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Economic Valuation of Protecting Urban River Water Pollution in Addis Ababa, Ethiopia: A Choice Experiment Approach

By

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Addis Ababa, Ethiopia

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This is to certify that the thesis prepared by Gebretsadik Teshager, entitled: *Economic Valuation of Protecting Urban River Water Pollution in Addis Ababa, Ethiopia: A Choice Experiment Approach* and submitted in partial fulfillments of the requirements for the Degree of Master of Science in Economics (Natural Resource and Environmental Economics) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Economic Valuation of Protecting Urban River Water Pollution in Addis Ababa, Ethiopia: A Choice Experiment Approach

Gebretsadik Teshager

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The objective of the study was to analyze households' willingness to pay for protection of river water pollution that attaches an economic value to the river. The choice experiment technique was employed by means of interviewing 315 respondents. For the protection options, five attributes; river water quality, river water volume, riparian buffer zone, recreational facilities and monetary payments were identified and developed.

Attributes and socioeconomic characteristics were estimated using multinomial logit and random parameter logit models. Based on the best model fit, random parameter logit model with interactions result, respondents are willing to pay on average birr 90.34, 12.89 and 27.87 /respondent/year for additional level and birr 1.48/respondent/year for extra meter for river water quality, river water volume, recreational facilities and riparian buffer zone, respectively. Moreover, it is found that respondents are willing to pay on average birr 607.2, 753.2 and 886.2 /respondent/year for low, medium and high impact improvement scenarios. Priority should be given to the improvement of the water quality, since households attached a higher value for the attribute of river water quality.

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Acronyms

AAEPA	Addis Ababa Environmental Protection Authority
AAWSA	Addis Ababa water and Sewerage Authority
AIC	Akaike Information Criterion
ASC	Alternative Specific Constant
CE	Choice Experiment
CL	Conditional Logit
CV	Contingent Valuation
DCE	Discrete Choice Experiment
ETB	Ethiopian Birr
EU-WFD	European Union-Water Framework Directive
GIS	Geographical Information System
GPS	Global Positioning System
IIA	Independent from Irrelevant Alternatives
IID	Independently and Identically Distributed
LLF	Log Likelihood Function
MNL	Multinomial Logit
MWTP	Mean/marginal willingness to pay

RPL	Random Parameter Logit
RUM	Random Utility Model
SP	Stated Preference
SQ	Status quo
STP	Sewage Treatment Plant
TEV	Total Economic Value
WTA	Willingness to Accept
WTP	Willingness to pay

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Water is one of the essential elements of life. Clean and adequate fresh water plays a paramount importance to the survival of all living organisms and the smooth functioning of ecosystems and economies (Curry, 2010). But, studies indicated that from all water on earth, only 1% of the earth's fresh water is located in streams and lakes available for human use (UN-Habitat, 2010). For these reasons, it is a source of economic and political power and its pollution and scarcity is becoming a limiting factor in economic and social development (Narasimhan, 2008) as well as a possible source of trans-boundary conflict (Rahman, 2012).

According to the United Nations cited by Tietenberg and Lewis (2012), about 40 % of the world's population lives in areas with moderate to high water stress areas. Access to clean water in Africa is one of the most critical aspects of human survival (Rahman, 2012). Africa and Asia suffer the most from the lack of access to sufficient clean water. Up to 50 % of Africa's urban residents and 75 % of Asians lack adequate access to a safe water supply (Tietenberg and Lewis, 2012). Despite the fact that Ethiopia has great potential of both surface and ground water resources and dubbed as 'the water tower of East Africa', it did not supply clean water for half of the total population until recently (Arega and Molla, 2014). Furthermore, by 2025, it is estimated that about two thirds of the world's population will live in areas facing either moderate or severe water stress (Tietenberg and Lewis, 2012).

Despite the fact that rivers are sources of significant portion of fresh water, they are polluted by inappropriate disposal of wastes of the economy. Consequently, declining water quality further intensified by industrialization, urbanization, population growth and expansion of agricultural activities, along with inadequate sanitation infrastructure provision, becomes a global issue of concern especially in developing nations where access to clean water, sanitation and hygiene are the significant elements for poverty alleviation target of the development plan (UN-Habitat, 2010; Elias, *et al.*, 2012). The pollution of water disturbs the biophysical entities of a water body and affects the socioeconomic values of water. According to the United Nations, 90 % of sewage and 70 % of industrial wastes in developing countries are discharged directly into surface water bodies without treatment (UN-Water, 2008).

Access to safe water is a human right, but polluting and discharging contaminated water into the environment and polluting the water of downstream users is not (UNDP, 2006). Hence, the Society should take responsibility in protecting polluted streams. However, protection of rivers is not a simple task from the virtue of rivers being common goods that any one uses them without paying since there is no market. When market fails, externality emerges and divergence between social costs and private costs is revealed. To not incorporate the impact of externalities in prices is to implicitly assign a value of zero, because the social costs comprise valuation for the impacts of externalities in addition to private costs. However, disequilibrium between the costs has an impact on the social welfare maximization, economic inefficiency and misallocation of resources (Dascalu *et al.*, 2010).

Who pays for the protection of polluted rivers remains a debate in environmental economics. According to Pigou (1932) polluters should pay for the damage they brought to the society. Polluters pay principle has been supported by other economists and known as Pigouvian taxation (Baumol, 1972; Roman-Sanchez and Carra, 2013). However, Ronald Coase (1960) argued that assignment of property rights would allow negotiation between polluters and victims, resulting in internalization of externalities. Yet the assumption of Coase theorem is restrictive as the number of negotiating parties increase (Hanley *et al.*, 1997), for instance, in the case of river water pollution where the victims of downstream and the polluters in upstream are enormous.

