infestation is 2151$ per household.

Extrapolating to 39,000 household in the region, the economic loss due to water hyacinth is estimated at 83.9$ million. For this studies analysis, simple descriptive statistics has used and among a huge population only 192 samples has taken thus the strength of the study seems weak because of less chances of representation to the realistic population parameters from sample statistics. Moreover, descriptive statistic analysis concept is useful in our case as well before conducting inferential statistic.

Opande *et al,* (2004) carried out a study to know the socio – economic effects of WH carpets in Winam Gulf bay and beaches of Kenya near to Lake Victory. In order to understand the way water hyacinth carpets that blocked a beach or a bay affected a lakeshore community, face to face interviews are conducted using open ended questionnaire at Dunga, Kusa, Kobala. Nyakwere, Kendu bay, Homa bay, Son bay. Lua add-kottieno and Luanda-nyamasaria. These surveys are conducted in selected beaches between June 1995 and November 1999. Interviews conducted on selected beaches/bays indicate that weed carpets impacted both positively and negatively. The positive aspects of WH are useful to make furniture and others product for home use in some of beaches. With the same token, researcher found that aquatic weeds created major economic losses, diseases, transport problems and interference to irrigation and water treatment plants to the communities. Additionally, they recommended that economic losses should be quantified in study site. Ultimately, face to face interview is applicable in our study because impact scenarios would not be clear without doing such in our case.

Tiwari *et al,* (2005) conducted a study to enumerate the invasive alien plant species in Nepal and undertake an assessment of risk possesses by them in different ecosystem of Nepal. The study covers forests, fallow land, cropland and wetlands distributed in 16 districts spread to east to west of Nepal representing tropical, subtropical and temperate regions. To fulfil the study, some technical field works, participatory tools and techniques, expert consultation, secondary as well as primary data collection method are adopted and a modified "invasiveness rank form" developed by Virginia Department of Conservation and Recreation Division of Natural Heritage in June 2001 has used for assessment purpose in which invasiveness is categorized into four ranks, (high, medium, low and insignificant). Here used

methodology seems simple and flexible .Among all techniques primary and secondary data collection method is relevant in our study.

Some literature review, experts' consultation and field visit has identified that total number of IAS (Invasive Alien Species) is 21 for this particular study. Among them 6 is categorized into high risk posed invasive alien species. Similarly, others 3 are kept in medium risk posed invasive alien species group. Finally, 11 others are kept in low risk posed invasive alien species especially into four ranks based on four criteria impact, biological characteristics, distribution and difficulty of control.

According to the field survey, WH is invaded in paddy field of Rupandehi- Tamnagar cropland site. Its density, frequency and coverage in agriculture land are unrecorded. Likewise, the survey depicts that WH invasion is found in Ghodaghodi lake complex (a Ramsar Site) of Kanchanpur- Shreepur wetland site. Similarly, Jagadishpur reservoir (a Ramsar Site) in Kapilvastu district, wetlands of Rupandhi district, the Beeshazari tal of Chitwan district (another Ramsar Site),the wetlands of Koshi Tappu wildlife reserve (the Nepal`s first Ramsar Site) and the wetlands of Kathmandu and Pokhara valley is also dominated by WH. The survey shows that WH density is 0.84. Its frequency is 83.33% and coverage is 10.42% in wetlands ecosystem of Nepal. In addition, WH invasion is not seen in forests and fallow land ecosystem. Among a three category of risk posed, WH also lies in high risk posed invasive alien species group because of its high intensity of impact, high distribution, high biological characteristics ,high difficulties of control and high rank of invasiveness. Therefore its cost of control and impact should be quantified in whole Nepal. Moreover for our study, this study makes us confirm that WH is found in Pokhara valley and it is highly invasive in nature and one of the vital problems of Pokhara valley. Finally, it concludes with that the already existence plan and policy regarding biodiversity, wetlands etc should revise time to time.

Kafle *et al,* (2009) carried out an experiment on making compost from invasive WH in Begnas and Rupa lake areas of pokhara. Compost is prepared using heap/pile method. For this experiment, 1.2 meter wide and 2 meter long heap are prepared. The additional things used for making compost in these methods are: Black colour plastic sheet, Black Plastic Drum, small wooden stick and some stones to press the covered

plastic sheet. The compost is tested in lab. The laboratory results show that the prepared compost has 8.4 PH value along with nitrogen (N) 1.78 per cent, phosphorous (P) 0.93 per cent and potassium 0.75 per cent. Both nitrogen and phosphorous are comparatively higher than common compost but Potassium is low. Despite this, compost obtained from water hyacinth is usable in agriculture for the crop production because it has good combination of PH, N, K, and P. However, the used methodology is unsound because method explains only how to prepare the compost and thereafter tested in a lab so that for our case it is not applicable. In our view, firstly cost benefit analysis should conduct to run a huge project of compost making from WH in Begnas and Rupa Lake.

2.3 Literature Related to Contingent Valuation Methodology

"Contingent valuation method (CVM) is probably the most commonly used stated preference technique in environmental economics. This method constructs a market for an environmental good and elicits the economic welfare change associated with the change in the environmental good or service. It is commonly structured as a hypothetical referendum in which respondents vote on accepting an environmental improvement (or not) in exchange for an increase in tax payments (or no increase)." (See Grafton et al., 2004)

Contingent valuation has found evolve significantly since the 1970s. CVM has been rigorously tested on a number of different dimensions and substantial improvements in the protocols and methods have been developed. The current standards for a contingent valuation task are outlined in the National Oceanic and Atmospheric Administration (NOAA) Panel's recommendations (Arrow et al., 1993). These are summarized in table 2.1. There is some debate about specific elements in the NOAA recommendations, but in general they provide sound guidelines on the collection of values.

Table 2.1 NOAA Panel Recommendations: a Selected Shortlist

1.Use unbiased/probability sampling	2. Minimize non-response
3. Employ personal interviews	4. Pre-test for interviewer effects
5. Pre-test the CVM question	6. Employ a conservative design
7.Use a willingness to pay format	8. Use a referendum format
9. Remind respondents of substitutes	10. Pre-test the photographs/description.
11. Allow for adequate time lapse from the incident.	12. Average responses from several time periods.
13. Include a no-answer (don't know) option.	14. Include checks on the respondent's understanding.
15. Include debriefing questions	16. Present simple cross tabulations
17. Reduce the warm glow effect	18. Burden of proof on survey designers
19. Report: the sampling scheme, non-response rates, item non-response rates, the actual questions	20. Remind respondents of alternative expenditure possibilities

Source: Arrow et al, 1993

Especially in the case of environmental goods and services valuation, market data is not easily available because of non existence of market. Thus, non market valuation method is implemented while valuing goods and services. There are two categories of non market valuation method. First is revealed preference method. Since a long time economists are using two of the most popular revealed preference methods are: hedonic price technique and travel cost technique where they are using proxy concept taking the characteristics of environmental goods and recreational costs simultaneously to estimate actual use value. For our study both revealed preference technique is not useful because here we are monetizing the WH of lake. Next category is stated preference where directly WTP is asked through survey using CVM.

García-Llorente *et al,* (2011) has also stated that stated preference method as a viable tool for exploring social preferences and gauging public support related to invasive plant species management .Particularly, CVM is applied to estimate non use value or passive value or existence value of environment goods and services for hoping to use by present people and future generation. Our theoretical framework also deals with future time period to estimate the passive value. Therefore we use

CVM survey in our study. Several researchers have also employed CVM method; the most widely used stated preference method, to estimate the value of controlling invasive species (Nunes et al. 2004; Mcintosh et al., 2007, García-Llorente et al., 2011).Some of the national and international empirical studies using contingent valuation method is reviewed and documented as follows.

Law, (2007) studied the willingness to pay (WTP) and cost benefit analysis for the control of water hyacinth in an urban environment of South Africa of Nahoon River, East London. Firstly, pilot study is conducted on a bank of vaal river to pre-test the questionnaire for CVM. Pilot study has undertaken during the period 15 – 19 May 2006. Two researchers have gone from 'door to door' to homes situated within 500m of the river (homes on the river side of Bree Street and Loop Street). 40 samples are taken randomly within a range and estimated annual average WTP is R 123.96. Here, multiple log linear regression models are run. The people are against the payment of vehicle in pilot study. So that questionnaire has updated with new payment of vehicle method for future study.