1.2. Statement of the Problem

Ethiopia is characterized by high population growth, urbanization and industrialization. Being the socio political and industrial center of the country, Addis Ababa is severely affected by the problem of water pollution that tributaries and the two major rivers-the 'Tiliku' and 'Tinishu' Akaki Rivers are highly polluted by receiving effluents and solid wastes.

The high population growth increased the municipal solid and liquid waste generation of the city. In addition, municipal waste collection system is less efficient and access to sanitation services is low. But, the sectoral and compositional contribution of wastes has shown tremendous growth. About 35% of the solid waste generated in Addis Ababa is dumped on open sites, drainage channels, rivers, valleys and streets; as a result it greatly contributes to the pollution of rivers since all wastes dumped in other places eventually end up to rivers during run offs (Abdulshikur, 2007; Alebel *et al.*, 2011).

Since the city has inadequate and inefficient solid and liquid waste management facilities, all point and non point sources in the city discharge their effluents directly or indirectly to the nearby rivers. Domestic liquid wastes from overflowing and seeping pit latrines, septic tanks, public and communal toilets, open ground excreta defecation comprise the municipal liquid wastes. Even though the city has a centralized sewerage system and two wastewater treatment plants-Kotebe and Kality treatment plants, they operate bellow their capacities due to inefficient waste collection, whereas, daily production of waste water is over 85,000 cubic meter per day, while the performance of the water treatment plants is only around 15,000 cubic meters per day (Alebel *et al.*, 2009).

Among the Industries located in the city 90% of them discharge their effluents without any treatment into the adjoining rivers and open spaces. Although the majority of contaminants are human pathogens, chemical hazards are possible. The wastewater generated from some industries is categorized as toxic or hazardous to human and animal health (Alebel *et al.*, 2011; Samuel, 2005).

According to Mohammed (2002), industrial effluents surpass the Ethiopian provisional effluents discharge permit limits, and he indicated that rivers are grossly polluted in all seasons and throughout their courses. Hence the river water shouldn’t be used for irrigation, drinking, livestock drinking and washing. Moreover, based on the Slovak Technical Standard grade system (STN, 1998) and WHO drinking water guideline

(2004), the water quality of the ‘Tinishu’ Akaki River has been classified as badly polluted to very badly polluted river, and the pollution level of the river exceed the standard values defined by the Environmental Protection Authority for discharging wastes into surface water bodies by a large margin, especially the values for biochemical oxygen demand (BOD), phosphate, suspended solids (SS), ammonia (NH_3), total coli form bacteria and metallic content of the wastewater (EPA, 2003).

Despite the fact that rivers flow in the city are recipient of different sort of wastes as mentioned, they are being utilized by urban and peri-urban farmers for irrigation purpose. Moreover, a significant number of people use urban rivers for washing vegetables and clothes, animal drinking, bathing and even for drinking purposes (Abdulshikur, 2007; Alebel *et al.*, 2011). Using the polluted water, farmers grow cash crops like lettuce, Swiss chard, cabbage, carrot, beet root and potatoes. About 60 % of all vegetables and 90 % of leafy vegetables in the city market come from areas which use urban rivers (Alebel *et al.*, 2011). However, the use of wastewater in agriculture has a negative impact on crop production, public health and ecosystem (Getaneh and Van Rooijen, 2009).

In general researchers argue that the poor sewerage system, uses of old technology, lack of awareness on waste management, weak enforcement mechanisms on pollution prevention and regulation and lack of cooperation among stakeholders are exasperating contamination of rivers (Alebel *et al.*, 2011). Therefore, a lack of integration of environmental issues in future water improvement activities may lead to social and environmental pollution problems which in return create problem on the human health of the general public and may require enormous resources when the need is there to clean up the contamination (Getaneh and Van Rooijen, 2009).

1.3. Objectives of the Study

The main objective of this study is to estimate the mean willingness to pay of the Addis Ababa city residents for the protection of urban river water pollution.

The specific objectives are to:

1. Assess the WTP of households for protection of river water pollution,
2. Determine socio-economic factors that affect households' preference,
3. Examine how WTP is affected by attributes and identify the most important attributes of WTP and
4. Forward possible policy implications for urban river protection.

1.4. Significance of the Study

The study tried to extract information on the preferences of households on protection of river water pollution. Stakeholders, governmental and non-governmental organizations, whose target is environmental protection, could design appropriate policy to address the problem based on the preferences made by the respondents. Moreover, the study has further three significances: firstly, the procedures and designs could be applied by other researches that may conduct studies in other cities and towns of the country; secondly, the final results can be used to design policy intervention that have a similar scenarios by arranging the contexts in other towns; and, finally, it is a bench mark to conduct other studies on the other urban rivers of the city.

1.5. Scope and Limitation of the Study

The study is geographically delimited to Addis Ababa. Many perennial and intermittent rivers flow in the city, yet the study is confined to ‘Tinishu’ Akaki River. Though residents of the city and different industries and service providing organizations share responsibility to the pollution of the river, the study is focused on the residents who are responsible for the disposal of municipal wastes.

1.6. Organization of the Study

The study is organized into five chapters. The introduction part is presented in the first chapter followed by the literature review in the second chapter. Methodology of the study that comprises different models for estimation, sample sizes, description of attributes and allotment of attribute levels, experimental designs and questionnaire development are stated in the third chapter. In the fourth chapter the descriptive analysis and results of the models are discussed in detail accompanied by conclusions and policy implications in the fifth chapter.

CHAPTER TWO

RELATED LITERATURE REVIEW

2.1. Theoretical Literatures

2.1.1. Economic Value of Water

As per Ward and Michelsen (2002) water has economic value only when its supply is scarce relative to its demand. The economic value of water is high on account of its scarcity and applicability for different uses. The daily drinking water requirement for a person is at most 4 liters; however, it needs 2000 to 5000 liters of water to produce one person's daily food (FAO, 2007 cited in UN-Habitat, 2010). Moreover, 70 % of fresh water in the world is consumed by agriculture; and irrigated agriculture accounts for 40% of global food production (Rigby *et al.*, 2010). Around 20% of total water goes to industry (WWAP, 2009). Besides, the hydropower contributes 16 % of the world energy (Kaunda *et al.*, 2012). In Ethiopian, hydropower is the major energy supply.

According to the definition of Young (2005), nonmarket economic valuation is the analysis of actual and hypothetical human behavior to derive estimates of the economic value of goods and services in circumstances where market prices are missing or distorted. In a market system, an economic value of water is defined by its price (Ward and Michelsen, 2002). However, because of lack of markets for water related goods and services, shadow prices are a critical element of economic assessment of public water related policy options (Young, 2005). The use of stated preference methods to investigate the economic value of water has more typically been concerned with its public good aspects (Rigby *et al.*, 2010). But, producers' use of water is another important field of valuation (Young, 2005).

Most applied methods of water valuation fall into one of the two broad categories that differ in the basic mathematical procedures and types of data employed in the valuation process. The first one is the deductive method which involves the derivation of shadow prices where water is an input into production systems. Deductive method in valuation of water from producers' point of view starts with abstract models of human behavior; and the accuracy of behavioral postulates of optimization and assumptions about the production function depends on the validity of the behavioral and empirical premises, the appropriateness and detail of model specification.

The other category of water valuation technique is inductive method involving a process of reasoning from real world data to general relationships like observation of prices from water rights transactions, responses to survey questionnaires and government reports. Valuation results obtained from deductive and inductive methods are often inconsistent. Most of the time results obtained from the latter are lower than results from the former. The difference between the two methods might emanate from Potential biases from empirical predictions and model misspecifications (Young, 2005).

2.1.2. The Impact of Water Pollution on Human Health and Ecosystem

Pathogens, organic compounds, synthetic chemicals, microplastics, nutrients and heavy metals are elements that pollute fresh water. The majority of these pollutants are persistent, bioaccumulative and toxic which have impacts on human health and cause environmental degradation (Engler, 2012; Donnachie *et al.*, 2014; Ivar do Sul and Costa, 2014). Over 100,000 chemicals are in use worldwide (Holt, 2000; Schwarzman and Wilson, 2009). Plastics are vehicles of pollutants to water bodies and persist in the environment for longer periods. Heavy metals also accumulate in the food web especially in fishes and vegetables and threat living organisms (Schwarzenbach *et al.*, 2010). Individuals who swallow microplastics suffer physical harm, like internal abrasion and blockage (Ivar do Sul and Costa, 2014).

Along with lack of sanitation and hygiene, unsafe drinking water affects more than one third of the world population (Schwarzenbach *et al.*, 2010). The easily preventable diarrheal diseases contribute to 6.1% of all health related deaths. 90% of the infectious diseases in developing countries are transmitted from polluted water (Pimentel *et al.*, 2004). Polluted water is also responsible for 15% to 30% of gastrointestinal diseases and the main acute disease risk associated with drinking water in developing countries is due to well known viruses, bacteria, and protozoa, which spread via the fecal-oral route (Ashbolt, 2004). Nine out of ten incidents affect children, and 50% of childhood deaths happen in sub-Saharan Africa (WHO- UNICEF, 2006). Water related diseases have taken more children's lives in the last decade than the combined deaths of those lost in armed combat in the world over the last sixty years (Curry, 2010). In Africa, due to water pollution and lack of sanitation, the overall economic loss is estimated to be 5% of the gross domestic product (UNESCO, 2009).

In addition to the risk of human health, water pollution has great impact on the ecosystem function. Unregulated discharge of wastewater undermines biological diversity, natural resilience and the capacity of the planet to provide fundamental ecosystem services (UN-Habitat, 2010). The accumulation of plastic debris distorts the scenery of water bodies. Excessive nutrients in water bodies cause a dense growth of plant life and the decomposition of the plants deplete the supply of oxygen that leads to the death of aquatic animals (Tietenberg and Lewis, 2012). Moreover, Freshwater aquatic organisms face the challenge of being exposed to chemicals discharged by the society (Donnachie *et al.*, 2014). Inorganic chemicals and minerals comprise the main examples of stock pollutants which are not degradable by natural process rather accumulate in the environment. The watercourse cannot clean itself from stock pollutants (Tietenberg and Lewis, 2012).

According to United Nations (UN-Habitat, 2010), the financial, environmental and societal costs in terms of human health, mortality and morbidity and decreased environmental health are projected to increase dramatically unless wastewater management is given very high priority and dealt with urgently.

2.1.3. Application and Challenge of Waste Water Use in Agriculture

Waste water has been used extensively in different part of the world particularly in developing countries. Several studies show that about 20 million hectares of land in the world that comprises 7 % of the land is irrigated with wastewater (Jimenez and Asano, 2008). In the city of Kumasi, Ghana, around 11,900 ha of peri-urban agriculture areas use untreated wastewater, compared with less than 6000 ha of formal irrigation for the entire country (Keraita *et al*., 2002). In Vietnam, 7000 ha of wastewater irrigated area is found within metropolitan boundaries of cities (Raschid-Sally *et al.*, 2004). A similar exercise in Pakistan is estimated to be 30,600 ha (Ensink *et al.*, 2004). Along the Musi River in India, an estimated 9675 ha of agricultural land is irrigated by wastewater (Buechler and Gayathri, 2005). In Mexico the area of land irrigated reaches up to 350,000 ha (Peasey *et al.*, 2000). Contaminated river water has been used in crop production within and around Addis Ababa since the 1940s for home consumption and urban market supply (Alebel *et al.*, 2011).