Improved open ended questionnaire with WH picture is used to know the WTP where questionnaires are divided into three sections. First section explains the knowledge about the WH, second section covers wtp questionnaire where payment card has used with value ranging from R0 to R50 and last section covers socio- economic related questions. Near to the Nahoon River eight streets are randomly selected for survey. Four streets are covered in first phase and another four streets are covered in second phase with same questionnaires. The first phase of the study has undertaken over the period of 7 - 10 September 2006 and the second phase of the study is conducted over the period 11 - 14 February 2007. In a survey, all together 132 respondents have responded among 160 issued. Both two phases has used CVM to capture valuation and reported that annual average WTP in first phase is R213.12 and in second phase accounted is R251.76. Furthermore, the herbicidal control and integrated control are used practise in Nahoon River. Some costs are forgone to control WH in river. Therefore benefit cost ratio found is 4.2:1 and 5.8:1 simultaneously. Moreover, this study does not estimate the demand curve because of single scenario questions however sample selection process of pilot study and CVM technique is applicable in our valuation study.

A study is conducted by **García-Llorente *et al,* (2011)** about the social factors influencing willingness to pay for invasive alien species management under two different regimes: eradication and prevention in the Don˜ana Natural Protected Area (SW Spain). Here, Sample population is represented by residents, visitors, researchers, and individuals who has involved in public policy and provides opinions regarding the economics of IAS management. The sample is collected among the sample population using random sampling method. The open ended questionnaires with two section: first section covers demographic information and second section covers valuation questions are used to conduct face to face interview and some questionnaires are sent from email as well at 19 sample points in Don˜ana, including visitor centers, villages, recreational areas, beaches, and agricultural fields and in the Department of the Environment of the Andalusian Government located in Seville, Spain for data collection. The Data is collected between June 2006 and September 2007. Altogether , 472 respondents are completed the questionnaire based on contingent valuation approach (CVM) which shows that mean willingness to pay for invasive alien species management under the eradication is 44.55 € , prevention regime gets 28.81 € only and while pooling both eradication and prevention gets 36.32 € .The study, however, seems that prevention gets lower support comparing to eradication. This studies CVM, face to face interview method, sampling process,survey design ie. Open ended questions formation is applicable in our case because we are also going to calculate the willingness to pay for invasive species control in our case as these did with two scenarios.

Rai et al, (2012) conducted a study to estimate the non-market benefits of the mitigation of Mikania Micrantha in the buffer zone of Chitwan National Park, Nepal. In order to fulfill the study, choice experiment (CE) with personal interviews are conducted in five buffer zone community forest user groups (BZCFUGs) ,of the total (325) heads of households interviewed, among a total of 21 forestry user committees and one sub-committee, i.e. approximately 44,918 households. Here, the Choice Experiment (CE) method ,one of the stated preference technique, is based on a questionnaire survey where respondents are presented with a number of alternative policy options and asked to select a set of options within a choice set assuming that respondents will prefer the best alternative that provides them with the highest utility,

subject to resource constraints and choices made in CE are analyzed based on the random utility model where indirect utility function is made for estimation on a ground of socio- economic variables and alternative specific constant.

This choice experiment allows estimating the social benefits of a Mikania management program in Chitwan national park. This study estimates that households in the buffer zone area of Chitwan National Park are willing to make an annual payment of NRs. 2,382 (USD 30.5) for a management program since implementing a Mikania management program for about 5 years. Therefore, annual household benefits are re-calculated in present value terms. Then found that per household benefits from a five-year management program are in the range of NRs. 10,450 (US$ 134) to NRs. 11,236 (US$ 144). If aggregating these benefits over the entire buffer zone community (approximately 44,918 households), the net present value of benefits are in the range of NRs. 168.98 million (US$ 2.16 million) to NRs. 500 million (USD6.41 million). This study is different than ours, because choice card has used for this experiment to capture a stated preference but in our case through CVM, Directly WTP is asked to capture the stated preference.

2.4 Summary of Literature Review

The summary of the literature review cover is presented in table 2.2.

Table2.2 Summary of Literature Review Conducted in this Study

SN	Study	Methodology	Remarks
1	Pimentel et al., (2001)	Secondary data collection method	Secondary data collection method is applicable in our study.
2	Sinden et al., (2004)	Top Down approach	Not applicable in our study
3	Buhle et al., (2005)	Population elasticity analysis	Not applicable anything of this study for us.
4	Pimentel et al., (2005)	Secondary data collection method	This data collection method is applicable in our study.
5	Ceddia et al., (2009	Ecological Economic model	Nothing is applicable in our study
6	Haight et al., (2010)	Partially observable markov decision process (POMDP)	Not applicable
7	Hester et al., (2012)	Spatially-explicit simulation model	Not Applicable for our study.
8	Mara (1979)	Linear Programming	Not applicable

		Method	
9	Groote et al., (2003)	Participatory and quantitative method	Useful descriptive statistics concept for estimation
10	Opande et al., (2004)	Face to face interview method	Face to face interview method is applicable in our study.
11	Tiwari et al., (2005)	some technical field works, participatory tools and techniques, expert consultation, secondary as well as primary data collection method, invasiveness rank form	Secondary as well as primary data collection method is applicable.
12	Kafle et al.,(2009)	Heap/file method for compost formation	Not applicable
13	Law (2007)	CVM/Cost Benefit Analysis(CBA)	Sample selection process, CVM is applicable.
14	García-Llorente et al., (2011)	CVM	CVM, face to face interview method, survey design, sampling process are useful in our case.
15	Rai et al., (2012)	CE	Not applicable

Source: Created by Author,2014

Based on the literature review, the present study differs from the previous studies in several respects. Firstly, existing studies on valuing the damage caused by WH in Lake Phewa is limited by impact scenarios issues, demand curve formation issue and WTP relationship with others variable though methodology issue is similar to (Law, 2007, García-Llorente et al., 2011) where study tries to capture three scenarios of invasive water weeds impact because changes in environmental quality related to invasive species will occur over time so obtained data has cross section in nature. Therefore analysis and result also differs from previous studies. Finally, as a theoretical frame work the concept of life time utility with budget constraint in a dynamic model has used in this study that is itself differs on previous study in the form of model and theory.

CHAPTER III

RESEARCH METHODOLOGY

A systematic research study needs to follow a proper methodology to achieve the predetermined objectives. The following method has carried out to fulfil the objectives of this study.

3.1 Theoretical Framework

Following to both Shogren et al., (2006) and McIntosh et al., (2007,) person's life time utility can be written as

$$U = \int_0^{\tau} \bar{U}^0 e^{-\rho t} dt + \int_{\tau}^{T} \bar{U}^1 \left[c(t) - \alpha D\left[x(t) + \tilde{x}(t)\right], Q^1\right] e^{-\rho t}\, dt \ldots\ldots\ldots\ldots (1)$$

Where,

U =Fixed level of utility

$\bar{U}^0$ =Constant utility at good state

$\bar{U}^1$ =Utility in the bad state

p= Rate of time preference

c =Consumption in period t

D = Damage function

τ =Invasion time

T =Time of death

α=Proportion of damage faced by the person

$\tilde{x}$ =All contributions to invasion control by other parties

x =Monetary contributions to invasion control

Q^1 =Environmental quality in bad state

Let us assume that person is endowed with wealth (W). Therefore, simplified budget constraint is expressed as

$$W = \left[\frac{c(0)}{r}\right] * (1 - e^{-r\tau}) + \int_{\tau}^{T} [c(t) + x(t)]\, e^{-rt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

r =Interest rate, *c (t)* = Consumption choices, *x(t)*= Contribution toward lowering market damage.

The Lagrangian expression for a person's problem of maximizing utility over good and bad states subject to a budget constraint is:

$$\underset{c,x}{L} = \int_{\tau}^{T} [\bar{U}^1(c(t) - \alpha D\,(x(t) + \tilde{x}(t), Q^1) - \bar{U}^0]\, e^{-\rho t}\, dt$$
$$+ \lambda \left[W - \left[\frac{c(0)}{r}\right] * (1 - e^{-r\tau}) - \left[\int_{\tau}^{T} [c(t) + x(t)]\, e^{-rt}\, dt \right] \right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Differentiating equation 3 with respect to consumption and control expenditures and letting $M^1 = c(t) - \alpha D\left(x(t) + \tilde{x}(t)\right)$ and $\hat{X} = x + \tilde{x}$ leads to following first order condition:

$c(t): \bar{U}^1_{M^1}[c(t) - \alpha D\left(x(t) + \tilde{x}(t)\right),\ Q^1]e^{-\rho t} + \lambda\left(-e^{-rt}\right) = 0$ for $\tau \leq t \leq T$ ………………………………………………………………………………(4)

$x(t): -\alpha \bar{U}^1_{M^1}[c(t) - \alpha D\left(x(t) + \tilde{x}(t)\right),\ Q^1]D_{\hat{X}}e^{-\rho t} - \lambda e^{-rt} = 0, D_{\hat{X}} \leq 0$ for $\tau \leq t \leq T$ ………………………………………………………………………………(5)