On account of growth in population and urbanization along with rising income that brings higher global food demand (UN-Habitat, 2010), economic development demanding for improved sectoral allocation of groundwater and surface water for domestic, agricultural and industrial use (Arisoa, 2012), water scarcity in arid and semi arid areas (Galavi, *et al.*, 2010), shortage of clean water due to contamination and infrastructural constraints (Ghanem, 2012), the need of nutrient value of elements contained in waste water attributed by an increase market price of nitrogen and phosphorus fertilizers (Wichelns and Drechsel, 2011); the demand for untreated wastewater is sufficiently strong that the farmers have fought to establish a legal right to their historical use pattern (Wichelns and Drechsel, 2011).

In the contemporary context, the use of waste water in agriculture is controversial. Urban agriculture provides benefits to the economy in terms of employment creation, improved economic base for the poor, especially for women and other disadvantaged groups and supply of fresh vegetables to the urban market (Karanja *et al.*, 2010; Alebel *et al.*, 2011). There are advantages related to the use of wastewater in agriculture. It is estimated that 10 % of the population of the world relies on food grown with contaminated wastewater (WHO-FAO, 2006). In Dakar, Senegal, more than 60% of the vegetables consumed in the city are grown in urban areas using a mixture of groundwater and untreated wastewater. In Pakistan, about 26 % of national vegetable production originates from urban and peri-urban agriculture irrigated with wastewater. About 90% of lettuce and spring onions consumed in Kumasi, Ghana are produced in the urban areas. In Hanoi peri-urban agriculture, using diluted waste water provides 60 to 80 % of the perishable food for local markets (Faruqui, *et al.*, 2004; Ensink *et al.*, 2004 and Van den Berg *et al.*, 2003). Approximately, 61 % of all vegetables and 90 % of leafy vegetables in Addis Ababa come from farm areas which use waste water (Alebel *et al.*, 2011). On account of this, the life of many urban farmers and sellers depend on the production and sale of vegetables and the residents are benefited, for they obtain fresh vegetables with low prices (Alebel *et al.*, 2011). The high nitrate and phosphate levels and organic matters such as potassium, calcium, and manganese are beneficial to farmers which could partially offset health risks to farm families (Rutkowski *et al.*, 2007)

However, untreated wastewater may contain harmful constituents of pathogens including bacteria, intestinal worm infestations, parasites, viruses, toxic chemicals, biological pollutants, and heavy metals which could not be decomposed by biological or chemical processes. Their accumulation degrades the quality of water in the river; soil and ground water thereby generate health risks for farm communities that have direct contact to the waste water, and consumers of farm products (Drechsel *et al*., 2010; Wichelns and Drechsel, 2011). A study revealed that the use of contaminated industrial wastewater for crop production in China has been associated with a 36% increase in hepatomegaly or enlarged liver; and a 100% increase in both cancer and congenital malformation while in Japan, Itai-itai disease, a bone and kidney disorder, is associated with chronic cadmium pollution of paddy water coming from the Jizu River (Kakar *et al*., 2006).

A careful policy intervention is vital since the use of wastewater for irrigation likely will increase substantially in future, as higher-quality water supplies are shifted from agriculture to cities and as the cost of comprehensive wastewater treatment remains too expensive in many developing countries. Hence, comprehensive wastewater collection and larger treatment facilities will not be financially visible, while the generation of wastewater increases with urbanization, industrialization and population growth (Wichelns and Drechsel, 2011).

Non treatment intervention options provide cost effective safeguards to public health. Strategies that might encourage behavioral change on farms and consumer markets, awareness creation and education, market incentives and regulations should be implemented. It is essential that public officials encourage safe use of wastewater on farms, and that safe food practices are adopted by all participants along the value chain and employing risk reduction innovations like crops restriction that different plants have varied capacities to uptake and accumulate heavy metals and resisting salinization, protective clothing, safer application, and irrigation cessation (Karanja *et al.*, 2010).

Developed nations have recognized that in theory it is simpler and more cost effective to deploy cleaner production processes than to clean up large scale industrial pollution. Moreover, as per UN-Habitat (2010), households should practice a wastewater treatment system at the source like a closed loop ecological toilet that separates urine and faeces so that they can be easily treated and then used safely in agriculture. Encouraging a greater participation of the private sector in the collection, management and utilization of wastewater and fecal sludge for aquaculture, biogas recovery, compost production, and industrial fuel, and then marketing of valued by products through providing addressable markets, revenue streams and potential efficiency of scales is another policy intervention (Wichelns and Drechsel, 2011).

2.1.4. Evolution of Environmental Valuation Techniques

From the perspective of neoclassical economics, economic value is judged as being dependent on the degree of social well being, which is the aggregation of individual well being. In turn, individual well being is measured by utilities that are provided by the environment in the form of inputs and outputs. In general, the environment has two major roles that could strengthen its linkage with the economy where human being is the prime mover and primary beneficiary of the output. These roles are the provision of resources, and as a sink for waste products resulted from production and consumption (Hanley *et* *al.*, 1997). However, the accumulated pollutants affect the environment and in turn the affected environment influences the performance of the economy.

Environmental pollution has been an intensive agenda in the second half of the 20th century. Especially, the 1960s and 1970s were important periods that environmentalists were aware of the problem and awakened in proposing solutions and called the periods-the period of “environmental revolution”, (Baumol and Oates, 1988). The Stockholm Declaration on the Human Environment was important episode which declared the rights and obligations of stake holders with regard to the preservation and improvement of the environment, (Louis, 1973), followed by the report of Our Common Future that took sustainable development in to consideration, (United Nations, 1987). Furthermore, in these decades environmental valuation methods, which attempt to extract use and non-use values of environmental resources, were developed and further strengthened; and other theories, that are either substantiate or deviate from the neoclassical doctrine, were developed (Luce, 1959; Coase, 1960; Lancaster, 1966; McFadden, 1973).

In the orthodox economics, price is a typical mechanism in settling market imperfections. The value of goods or services is measured by the price they posses and ones preference is revealed by that price. Despite the fact that environmental and natural resources have use, passive use and non-use values; they have not priced, which is emanated mostly from their virtue of being public good characterized by non-rivalry and non-exclusion, so that the society use them beyond the optimal level without paying. Hence, the first step in protecting the environment is valuing the resources and then attaching a price.

Nevertheless, there are arguments on the valuation of the environment. The supporters of deep ecology, introduced by Arne Naess that is guided by eight principles (Ambrosius, 2005), argue that ecological policies are restricted to the 'shallow ecology movement', which are only concerned on pollution and resource depletion and their central objective is the health and prosperity of people in the developed countries; yet, "there are deeper concerns which touch upon principles of diversity, complexity, autonomy, decentralization, symbiosis, egalitarianism, and classlessness" (Naess, 1973). Moreover, they enforce egocentrism rather than anthropocentrism (Ambrosius, 2005), that the nonhuman environment has intrinsic value independent of human interest which is contradicted with instrumental value that is derived from its usefulness in satisfying human wants (Naess, 1973). Hence, "allowing humans to determine the value of other species would have no more moral basis than allowing other species to determine the value of humans. [Besides], economic valuation contributes little to environmental management and isn't helpful in determining survival necessity" (Daily *et al.*, 2003, cited by Tietenberg and Lewis, 2012).

In the contrary, environmentalists argue that when humans fail to value the environment, it may be assigned a default value of zero (Loomis, 2000). However, "to say that we should not do valuation of ecosystems is to deny the reality that we already do, always have and cannot avoid doing so in the future" (Costanza *et al.*, 1998). So, environmental goods and services have values larger than zero (Dailey, 1997).

For Tietenberg and Lewis (2012), it might be difficult to place an accurate value on certain environmental amenities, but not doing so leaves us valuing them at zero.

However, valuing them at zero doesn't lead us to genuine policy decisions even if a more appropriate value that attempts to replace zero doesn't solve the controversy.

So far there are two broad valuation techniques as far as environmental valuation is concerned which help collect information about society's preference for environmental protection (Rolfe *et al.*, 2004). These are known as revealed and stated preference methods. Revealed preference methods rely on data obtained from actual behavior of consumers. The popular revealed preference methods are travel cost and hedonic pricing methods. While stated preference data are collected through surveys, where people state what their choices would be in a hypothetical scenario. Contingent valuation, choice experiment, ranking and rating are types of stated preference methods though the last two are more applicable in marketing and transportation. The validity and reliability of economic models are tested by examining the degree to which they can explain actual behavior of individuals (Tietenberg and Lewis, 2012).

As an SP method, CV is the pioneer in valuation of natural and environmental resources. Its results are consistent with the theoretical prediction and actual behavior, and has an appropriate justification when divergence occurs which may also inevitable in the consumer behavior in actual markets. Even CV has an advantage of flexibility, and has extensions, clarifications and deeper understanding on some issues which are ignored by the conventional neoclassical economic theories (Carson and Hanemann, 2005). However, cautiousness should be taken during survey design in which most of the criticisms emanate thence (Arrow *et al*., 1993).

2.1.4.1. The Choice Experiment Technique

As cited by Hanley *et al*. (2001), the choice experiment approach was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983) though the origins of discrete choice models, in general, are rooted in the early studies of psychophysics-the physical study of the relations between physical stimuli and sensory response; and later applied in biology with the expression models with discrete responses. Today they frequently occur in product market, transportation, demand theory, in labor econometrics, as well as in other social sciences. More importantly, the choice models in general and the CE in particular play a paramount importance in environmental valuation in recent decades (Holmes and Adamowicz, 2003). That the CE technique was applied to environmental management problems by Adamowicz *et al.* (1994) and used to estimate non-use values by Adamowicz *et al.* (1998) for the first time.