Solving equation 4 and 5 we get λ and is written as

$$\lambda = \frac{U^1_{M^1}(1 - \alpha D_{\hat{X}} e^{-\rho t})}{2e^{-rt}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The WTP is obtained when value of a change in the time of transition from good to bad state τ .Here indirect utility is f (W,τ) (and other parameter held at their original position) and slope of indifference curve (MRS) is

$$-\frac{dW}{d\tau} = \frac{\partial L / \partial \tau}{\partial L / \partial W} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Using envelope theorem in equation 3 to determine the WTP value, V:

$$V = -\frac{dW}{d\tau} = \frac{\partial L / \partial \tau}{\partial L / \partial W}$$
$$= \frac{-[U^1(c(\tau) - \alpha D\,(x(\tau) + \tilde{x}(\tau), Q^1) - \bar{U}^0]e^{-\rho t} + \lambda[(-c(0) + c(\tau) + x(\tau))e^{-r\tau}]}{\lambda}$$

Allowing c(0)=c(τ), keeping c and x at their optimum level (provided by equations 4 and 5)and employing dual optimality condition in 6 to simplify allows value at t= τ to determined as follows :

$$V = \frac{[\bar{U}^0 - \bar{U}^1(c(\tau) - \alpha D\left(x(\tau) + \tilde{x}(\tau)\right), Q^1]e^{-rt}}{\left[\bar{U}^1_{M^1}(c(\tau) - \alpha D\left(x(\tau) + \tilde{x}(\tau)\right), Q^1 * (1 - \alpha D_{\hat{X}})\right]/2} + x(\tau)\, e^{-r\tau} \ldots\ldots\ldots\ldots (8)$$

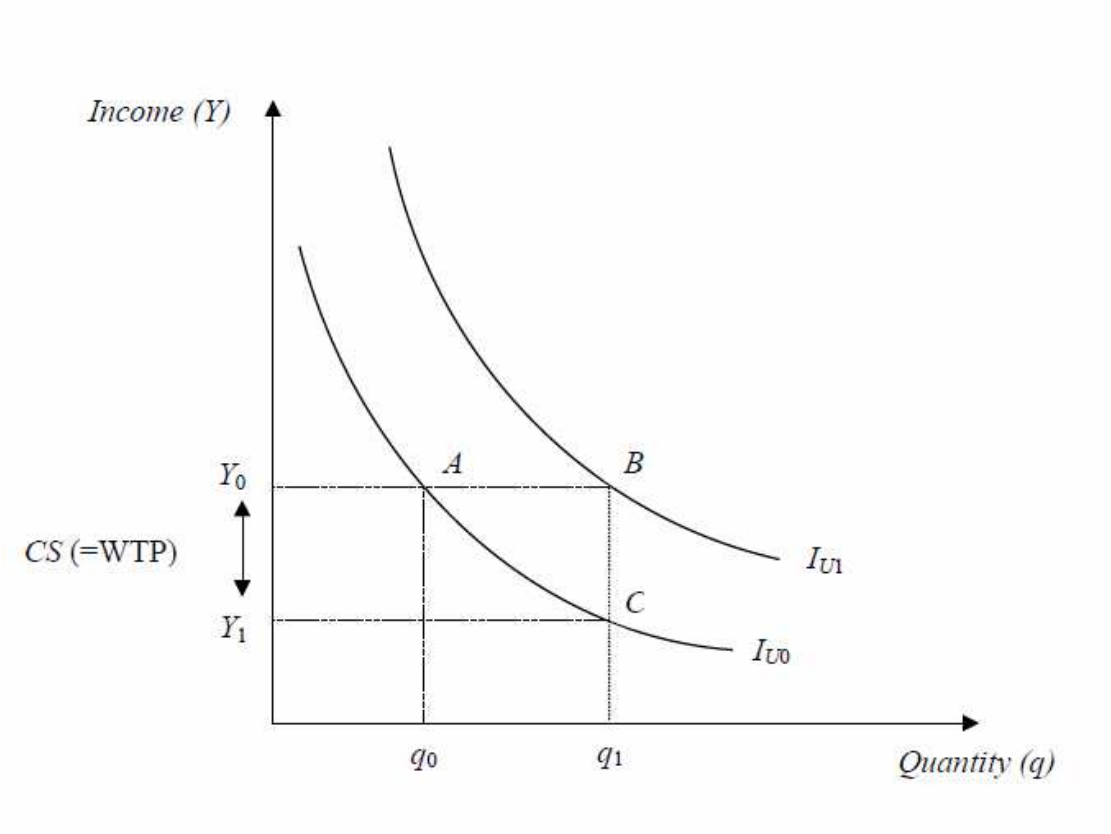
We assume that $\bar{U}^0 > \bar{U}^1$ and $D_{\hat{X}} < 0$, V is always positive and equal to the difference in utility from bad state to good state

3.2 Willingness to Pay Theory

Environmental goods and services provide benefits to humans in much the same way as market goods. However, because of the public goods nature of environmental goods many do not have markets and thus prices do not exist. Thereby, the value of environmental goods is difficult to measure. Theoretical concepts of economic welfare used to evaluate the value of environmental goods include consumer surplus, compensating and equivalent variation, and compensating and equivalent surplus. Compensating surplus, which is a special case of compensating variation, is more appropriate for stated preference methods, as used in the present study because the response elicited in the present survey is one in which utility is assumed held constant given a change in income and the good being valued is a case of "restricted demand'(Kolstad 2011).

Compensating surplus can be defined as the monetary compensation (positive or negative) needed in order to return and individual to his original level of wellbeing (or. "Utility" in economics jargon) after the quantity change occurs. Figure 3.1 shows compensating surplus graphically where *Y* on the vertical axis represents income, or equivalently, consumption of all other market goods and *q* on the horizontal axis represents quantity of the environmental good. Suppose a person has income *Y*0 and the current quantity of the environmental good is *qo.* This person is then at point *A* and has a utility of *U0.* Then there is an increase in the quantity of the environmental good *q* from *qo* to *q1*. This change moves consumption from Point *A* to point *B* and raises the person's utility to *U1.* An indifference curve shows the locus of points that give a person the same level of well-being or utility. *Iυ0* is an indifference curve with initial utility of *U0*, and *Iυj* is a new indifference curve with new, higher utility of *U1.* In figure 3.1, compensating surplus is the difference between income levels *Y0* and *Y1* because, if, from consumption point *B*, we take away this amount of income, the person will once again be at his initial utility level, *Uo*, at consumption point *C*. In this case, the compensating surplus represents the individual's maximum willingness to pay (WTP) to obtain the quantity change from *qo* to *q1*.

Figure 3.1: Compensating Surplus



Source: Kolstad, 2011

3.3 Econometric Specification of the Model

CVM studies include often an estimation of the WTP function or valuation function that function depends on income and other socio -economic characteristics of the respondents to the CVM. Therefore,

$$WTP = f(r) \quad \ldots\ldots(1)$$

Where,

WTP= Willingness to Pay

r= Vector of Explanatory variables (Scenarios, Income and socio-economic characteristics)

For this particular project assume WTP function is

$$WTP = f(Z1, Z2, Z3) \quad \ldots\ldots(2)$$

Where,

WTP=Willingness to pay per year

Z1= Scenarios Z2=Income

Z3=other remaining variable

As the f `Z1 >0 then WTP/yr>0, f `Z2 >0 then WTP/yr>0

f `Z3 >0 then WTP/yr>0 or f `Z3 <0 then WTP/yr<0

Writing equation (2) in the econometric model form

$$WTP = \beta 0 + \beta 1Z1m + \beta 2Z2n + \beta 3Z3o + \cdots \ldots \ldots \ldots + e \ldots \ldots \ldots (3)$$

Where,

WTP=Willingness to pay per year

β0= Intercept of the model

β1= Coefficient of Scenarios

β2= Coefficient of Income

β3= Coefficient of other variables

e= Error term

Z1m= Scenarios that run from 1, 2, 3…i. 1 indicates zero to low level of invasion for one year, 2 reveals low to high level of impact for one year and 3 indicates low to high level of invasion for 10 years.

Z2n=Income that run from 1, 2, 3……j. 1 indicates income during zero to low level of invasion for one year, 2 reveals income during low to high level of impact for one year and 3 indicates income during low to high level of invasion for 10 years.

Z3o= other remaining variables that run from 1, 2, 3……k according to scenario wise.