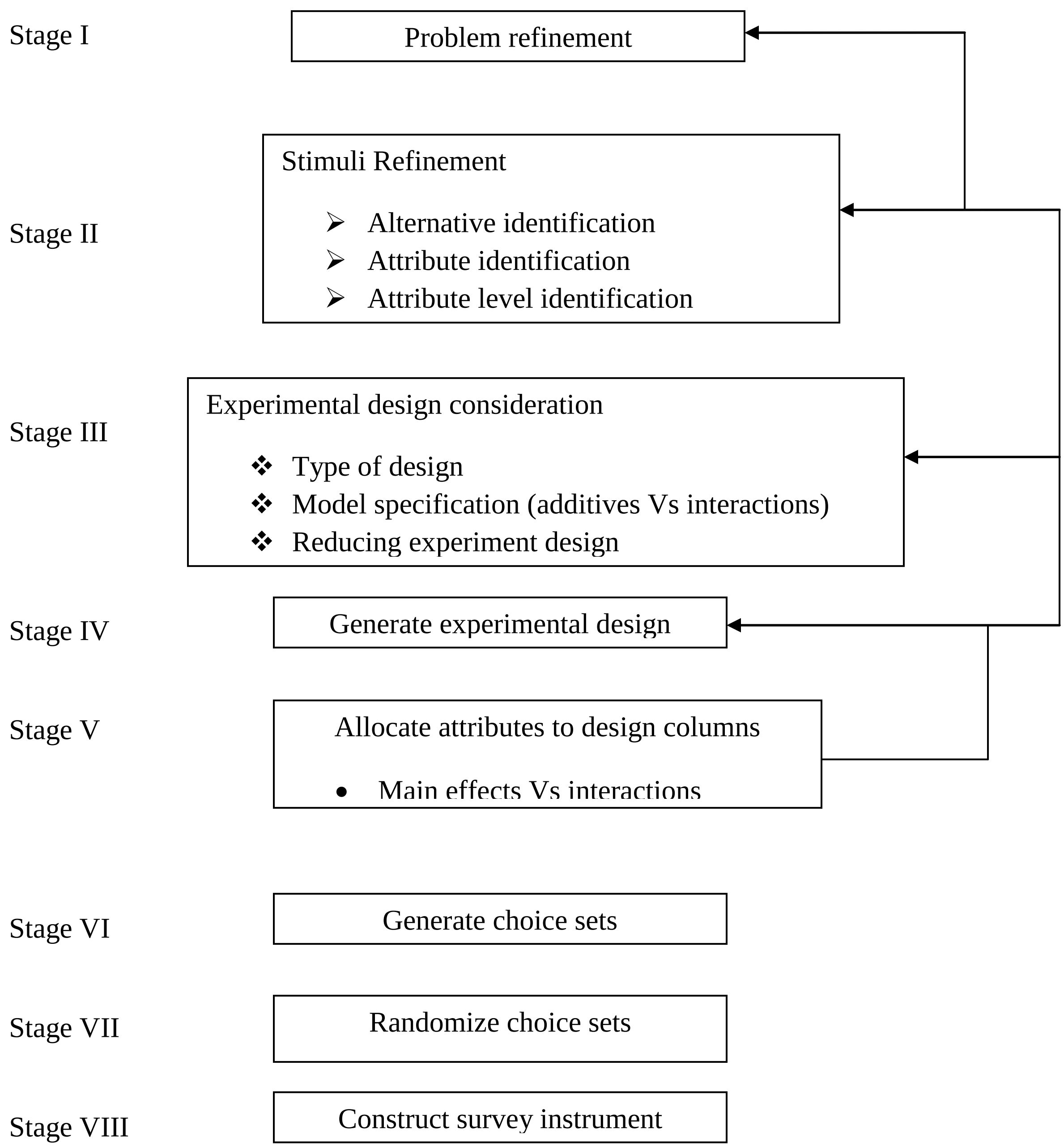
Though it is difficult to conclude that CE could entirely substitute CV, recent interest in the former has arisen in part in response to criticisms on the latter (Green, 1995, cited by Adamowicz *et al*., 1998). Some of the problems of CV may be solved by CE due to the fact that CE involves a broader attribute based perspective and focuses on tradeoffs between the levels of the attributes in the different alternatives included in a choice set, rather than concentrated only on the payment. The repeated choice in CE allows for internal validity which in turn yields information about the consistency of individual responses (Adamowicz *et al*., 1998; Hanley *et al.*, 1998).

More importantly, there is significant evidence on the validity of the application of CE in use values that could in part address the concern on the predictive ability of the real world choice behavior of consumers. However, "careful experimental design, including the selection of attribute levels, choice contexts, survey design and implementation, and sampling methods are required for [CE] tasks to provide the best results" (Adamowicz *et al.*, 1998). Despite models are useful abstractions, the conclusions they provide are dependent on the formation of the model and changing the model may likely change the conclusions. Therefore, they should be analyzed with some skepticism (Tietenberg and Lewis, 2012).

Application of the CE technique should pass several stages. According to Adamowicz *et al.* (1998), there are seven steps. The first step is characterization of the economic and environmental problem. Then, attribute level selection follows, yet it can be done with step one simultaneously. After attribute selection, experimental design procedures are used to combine the alternatives and attributes. Questionnaire development is undertaken in step four that is either self-administered or presented via interview. Then, data collection procedure follows in step five from sampled respondents. The collected data is estimated in step six. Finally, the estimated results are interpreted for policy analysis and decision support.

Even though all steps are important, the third step-experimental design requires much attention in CE technique. Hence, experimental design procedure in turn has to pass several stages. The stages are portrayed in the following figure which is adopted from Hensher *et al.* (2005).

Figure 2.1 Experimental design procedures



Source: Adopted from Hensher *et al.* 2005

2.2. Empirical Literatures

Hanley *et al*. (2006) conducted a study on estimation of economic value of improvements in river ecology using CE method which was applicable to the EU-WFD from 420 sample respondents on River Wear and Clyde. Even though they rejected the IIA assumption, they used MNL and RPL models in the estimation. Both models generated a set of implicit prices that are very similar for River Wear, i.e., river ecology, aesthetics and bank sides; £12.54, 12.35 and 12.92 for MNL and £ 12.19, 12.07 and 12.67 for RPL, respectively. They argued that preference heterogeneity is likely not a factor of much importance and the prices are robust. Whereas, for River Clyde, the MNL model generates prices that are not statistically significant to zero. Yet, the RPL model gives prices that are statistically significant at 5%, which are £38.78, 28.57 and 42.99 for river ecology, aesthetics and bank sides, respectively. Based on their argument, the fact that the prices are not significant in the MNL but are significant in the RPL model demonstrates the potential importance of controlling for preference heterogeneity in CE. They also analyzed the practicability of benefit transfer on the two rivers by conducting the Chow test. However, the results of the test for MNL and RPL models confirmed that the equality of parameters is firmly rejected; and hence benefit transfer is not advisable.

Birol *et al*. (2008) also applied the CE method to value benefits from reduction in flood risk in Europe, and estimated the value of biodiversity and households' demand for recreational activities in the area. They developed four attributes; flood risk, river access, biodiversity and local tax. The survey was conducted on 192 households. Through conducting a Hausman test and Swait-Louviere log likelihood ratio test, they showed that the RPL model is the correct specification for the data. Therefore, the estimation of the WTP was based on results they obtained from the RPL model with interactions. Accordingly, they reported the MWTP for river management strategy attributes for the RPL model with interactions for average, flooded, visitor, wealthy and poor households. The results indicated that the average households were willing to pay the highest level for low flood risk, followed by river access and biodiversity. They also compared the WTP of the household types and found that the flooded household was willing to pay the highest for low flood risk, whereas the wealthy household was willing to pay more for biodiversity and river access attributes.