3.3.1 Empirical Econometric Model

The Logit regression model has employed in this study. The econometric model is as follows

$$WTP = \alpha_0 + \alpha_1 Age + \alpha_2 Dep\_Family\_Member + \alpha_3 No\_of\_Visit + \alpha_4 Expenditure + \alpha_5 Assiatance + \alpha_6 Cost\_Loss\_in\_Rs + \alpha_7 DelX + \alpha_8 DelY + e$$

....(4)

Where,

WTP= Willingness to pay

α_0=Intercept of the model

α_1=Coefficient of age of respondent

α_2=Coefficient of number of dependent family member

α_3=Coefficient of number of times household member visiting lake

α_4=Coefficient of Expenditure

α_5= Coefficient of Assistance

α_6=Coefficient of Cost loss

α_7=Coefficient of difference of WTP from low impact to clear of WH for one year

α_8= Coefficient of difference of WTP from low impact for 10 year to low impact for one year

Age = Age of the respondent

Dep_Family _Member=Number of dependent family member

No_ of_Visit=Number of times household member visit in lake

Expenditure=Expenditure made by household

Assistance=Money got by household in the form of subsidy

Cost_Loss= Cost loss by the household

DelX=Difference of WTP from low impact for one year to clear of WH for one year

DelY=Difference of WTP from low impact for 10 year to low impact for one year

e= Error term

3.4 Rationalisation for Selecting the Study Area

The stud has carried out in surrounding of Phewa Tal which description is as follows. Phewa Tal is a freshwater Lake in Nepal located in the south of the Pokhara Valley that includes Pokhara sub municipality ward number 6 and 17 ; parts of Sarangkot VDC ,Pumdi Bhumdi VDC,Kaskikot VDC and Chapakot VDC. The Lake is stream-fed but a dam regulates the water reserve, therefore, the lake is classified as semi-natural freshwater lake. It is the second largest lake in Nepal, the largest in Gandaki Zone followed by Begnas Lake. Phewa Lake is located at an altitude of 742 m from sea level. It covers an area of about 5.23 km2 with an average depth of about 8.6 m with maximum water depth is 24 m. Maximum water capacity of the lake is approximately 43,000,000 cubic metres. The Annapurna range on the north is only about 28 km far from the lake, and the lake is famous for the reflection of mount Machhapuchhre and other mountain peaks of the Annapurna and Dhaulagiri ranges on its surface. The Taal Barahi Temple is situated in the middle of lake an island in the lake. Phewa Lake and water sports is the main tourist attraction of Pokhara city and the north shore of the lake has developed into a tourist place, commonly called Lake-Side, with hotels and restaurants to the tourists. The water from Phewa Lake's outlet is used to generate electricity and irrigation facility to local. The Phewa Power House is located about 1.5 km from the southern part of the Phewa Lake. Some part of the lake is also used as commercial fishing. The rationale of selecting this lake for study is that it has huge biodiversity; the most popular tourist destination of Nepal and (NARC-FRCP, 2004/05) stated that the lake is infested with floating water hyacinth.

Figure 3.2: Map of the Study Site

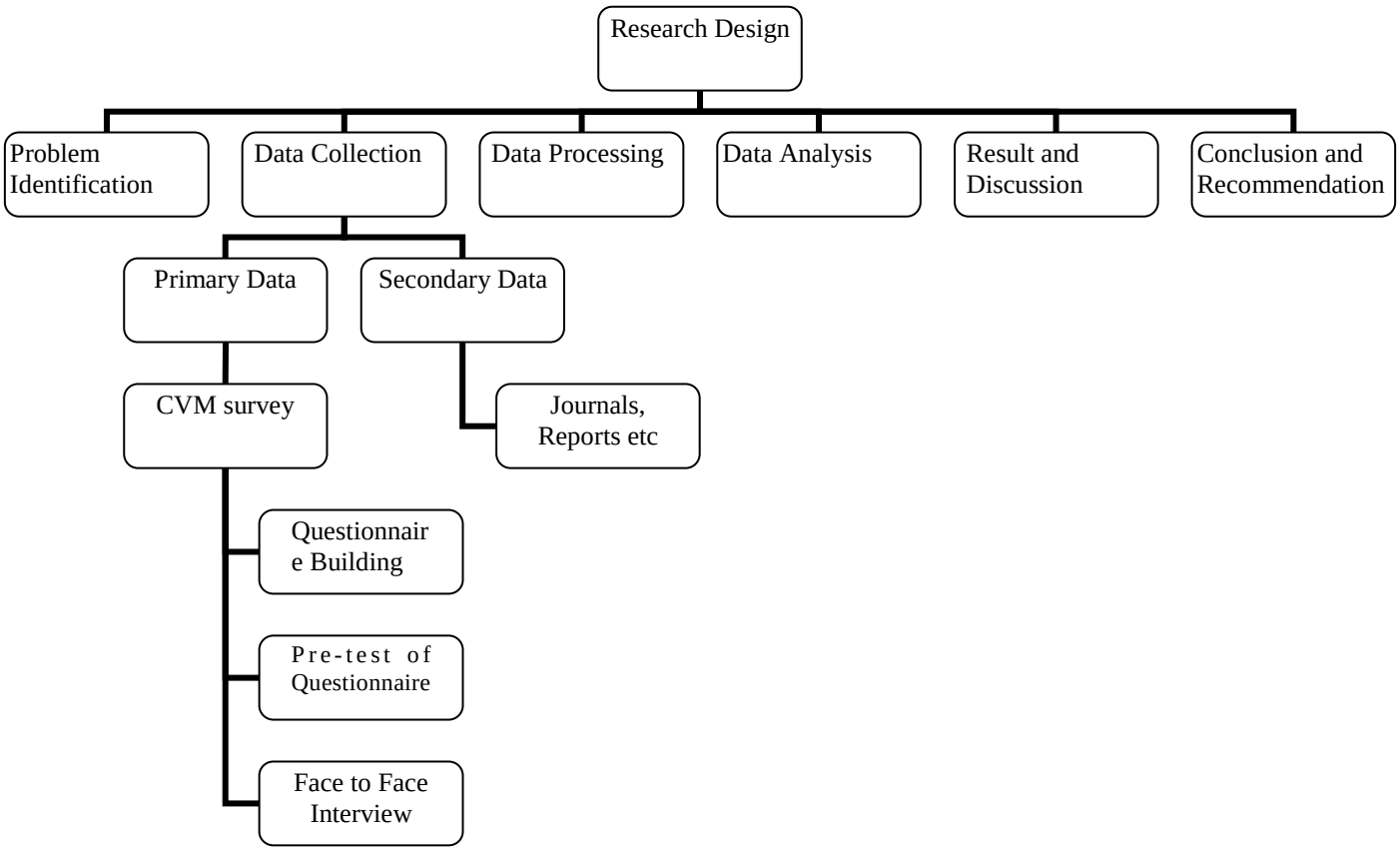
Source: Google Map,2014

About 79,104 external tourists visited in Pokhara in 2012 (MOTCA, 2012). Thus, it is assumed that more number of tourist visit more threat of spreading invasive plants in visited area. Moreover, several Biologists revealed that WH becomes invasive if it has taken to grow in non native place without its enemy plants. Therefore, we can claim that Lake Phewa also colonizes from WH with high intensity because its enemy's plants are not present there.

3.5 Research Design

This research design shows the initiation of research problem with termination of research solution.

Figure 3.3: Research Design of the Study



Source: Created by Author, 2014

3.6 Survey Design

Every primary research is conducted using survey study. For that survey design is created. Generally, survey design shows which questionnaire is elicited to gather main information making different appropriate questions to fulfil the objectives.Our survey is designed to elicit a subject's willingness to pay to control invasive species damages. The survey instrument has three sections: introduction, valuation questions, and closing. The introductory section asks respondents several demographic questions. Respondents are then informed of the definition of lake. After these terms are known, respondents are asked about usage of lake and the activities they took part during their presence near to lake. These questions are included to help participants consider how invasive species protection may be of value, and may be important in explaining the

magnitude of their values. Next, respondents are given information about invasive species. The following definition is provided in the survey:

An invasive species in a lake is water hyacinth only that

- is not native to the waters of the lake- it is a foreign species and
- is likely to harm nature, human health or the economy

Invasive species can get into lakes and rivers by accident and people may bring them by mistake or with some purpose.

The following definition describes how we define Lake in the Pokhara: When a question asks about aquatic invasive species, please think about Phewa Lake WH only by respondent.

We use these definitions to ask respondents questions about their prior knowledge of aquatic invasive species, and their opinions about whether aquatic invasive species will cause harm to nature, human health, or the economy in their region.Finally, the survey provides more specific information about when a lake is considered invaded and the types of impact invasions could cause.

A lake is invaded if it has a non-native species and if that species:

- gets rid of native plants fish, and other water life, or
- is a threat to human health, or
- damages the economy

If a body of water is not invaded, then there is no impact from non-native species. If a lake or river is invaded, the impact can be divided into two levels.

- Low impact: there is little effect from invasive species.
- High impact: there is a major effect from invasive species.

Participants are introduced to the impact types. Table 3.1 show the impact chart created to summarize the different types of impacts that may be expected from aquatic invasive species. There are six impact categories: 1) impact on beauty, 2) impact on nature, 3) impact on health. 4) Economic impact, 5) navigation impact, and 6) recreational impact. The valuation section describes controlling problem. Respondents are informed that Phewa Lake will be invaded, the only question is when. It is described that a prevention technology exists that can control the invasion, and if used it will delay the invasion for the given amount of time from today.

Table 3.1: Probable Impact of WH is Invaded in Lake Phewa

Lake Aesthetics	Risks to Biodiversity Health	Risk to Human Health	Economic Production	Navigation Impact	Recreation Impact
Lake will be full of weeds.	Reduce native plants ,native fish & native animal, depletion of dissolved oxygen, block breeding, nursery& feeding ground of economically important species	Increase mosquitoes & snakes, Swimmer's itch, spread diseases like malaria& pests	Clog irrigation & water treatment intake pipes, reduce electricity generation, tourist flow, commercial fish, filtering of water, agriculture production& municipal water supply	Stick to boat Propellers, clog locks, dams & canals	Stick to fishing line and nets; Reduce sport fish; reduce swimming area, reduce boating activities

Source: Created by Author, 2014

The technology will be paid for using one-time donations from households within the lake area to a "trusted public or private environment organization in your region" to be used only for the protection of lake from invasive species. They are then given three conditions under which to consider their donation (Table 3.2).

Condition 1: Imagine that Phewa Lake has not yet been invaded by non-native species like those in the chart. A method exists that will keep Phewa lake Not Invaded (No impacts) for ONE YEAR. After one year, non-native species will cause LOW impacts for the foreseeable future. If the prevention method is NOT used, Phewa lake will be invaded within a month, causing a low level of impact for the foreseeable future.

Keeping in mind your household's current income, please tell us the maximum Rupees amount that your household would be willing and able to donate, for a one year delay in the impact of non-native species under condition 1.

Table: 3.2 Aquatic Invasive Species Survey Condition1

	Impact Level for One year	Future Impact Level	HH Level Max. Donation to cover One year
Condition 1	None	Low	Rs…….
Comments			

Condition 2: Imagine that Phewa lakes has already been invaded by non-native species like those in the chart A method exists that will keep Phewa lake at LOW impacts for ONE YEAR. After one year, non-native species will then cause HlGH impacts for the foreseeable future. If the prevention method is NOT used, Phewa lake will be further invaded within a month, causing a HlGH level of impact for the foreseeable future.

Keeping in mind your household's current income, please tell us in the maximum Rupees amount that your household would be willing and able to donate, for a one year delay in the impact of non-native species under condition 2.

Table: 3.3 Aquatic Invasive Species Survey Condition 2

	Impact Level for One year	Future Impact Level	HH Level Max. Donation to cover One year
Condition 1	Low	High	Rs…….
Comments			

Finally, suppose that the treatment in condition 2 will last for ten years instead of just one. Voluntary donations would be collected only once, during the first year, by a trusted public or private wildlife organization in your region. The donations would be used only to protect lakes from invasive species.

Condition 3: Imagine that Phewa lake has already been invaded by non-native species like those in the chart. A method exists that will keep lakes at LOW impacts for TEN YEARS. After ten years, non-native species will then cause HIGH impacts for the foreseeable future. If the prevention method is not used, all lakes and rivers in your region will be further invaded within a month, causing a HIGH level of impact for the foreseeable future.

Keeping in mind your household's current income, please tell us the maximum Rupees amount that your household would be willing and able to donate, for a ten year delay in the impact of non-native species under condition 3.

Table: 3.4 Aquatic Invasive Species Survey Condition 3

	Impact Level for Ten year	Future Impact Level	HH Level Max. Donation to cover ten year
Condition 3	Low	High	Rs…….
Comments			

3.6.1 Structure of Questionnaire

Open ended nature questionnaire has used for CVM survey. Questionnaire has kept into five chapters. First chapter describes household and personal related questionnaire. Second chapter is concerned with WH related in Lake Phewa. With a same manner third chapter is related with recreation in Lake Phewa. Fourth chapter is related with opinion regarding impact from WH. Finally, final chapter captures willingness to pay scenarios for aquatic aliens. All together three scenarios questions have kept.

3.6.2. Data collection Tools and Technique

Primary as well as secondary data has collected applying following tools and techniques. Firstly, Primary data has been collected using CVM survey. For this purpose, Open ended questionnaire has made for valuation. The seven questionnaires have pre tested in Lake Phewa in different sample point for WH controlling before employing in whole field survey and required correction in first chapter has made in income code. Finally, tested questionnaire has performed as face to face interview to know the WTP of household and other information telling scenarios to respondents with impact chart table3.1. Literature review and required secondary data has taken from different books, journals, newspaper, research report and internet.

3.6.3 Sampling Procedure

For the sample size determination, there is some mathematical formula and for the sampling process there is probability and non probability sampling techniques are available when total populations are known and total populations are unknown cases. For this study also there is a total population of the study site are known. If we

consider the study from total population concept, impact of WH is concentrated on resident only therefore to capture the impact of WH in heterogeneous sectors probability and non probability sampling technique is dropped. For this study sampling, we are following to (García-Llorente et al., 2011). 13 sample points are determined to capture heterogeneity in this study according to the impact face by respondent. Sample is selected randomly from sample points and total number of sample is further break down as requirement. The sample points with sample break down is shown by table 3.5.

Table: 3.5 Sample Populations with Sample Break Down

Serial no.	Sample Points	Total no. of Sample	Sample Break Down
1.	Tourist centres	8	International tourist-2 Domestic tourist- 5 Guide-1
2.	Canals users group	15	Farmers-7 Rented guys-4 Local users-4
3.	Electricity users group/ dam site point	11	Electricity user household-11
4.	Boating place	15	In front of Tal Barahi Temple boaters-11 Near to fish tail boaters-2 Others place including dam site -2
5.	Shopping points	7	Shopkeepers near to lakesite-7
6.	Vendors	5	Vendors near to lakesite-5
7.	Lake site hotels	5	Small hotel-2 Medium hotel-2 Huge hotel-1
8.	Tal Barahi Temple	5	Praying people -5
9.	Morning walk group	3	Lake site road-3
10.	Fishing point	4	Fishers-4
11.	Swimming place	3	Swimmers -3
12.	Resident	15	Sarankot 2,7 ward -5 Pokhara 7 ward-5 Pokhara 17 ward -5
13.	David falls area	5	Local people-5
Grand total sample		101	

Source: Field Survey,2014

Altogether 115 questionnaires have been approached to the respondent in the sample point. Among them, only 101 respondents faced face to face interview.

3.7 Variables Used in the Study

This research has set some expected sign which plays the major role for research finding. The table below shows the independent variables used in model, its description and expected sign for WTP to control WH in Lake Phewa. The dependent variable takes the value 1 if people are willingness to pay for the control of WH otherwise it is zero.

Table 3.6: Independent Variables with Expected Sign

SN	Variables	Description	Expected Sign
1.	Age	Age of respondent in years	+
2.	Dependent Member	Number of dependent family member those are 0 to 14 and > 60 years old people	_
3.	Number of Visit	Number of times household member visit in lake	+
4.	Expenditure	Expenditure made by household in Rs annually	_
5.	Assistance	Money got by household in the form of subsidy,helpfrom relatives,temple,church,NGO and INGO in Rs	+
6.	Economic loss	Loss due to boat engine damage and enter of WH in field ,have to travel further for recreation purpose etc is measured in Rs	+
7.	DelX	Difference of WTP from low impact for one year to clear of WH for one year in Rs	±
8.	DelY	Difference of WTP from low impact for 10 year to low impact for one year in Rs	±

3.8 Data Analysis, Tool and Technique

Collected data has processed with the help of Microsoft Excel 2007 and STATA 10 has used for analysis and estimation purpose. Summary statistics has deduced from Gretel.

CHAPTER IV
PRESENTATION AND DATA ANALYSIS

The general objective of this research is to determine the willingness to pay for the control of WH of Lake Phewa. Along with these, the specific objective is to examine the relationship between WTP and others variables and derive a demand curve of environmental goods that is water hyacinth. Sections 4.1 and 4.1.1 below fulfils the general objective of this study .With a same manner section 4.2 and 4.3 describes the specific objective.

4.1 Descriptive Statistics of Sample Characteristics

This section describes the variables used in the study and their obtained mean median, minimum value, maximum value and standard deviation.