A study on the value of achieving water quality improvements in the rivers of the metropolitan region of Berlin and Brandenburg was conducted by Meyerhoff *et al*. in 2013. They employed a CE survey on 752 individuals through web-based interviews and 2181 individuals on phone survey. The attributes of the CE were lower and upper Havel, city stretch Spree, Spree Kopenick, Dahmescharmutzelsee and costs. They used the basic MNL and the extended mixed logit models for estimation. In their estimation they divided the respondents based on spatial distribution as urban and rural residents. Both models indicated differences between urban and rural dwellers. Generally, the sizes of the coefficients are larger in the group of urban dwellers compared to rural dwellers except for upper Havel. They also calculated the WTP based on the estimation of RPL. Thus, on average respondents were willing to pay around €43 (urban dwellers) and around €30 (rural dwellers) for the welfare change.

Bliem and Getzner (2008), conducted a survey on the estimation of non-market benefits of ecological restoration of heavily modified river stretches along the Danube River using stated preference methods-CE and CV on three European countries, Austria, Hungary and Romania, yet the report was based on the survey of the Austrian respondents. The CE was composed of three attributes, flood frequency, water quality and price; and a total of 506 respondents were interviewed. The water quality has three levels; moderate, good and very good. The flood frequency has four levels that are experience of flood risk once in 5, 25, 50 and 100 years. The payment levels used in the choice experiment are € 3, 10, 30 and 50. After estimating using both MNL and RPL models they found that all attributes are highly significant and have a positive sign except price that confirms the standard economic theory. Respondents were willing to pay around € 23, 44.5 and 75.3 to reduce the probability of floods and improved water quality from SQ to good and very good water quality, respectively. They pointed out the criticism on the aggregation of total economic valuation when using non-market valuation study results in a cost-benefit analysis. To solve the problem, they made the aggregation using GIS and included the distance decay and income effect. Then, the adjusted values are added up to estimate the TEV of river restoration to good and very good water quality. The results showed a big difference between the TEV based on the country as a whole and the adjusted TEV determined by the estimated distance decay and income effect.

A study by Birol *et al*. (2009) employed the CE method, to estimate local public's WTP for improvements in the capacity of sewage treatment plant in Chandernagore Municipality, located on the banks of the River Ganga. They conducted a pilot CE survey on 100 randomly selected Chandernagore residents and analyzed the data using the CL model. They identified four attributes; quantity of treated wastewater, quality of treated wastewater, regeneration of the park and a monthly increase in the municipal tax.

Based on the CL model estimation, all of the coefficients are statistically significant. In order to investigate whether there is any heterogeneity in the preferences of the sample; the researchers divided the respondents in to rich and poor households as per households' total monthly expenditure per capita and found that the two subsample households had distinct preferences for wastewater treatment attributes. Besides, richer households were willing to pay more for higher wastewater treated to a quality, whereas poorer households were willing to pay more for higher quantity of wastewater treated. They also pooled the two samples together, and the pooled estimation indicated that the households value the most in improvement of water quality, and were willing to pay Rs 10.86 more in monthly municipal taxes. The respondents also preferred to pay Rs. 16.46 per month for both quality and quantity improvements.

Sangkapitux and Neef (2009) conducted a study on the willingness of upstream and downstream resource managers to engage in compensation schemes for environmental services. CE was used to elicit upstream resource managers' WTA compensation and to determine downstream resource managers' WTP. Upstream respondents were presented with four attributes; installing water saving technology, planting vetiver grass strips for erosion control, applying bio-insecticides and compensation. They interviewed 371 farm households located in the upstream to state their preferences on WTA compensation. Whereas, 151 farm households presented with four attributes; water for agriculture, water for household consumption, water quality and water fee.

They employed CL model to estimate WTP/ WTA compensation. Based on the estimation results, the attributes of applying bio-insecticides and planting vetiver grass have negative coefficients which affect utility so that respondents need compensation. But, the coefficients for installing micro-sprinkler systems on 50% of the area and for installing drip irrigation on 50% and 100% of the area respectively have a positive sign that farmers do not need any compensation for adopting the practices. They also found positive sign for sufficient water for cultivation and drinking for the whole year and good water quality for drinking and household use which imply positive utility of the respondents. Thus, the downstream farmers' WTP was 755.19, 737.42, 477.43 and 178.68 Baht/household/year to have the water quality improvement. In their conclusion part they raised the problem of free riding and lack of trust between beneficiaries and providers of environmental services and recommended experienced and trustworthy intermediary organizations to play a crucial role in facilitating, mediating in the negotiations and setting up appropriate monitoring and enforcement mechanisms.

Marsh *et al*. (2011) employed CE to assess a community's preferences for stream water quality improvements focusing on the effect of perceived versus described status quo alternatives. Suitability for swimming, ecology, presence of native fish and eels, presence of Trout and water Clarity were the attributes in the study. To take in to consideration the discrepancy between the SQ given by the researcher and what the respondents perceived, they took respondent perception of the quality of local streams and divided the respondents as SQ provided and SQ perceived. Those respondents who were unable to give their own assessment were labeled as SQ provided, while respondents who were able to assess current water quality used their own SQ as SQ perceived.