Table 4.1 Summary Statistics

Variable	Mean	Median	Minimum	Maximum	Std. Dev.
Age	34.93	35.00	17.00	63.00	11.41
Assistance	475.25	0.00	0.00	6000.00	1628.46
Benefit	1.09	1.00	1.00	2.00	0.29
Boating_Swimmimg	3.04	3.00	1.00	5.00	1.39
Cost__loss	1.82	2.00	1.00	2.00	0.38
Cost_loss_in_Rs	4938.42	0.00	0.00	246000.00	30185.00
Economics _College	1.67	2.00	1.00	3.00	0.49
Education	2.64	2.00	1.00	6.00	1.67
Employment	3.49	3.00	1.00	9.00	1.83
Enjoying_nature	4.20	4.00	1.00	5.00	1.02
Env _College	1.78	2.00	1.00	3.00	0.44
Expenditure	324238.0	264000.0	60000.0	1300000.0	199773.0
Fishiing_Hunting	2.24	2.00	1.00	5.00	1.33
Gender	1.16	1.00	1.00	2.00	0.37
Harm_to_Economy	3.96	5.00	1.00	6.00	1.51
Harm_to_Health	3.08	3.00	1.00	6.00	1.39
Harm_to_Lake	4.55	5.00	1.00	6.00	0.94
Income	3.56	3.00	1.00	6.00	1.66
Language	1.08	1.00	1.00	3.00	0.37
Martial_Status	1.29	1.00	1.00	5.00	0.57

Org_Member	1.82	2.00	1.00	3.00	0.43
WTP	0.89	1.00	0.00	1.00	0.31
Picnic	1.82	2.00	1.00	4.00	0.79
Praying	2.96	3.00	1.00	5.00	1.09
TV	1.14	1.00	1.00	3.00	0.37
No_of_Visit	4.41	5.00	1.00	5.00	1.08
WH_G_Knowledge	2.61	3.00	1.00	3.00	0.55
WH_P_Knowledge	2.13	2.00	1.00	3.00	0.81
WH_Notice	1.01	1.00	1.00	2.00	0.10
WH_Problem	1.06	1.00	1.00	2.00	0.24
WTP1	920.51	500.00	0.00	5000.00	1236.06
WTP2	717.38	500.00	0.00	5000.00	877.39
WTP3	1848.17	1000.00	0.00	12000.00	2569.86
Hiking	2.98	3.00	1.00	5.00	1.53
Age_ group	5.24	5.00	3.00	7.00	0.84
Caste	1.46	1.00	1.00	3.00	0.71
DepFamily_Member	1.45	1.00	0.00	5.00	1.20
Indep_Family_Mem	2.77	2.00	1.00	6.00	1.04
Property	1.82	2.00	1.00	2.00	0.38

Source: Field Survey, 2014

According to the table 4.1 for the scenario one that is to clear the WH for one year mean WTP is 920.51 Rs .Similarly, mean WTP is 717.38 Rs for scenario second that is to make the WH low impact for one year in Lake Phewa. Finally, mean WTP for final scenario to keep the lake low impact for ten year is 1848.17Rs in the sample point alone. It concludes that people are ready to pay more for first scenario in comparison to second and third created scenarios.

4.1.1 Income Section Description

People of households in sample points have involved in different major and minor income generating activities for the livelihood. To capture them all together six income group is created which illustration is shown in table 4.2.

Table 4.2 Income at Different Level with its Frequency and Percent

Income	Frequency	Percent
<2,00,000	12	11.88
2 ,00,000 to 3,00,000	18	17.82

3 ,00,000 to 4,00,000	25	24.75
4 ,00,000 to 5,00,000	12	11.88
5,00,000 to 6,00,000	15	14.85
>6,00,000	19	18.81

Source: Field Survey, 2014

According to the Table 4.2 income of the household is divided into six categories where 11.88 percent household earns less than 2 lakh.17.82 percent household earns 2 to 3 lakh. 24.75 percent household income is 3 to 4 lakh. Similarly 11.88 percent household earns 4 to 5 lakh. Last two category covers by 14.85 percent and 18.81 percent household respectively.

Table 4.3 Income at Different Level with its WTP Number of People

Income	WTPno	WTPyes
<2,00,000	2	10
2 ,00,000 to 3,00,000	0	18
3 ,00,000 to 4,00,000	4	21
4 ,00,000 to 5,00,000	1	11
5,00,000 to 6,00,000	1	14
>6,00,000	3	16

Source: Field Survey, 2014

According to table 4.3 among 101 household low income group people and high income group people less in number. Therefore it shows less likely to pay for the control of WH in different scenario. However medium income group people are more in number in the sample and more likely to pay for the control of WH in different created scenario.

4.2 Econometrics Model with Empirical Discussion

As we know that WTP depends on socioeconomic factors, income and others variables. For this particular study WTP acts as the binary dependent variable which takes value one if people are ready to pay and zero otherwise. On other side socioeconomic factors, expenditure the proxy of income and other variables are used

as independent variable. Logit regression model has run and analysis and interpretation is done accordingly. Below the table 4.3 shows logit regression model.

Table 4.4 Results of Logit Regression Model

Dependent Variable WTP	Coefficient
Independent Variable	
Age	0.0232 (0.0400)
Dep_Family _Member	-0.0744 (0.329)
No_ of_Visit	0.746** (0.308)
Expenditure	-2.96e-06* (1.79e-06)
Assistance	-0.000321* (0.000175)
Cost_Loss_Rs	0.000120 (0.000290)
DelX	8.17e-05 (0.000373)
DelY	-0.000353 (0.000292)
Constant	-0.637 (1.995)
Observations	101
Pseudo R2	23.11 Percent

Source: Field Survey. 2014

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

The result from the logit analysis indicates that among various determinant of WTP only expenditure, assistance and number of visit of household member to the lake are significant at 10 percent and 5 percent where number of visit is positively related with WTP and expenditure for household and assistance is negatively related with WTP.

For the variable age, as age of the respondent increases by one year, the odds ratio in favor of WTP for the WH control is increased by 0.0232 rupee and if dependent family member increases by one, the odds ratio in favor of WTP for WH control is decreased by -0.0074 rupee keeping others variable constant.Ceterius Paribus, as cost of loss increases by one rupee the odds ratio in favor of WTP for the WH control is increased by 0.000120 rupees. The difference of WTP from low impact to clear of

WH for one year in Rs is positively related with WTP. Similarly, difference of WTP from low impact for 10 year to low impact for one year in Rs is negatively related with WTP. Moreover the overall model is fit at 23.11 percent.

4.3 Different Elasticity of Econometrics Model

Table 4.4 depicts the different elasticity of econometrics model that is shown below.

Table 4.5 Different Elasticity of Econometrics Model

Dependent Variable WTP	Elasticities (Ey/Ex)
Independent Variable	
Age	.0301575
Dep_Family_ Member	-.0039937
No_ of_Visit	.1220071
Expenditure	-.0354358
Assistance	-.0056594
Cost_Loss	.0220621
DelX	.0006163
DelY	.0148078

Source: Field Survey, 2014

According to table 4.4 on an elasticity section first elasticity of WTP (Ep1) is 0.0006163 and second elasticity of WTP (Ep2) is 0.0148078 is estimated. Both the elasticity points are less than unity. Therefore it concludes that relatively inelastic demand curve can be deduced. Furthermore, this demand curve is negatively sloped demand curve. The reason of being relatively inelastic demand curve is that dominance of NGO and INGO for the control of WH in Lake Phewa and the concept of government should take care about the WH issue.

CHAPTER V
SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

Invasive species is the non native species that is generally found in temperate zone. The WH one of the aquatic exotic species was first noticed in 1972 in Nepalganj district of Nepal. The sources of WH may be trade route, using boat without sterilization, food of fish, pouring the holy water in Lake Phewa etc**.** WH may impact to the tourist, lake, economy of the pokhara valley, health impact etc. So that lots of the economic loss to curb them and income generation loss is bearing. This study is conducted to know the WTP to control the WH in Lake Phewa. Along with that to know the relationship between WTP and different socio–economic variables and derivation of demand curve. In order to achieve this objective CVM has employed using 13 sample points to capture heterogeneity.115 questionnaire approach employing face to face interview but 101 faced face to face interview. Summary statistics, Logit regression model and elasticity approach has used to fulfill the objectives. A brief summary of the findings of the study is as follows.

From the summary statistics, the scenario one that is to clear the WH for one year mean WTP is 920.51 Rs .Similarly, mean WTP is 717.38 Rs for scenario second. Finally, mean WTP for final scenario to keep the lake low impact for ten year is 1848.17Rs in the sample points. This shows that people are ready to pay more for first scenario than second and third created scenarios.For income, among 101 household low income group people and high income group people less in number. Therefore, it depicts less likely to pay for the control of WH in different scenario. However medium income group people are more in number in the sample and more likely to pay for the control of WH.The result from the logit regression indicates that only expenditure, assistance and number of visit of household member to the lake are significant at 10 percent and 5 percent and others all variables are insignificant where number of visit is positively related with WTP, the sign of coefficient of this variable is matched with expected sign of coefficient. Expenditure for household and assistance is negatively related with WTP where sign of the coefficient of expenditure

is exactly matched with expected sign of coefficient of expenditure however assistance has opposite one sign than expected.

For the variable age, age is positively related with WTP where coefficient sign is equalized with coefficient sign of expected one. On a case of dependent family member, dependent family member is negatively related with WTP where sign of coefficient is matched with expected one. Cost of loss is positively related with WTP where both sign is matched each other. The difference of WTP from low impact to clear of WH for one year in Rs is positively related with WTP. Similarly, difference of WTP from low impact for 10 year to low impact for one year in Rs is negatively related with WTP, where obtained coefficient sign is matched with expected coefficient sign. Furthermore, the overall model is fit at 23.11 percent.Finally, on an elasticity part first elasticity of WTP (Ep1) is 0.0006163 and second elasticity of WTP (Ep2) is 0.0148078 is determined. Both the elasticity points are less than unity. Therefore, this demand curve is negatively sloped demand curve.

5.2Conclusion

In Nepal, most of the household in the tourist area are fully dependent on the activities of domestic and international tourist. Tourist activates generate income to the local and they are sources of livelihood. On the other hand, more people visit means more food is brought from one place to another so that invasive species are more chance to transfer there. Phewa Lake WH is also may be reason of such activities in past and it is spreading from western part to eastern part of wetland of Nepal. This study shows that recently the effect of WH in the study area is found in lake only but less likely in other sectors but in the future more economic loss especially on the health issue, economic issues, and agriculture issues and even in aesthetic beauty of lake issues is visible more.In past, some amount of money is incurring to remove WH from Lake with the help of NTB(Nepal Tourism Board), municipality, FBA(Fhewa Boat Association), FFA(Fhewa Fish Association) and some national and international NGO with the manual try. They did to clear WH are in vain. Still complete recovery of lake did not get in natural form. Therefore, there is urgent need to introduce the advance technology to overcome these problems. On the other side, biological control and chemical control is not suggested because these further creates organism damage and hampers in the biodiversity of lake.

5.3 Recommendations

In this study we found that people are relatively like to pay for the control of WH in Lake Phewa. Along with that there are some challenges to control WH in Phewa Lake which are as follows:

- Sewage system of Pokhara valley is compulsorily managed because all sewage has thrown in Lake that helps to grow WH faster getting more nutrients.
- Seeds of WH which can survive till twenty five year may enter in fishing area via grains of fish thus separate place should allocate for fishing to all.
- Check dam in Harpen River and even in other auxiliary rivers should build to stop fertile soil, small stones enter in lake. Fertile soil plays major role to grow WH in lake.
- Replacement of fields of locals around the Lake or discourage to use chemical fertilizer while growing paddy and wheat because chemical fertilizer helps to grow WH faster getting enough nutrients.
- Set up artificial water filtration in Lake Phewa is necessary if water is not filtrated naturally from its slope.
- WH should use in economic benefit providing subsidy for the farmer group to prepare the compost fertilizer.
- NTB was working since a long time doing cooperation with FFA, FBA to remove WH providing two lakhas per year. It shows that WH problem of lake already is in policy of Nepal government even though beautification budget is going in vain because every year same WH problem is repeating especially in summer season.

Therefore it is imperative for policy makers to deal with these challenges if the problem of WH in Lake Phewa is to be seriously addressed.

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ANNEX: I ECONOMETRICS RESULTS

```
Iteration 0:   log likelihood = -34.767454
Iteration 1:   log likelihood = -29.369794
Iteration 2:   log likelihood = -27.119178
Iteration 3:   log likelihood = -26.836764
Iteration 4:   log likelihood = -26.806852
Iteration 5:   log likelihood = -26.768457
Iteration 6:   log likelihood = -26.734759
Iteration 7:   log likelihood = -26.732696
Iteration 8:   log likelihood =  -26.73269

Logistic regression                               Number of obs   =        101
                                                  LR chi2(8)      =      16.07
                                                  Prob > chi2     =     0.0414
Log likelihood =  -26.73269                       Pseudo R2       =     0.2311

------------------------------------------------------------------------------
    payyesno |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         age |   .0232458    .039954     0.58   0.561    -.0550627    .1015542
         dep |  -.0743882   .3292801    -0.23   0.821    -.7197654    .5709889
   visitnngl |   .7455932   .3077506     2.42   0.015     .1424131    1.348773
         exp |  -2.96e-06   1.79e-06    -1.66   0.098    -6.47e-06    5.42e-07
       assit |  -.0003206    .000175    -1.83   0.067    -.0006636    .0000223
costlossinrs |   .0001203     .00029     0.41   0.678     -.000448    .0006886
        delx |   .0000817   .0003729     0.22   0.827    -.0006492    .0008126
        dely |  -.0003526   .0002921    -1.21   0.227    -.0009252     .00022
       _cons |  -.6371186   1.995361    -0.32   0.749    -4.547953    3.273716



Elasticities
      y  = Pr(WTP) (predict)
         =  .96285979
------------------------------------------------------------------------------
variable |      ey/ex    Std. Err.     z    P>|z|  [    95% C.I.   ]
---------+--------------------------------------------------------------------
     age |   .0301575      .07151    0.42   0.673  -.110006  .170321   34.9307
     dep |  -.0039937      .01857   -0.22   0.830  -.040383  .032395   1.44554
visitn~l |   .1220071      .16106    0.76   0.449  -.193668  .437682   4.40594
     exp |  -.0354358      .05153   -0.69   0.492  -.136431  .065559    322099
   assit |  -.0056594       .0083   -0.68   0.495  -.021919  .010601   475.248
costl~rs |   .0220621      .02672    0.83   0.409    -.0303  .074424   4938.42
    delx |   .0006163      .00299    0.21   0.837  -.005246  .006479   203.129
    dely |   .0148078      .02123    0.70   0.486  -.026812  .056428  -1130.79
------------------------------------------------------------------------------
```

ANNEX II QUESTIONNAIRE

AN ECONOMIC VALUATION OF INVASIVE SPECIES

(A CASE STUDY OF WATER HYACINTH IN PHEWA LAKE, POKHARA, NEPAL)

Researcher:
Umesh Khatri
Tribhuvan University,Nepal

Code:
Date of Interview:
Time of Interview:
Name of Respondent:
Sample point:

I am Umesh Khatri , Master Thesis year student of TU is conducting research regarding water hyacinth of lake phewa.This research is the part of my master degree. Therefore, I assure you that the confidentality of the given information willl be maintened and the average result of the questionnaire will be published.

**An invasive species in a lake is water hyacinth only that*

- *is not native to the waters of the lake- it is a foreign species and*
- *is likely to harm nature, human health or the economy*

**Invasive species can get into lake by accident and people may bring them by mistake or with some purpose*

Chapter A: Household & Personal Related

SN	Question	Code	Skip
A1	What is your gender?	Male 1 Female 2	
A2	What is your martial status?	Married 1 Unmarried 2 Widow 3 Divorce 4 Separated 5	
A3	How many birthdays have you celebrated?	Number of years [ ][ ]	
A4	Please tell us how many people are there in your household, in each of the following age groups: *(Write in the number of people for each age group, including yourself in the count)(MA)*	Less than 5 years old 1 5 to 12 years old 2 13 to 17 years old 3 18 to 21 years old 4 22 to 39 years old 5 40 to 59 years old 6 60 to 64 years old 7 65 years or older 8	
A5	Which one of the following categories best describes your household's total income during 2013, before taxes and other deduction? *(Please include all income to the household such as wages, social security, interest, welfare payments, child support, etc. If you're not sure, please give us your best guess. This information is needed for statistical purposes, and will be kept confidential.*	< 2,00,000 1 2,00,000 to 300,000 2 300,000 to 400,000 3 4,00,000to 500,000 4 500,000 to 600,000 5 > 600,000 6	
A6	How do you describe the people in your household?	Bramin/Cheetri/Thakuri 1 Janajati 2 Other Specify……. 3	
A7	What is your home language?	Nepali 1 English 2 Other specify..... 3	
A8	Which of the following describes your own current employment?	Government sector 1 Private sector 2 Own business 3 Self employed 4 Farmer 5 Retired 6 Student 7 Unemployed 8	

		Other specify……. 9	
A9	What is the highest level of education you completed?*(SA)*	Did not complete high school 1 High School diploma 2 Some college or technical school, no degree 3 Degree from a 2 year college or technical school 4 Degree from a 4 year college or university(BA,BBS) 5 Post-graduate or professional degree(Masters, Ph.D, M.D etc) 6	
A10	Have you completed any courses in environment at college or technical school?	Yes 1 No 2 Do not know 3	
A11	Have you completed any courses in economics or business at college or a technical school?	Yes 1 No 2 Do not know 3	
A12	Is anyone in your household a member of any environment related organization or club?	Yes 1 No 2 Do not know 3	 ***A13*** ***A13***
A13	Please name the clubs or organization. ……..		
A14	Is anyone in your household watch an environment or wildlife related program in TV?	Yes 1 No 2 Do not know 3	 ***A15*** ***A15***
A15	Please name the TV program or channel. …….		
A16	In the past 12 months, how many times has anyone in your household visited lake Phewa?	No visit in the past year 1 1 to 2 visit 2 3 to 5 visit 3 6 to 9 visit 4 10 or more visit 5 Do not know 6	
A17	Has anyone in your current household ever owned or rented property along a lake Phewa?	Yes 1 No 2	
A18	How much does your household make expenditure on following heading time in Rs?	Weekly …….. Monthly ……. Annually ……	
A19	Did your household receive any of the following assistance in 2013 in Rs?		

Type	Amount
Government Subsidy	
Help from Relatives	
Help from church ,temple, I/NGO etc	
Help from any other source	
Total	

Chapter B: Water Hyacinth Related in Lake

SN	Question	Code		Skip
B1	Do you notice any water hyacinth in Lake Phewa?	Yes No	1 2	
B2	Do you think that the presence of water hyacinth is problem?	Yes No	1 2	 ***B3***
B3	If yes, why do you think water hyacinth is problem? (a)…… (b)…… (c)……			
B4	Do you think of any benefits that you would receive from clearing of water hyacinth?	Yes No	1 2	
B5	Has water hyacinth cost you or anyone else in your household, any money directly? (e.g. boat engine damage, have to travel further for recreational purposes, less people at guest lodge etc.)	Yes No	1 2	 ***B6,B7***
B6	If yes, Please describe: ……			
B7	Approximately, how much amount was spent? ……			
B8	Before conducted this survey, how much did you already know about water hyacinth, in general?	Almost nothing Some Quite a lot	1 2 3	
B9	How much did you already know about water hyacinth, in particular?	Almost nothing Some Quite a lot	1 2 3	

Chapter C: Recreation in Lake Phewa Related

For this survey, a lake means any standing body of fresh water, this is particularly natural lake

SN	Question	Code		Skip
C1	When anyone in your household goes to a lake, how often do they do fishing or hunting? *(Mark one response in column)(SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	
C2	When anyone in your household goes to a lake, how often do they do boating or swimming? *(Mark one response in column) (SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	
C3	When anyone in your household goes to a lake, how often do they do hiking or do-walking? *(Mark one response in*	Never Rarely Sometimes	1 2 3	

	column) (SA)	Usually Always Do not know	4 5 6	
C4	When anyone in your household goes to a lake, how often do they do picnicking or camping? *(Mark one response in column) (SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	
C5	When anyone in your household goes to a lake, how often do they do enjoying nature? *(Mark one response in column) (SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	
C6	When anyone in your household goes to a lake, how often do they do praying to temple? *(Mark one response in column) (SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	
C7	When anyone in your household goes to a lake, how often do they do other please specify ……? *(Mark one response in column) (SA)*	Never Rarely Sometimes Usually Always Do not know	1 2 3 4 5 6	

Chapter D: Impact of Water hyacinth Opinion Related

When these questions ask please think of Lake Phewa and its surrounding water bodies.

SN	Question	Code		Skip
D1	In your opinion, how likely is it that water hyacinth will cause harm to nature of Phewa Lake? *(Mark one response in each column) (SA)*	Impossible Unlikely Somewhat likely Very likely Certain No opinion	1 2 3 4 5 6	
D2	In your opinion, how likely is it that water hyacinth will cause harm to human health? *(Mark one response in each column) (SA)*	Impossible Unlikely Somewhat likely Very likely Certain No opinion	1 2 3 4 5 6	
D3	In your opinion, how likely is it that water hyacinth will cause harm to the economy? *(Mark one response in each column) (SA)*	Impossible Unlikely Somewhat likely Very likely Certain No opinion	1 2 3 4 5 6	
D4	In your opinion, how likely is it that water hyacinth will cause other harm please specify …….. *(Mark one response in each column) (SA)*	Impossible Unlikely Somewhat likely Very likely Certain No opinion	1 2 3 4 5 6	

Chapter E: Willingness to Pay for the control of Water Hyacinth with Different Condition Related

Many people will not have thought much about invasive species, so please read the following background information

A lake is invaded if it has a non-native species and if that species.……

** gets rid of native plants fish, and other water life, or*

** is a threat to human health, or*

** damages the economy*

If a body of water is not invaded, then there is no impact from non-native species.

If a lake or river is invaded, the impact can be divided into two levels...

Low impact: there is little effect from invasive species.

High impact: there is a major effect from invasive species.

We want to ask some questions about how much your household would be willing to pay to control the impact of invasive species. We are not asking for donations, and will not contact you again. We just need to know how much it would be worth to your household to control invasive species in the lake phewa.

Imagine that eventually lake Phewa will be invaded. The only doubt is when it will happen. Assume a method is available that will control the impact of invasive species in the lake for a limited time.

This method costs money. Imagine that it can only be paid for by using donations from household. These voluntary donations would be collected just once, by trusted public or private environment organization. we ensure you that the donated amount would be used only to protect lake Phewa from invasive species(Water Hyacinth).

Condition 1: Imagine that Phewa lake has not yet been invaded by non-native species like those in the chart. A method exists that will keep phewa lake Not Invaded (No impacts) for ONE YEAR. After one year, non-native species will cause LOW impacts for the foreseeable future. If the prevention method is NOT used, Phewa lake will be invaded within a month, causing a low level of impact for the foreseeable future.	
E1	Keeping in mind your household's current income, please tell us the maximum Rupees amount that your household would be willing and able to donate, for a one year delay in the impact of non-native species under condition 1.*(you can add comment if you wish*

	Impact Level for One year	Future Impact Level	Your Household's Maximum Donation to cover One year
Condition 1.	_____ None	_____ Low	Rs _____
Comments	…….		

Now consider a second condition

Condition *2:* Imagine that Phewa lakes has already been invaded by non-native species like those in the chart A method exists that will keep Phewa lake at LOW impacts for ONE YEAR. After one year, non-native species will then cause HlGH impacts for the foreseeable future. If the prevention method is NOT used, Phewa lake will be further invaded within a month, causing a HlGH level of impact for the foreseeable future.	
E2	Keeping in mind your household's current income, please tell us in the maximum

	Rupees amount that your household would be willing and able to donate, for a one year delay in the impact of non-native species under condition 2.

	Impact Level for One year _____ Low	Future Impact Level _____ High	Your Household's Maximum Donation to cover One year
Condition 2.			Rs _____
Comments	……		

Finally, suppose that the treatment in condition 2 will last for ten years instead of just one. Voluntary donations would be collected only once, during the first year, by a trusted public or private wildlife organization in your region. The donations would be used only to protect lakes from invasive species.

Condition 3: Imagine that Phewa lake has already been invaded by non-native species like those in the chart. A method exists that will keep lakes at LoW impacts for TEN YEARS. After ten years, non-native species will then cause HIGH impacts for the foreseeable future. If the prevention method is not used, all lakes and rivers in your region will be further invaded within a month, causing a HIGH level of impact for the foreseeable future.	
E3	Keeping in mind your household's current income, please tell us the maximum Rupees amount that your household would be willing and able to donate, for a ten year delay in the impact of non-native species under condition 3.

	Impact Level for Ten Years _____ Low	Future Impact Level _____ High	Your Household's Maximum one time donation to cover ten years
Condition 3.			Rs _____
Comments	……		

E4	Suppose that your household is contacted today to donate the amount that you answered for condition 1, in question ***#E1*** above (You will not be contacted for donation, but please imagine that you were). Keeping in mind your household's current income, how likely would you be	Impossible 1 Very Unlikely 2 Somewhat likely 3 Very likely 4 Certain 5	***E5*** ***E5*** ***E5***

	to actually pay that amount		
E5	Why are you not willing to donate for the control of water hyacinth?	Government should pay for this problem 1 I don't use the lake 2 I do not believe the money would be spent on the problem 3 Other (Please specify)…… 4	
E6	According to you how many individual are here like you in your field? (Based on sample point) ……		
E7	Do you have any comment about this survey or invasive species, please tell us. ……		

Thank you for providing your precious time

Impact Chart: Types of Probable Impact that will occur if Water hyacinth is invaded in Lake Phewa

Lake Aesthetics	Risks to Biodiversity Health	Risk to Human Health	Economic Production	Navigation Impact	Recreation Impact
Lake will be full of weeds.	Reduce native plants ,native fish & native animal, depletion of dissolved oxygen , block breeding, nursery& feeding ground of economically important species	Increase mosquitoes & snakes, Swimmer's itch, spread diseases like malaria& pests	Clog irrigation & water treatment intake pipes, reduce electricity generation, tourist flow , commercial fish , filtering of water , agriculture production& municipal water supply	Stick to boat Propellers, clog locks, dams & canals	Stick to fishing line and nets; Reduce sport fish; reduce swimming area, reduce boating activities

Source: Created by Author,2014

ANNEX III SOME PHOTO OF FIELD VISIT



Researcher Filling Contingent Valuation Survey at Different Sample Points


WH of Phewa Lake