The SQ provided model with all respondents and a model by excluding the outliers to avoid their impact showed estimates with the expected signs for all attributes. The ASC is negative and highly significant at the 1% level in both models implying preference for a change from the status quo. The results revealed that respondents have very strong preferences for water quality that is highly suitable for swimming with the presence of Trout, and lower preferences for the ecology attributes. Similarly, in the SQ perceived models, two models- a model with all respondents and another model that excludes the outliers were estimated. Both models showed that all water quality attributes are highly significant at the 1% level demonstrating that respondents had very strong preferences for all the water quality attributes. The ASC is positive and significant at the 5% level in the model with all respondents, but positive and insignificant in the second model. Hence, the positive ASC revealed that respondents are inclined to remain with the SQ. Since the SQ alternative in the second model is dependent upon each individual specific experience, as per their argument, the bias towards the status quo might be taken as a confirmation of the loss aversion hypothesis. They also argued that since respondents provided their own SQ, it has been perceived to be better than the alternative options provided.

In the Comparison of WTP in the SQ provided and SQ perceived treatments they indicated that respondents in the SQ perceived model were more willing to pay for water quality improvements than those in the SQ provided model for all attributes. They also argued that differences in WTP values between the two treatments appear to be quite substantial and significant.

The study of Tait *et al*. (2009) combined CE and biophysical data in GIS to evaluate the influence of local water quality on respondent's WTP for river and stream conservation programs in Canterbury. They developed four attributes; health risk, ecology, flow and costs and gathered information from 349 respondents via mail survey, then estimated using RPL model. Therefore, all attributes except the medium level of improvement of three months of low flow are statistically significant at 1%. Moreover, the lower the ecological quality and the poorer the flow conditions, the higher was their WTP. Aggregate compensating surplus estimates with biophysical data showed more than 100% larger than the standard compensating surplus estimation with no biophysical data. The researchers tried to emphasize the contribution of their study via including respondent's local biophysical data in estimating the WTP and compensating surplus for the implication of agri-environmental policy.

Alebel *et al*. (2009) estimated the mean willingness to pay for improved waste water irrigation using a contingent valuation study. In their study the respondents were farm households that live in and around Addis Ababa who use waste water and fresh water for irrigation. Freshwater farmers that are located about 40 kilometers east of the center of the city were included in the study for comparison purpose. A total of 372 farm households were included in the survey, of which 149 were fresh water and 223 were wastewater farm households. They used a double bounded dichotomous or discrete choice format with an open ended follow up to elicit respondents' WTP for improved use of wastewater for crop production.

They proposed two government policy options for wastewater farmers to choose-creation of awareness about using waste water safely and law enforcement on polluters. They also adapted a similar policy options to the specific situation of freshwater farmers. Then, they estimated three different models. A standard probit model was estimated using only the responses to the initial bid; the full responses to the double-bounded questions were estimated using a bi-variate probit; and the interval-data model. Accordingly, the mean WTP were 39.57, 39.1, and 39.72 for the total sample; 37.87, 37.15 and 39.88 for wastewater area and 41.89, 41.91 and 39.5 birr/hectare/year for freshwater area, respectively.

Alebel *et al*. (2011) studied the impact of using waste water in crop production on the health of farm households in peri- urban areas of Addis Ababa. A total of 415 farm households from both wastewater and freshwater farm areas from which 240 were wastewater farmers mainly using the 'Tinishu' Akaki River for irrigation and 175 were freshwater farmers using water from government constructed dams were surveyed. They estimated the Probability of illness using the theory of utility-maximizing behavior of households subject to the conventional farm household production model, augmented by adding a health production function. For the majority of farm households, vegetable production using wastewater is a major source of income. An average wastewater farm household earns a net income of Birr 4448 per year, of which about 70 per cent comes from the wastewater farm. The study findings suggested that working on a waste water irrigation farm significantly increases the prevalence of illness, which in turn reduces household income. All model specifications revealed that household members who work on wastewater irrigation farms incur higher monetary costs than those working on freshwater irrigation farms.

CE was used by Getahun *et al*. (2014) to determine residents' WTP for liquid waste management in Addis Ababa. 384 residents that live in five woredas were interviewed. The attributes of the study are: quantity of treated domestic liquid waste, quality of treated domestic liquid waste and the payment vehicle. They used two models-the RPL with and without interactions for estimation in the study. The results from the RPL model revealed that quantity and quality of treated domestic liquid waste are found to be statistically significant at 5% and 1%, respectively. But, the coefficient of quality of liquid waste treated is far higher than the coefficient of quantity of liquid waste treated. From this they argued that respondents prefer quality of treated domestic liquid waste water as the major component of preference heterogeneity. Based on the RPL model correlated with interactions, respondents were willing to pay 22.14 birr for high quality of liquid waste treatment and 4.60 birr for increased quantity of treated domestic liquid waste. The MWTP for improved quality of domestic liquid waste level is higher than higher quantity of domestic liquid waste. Hence, as per the study, residents gave more value for advanced STP types than increased quantity of liquid waste treated at low quality level.

Many studies have been undertaken on the 'Tinishu' and 'Tiliku' Akaki Rivers and their tributaries. Most of the researchers were concentrated on the factors, extents and impact of the river water pollution (Itanna, 1998; Samuel, 2005; Abdulshikur, 2007; Getaneh and Van Rooijen, 2009; Alebel *et al*., 2011; Tamiru *et al*., 2011; Frezer, 2012). Despite the number of studies conducted and far exploration and discovery of the problems, in my best of knowledge, researchers do not study policy intervention mechanisms beyond recommending solutions for the problem they studied; except Alebel *et al*. (2009) that they analyzed farm households' willingness to pay for improved waste water irrigation using a contingent valuation method in proposing awareness creation and law enforcement as a policy intervention scenario which is discussed above. Therefore, by means of employing a CE technique, in the very essence, my study attached economic value for the river in interest. The study is done by identifying the attributes of the river, and then scrutinizing the preference of the respondents towards the attributes thereby their willingness to pay for the protection of the river through direct survey that attaches an economic value to the river.

CHAPTER THREE

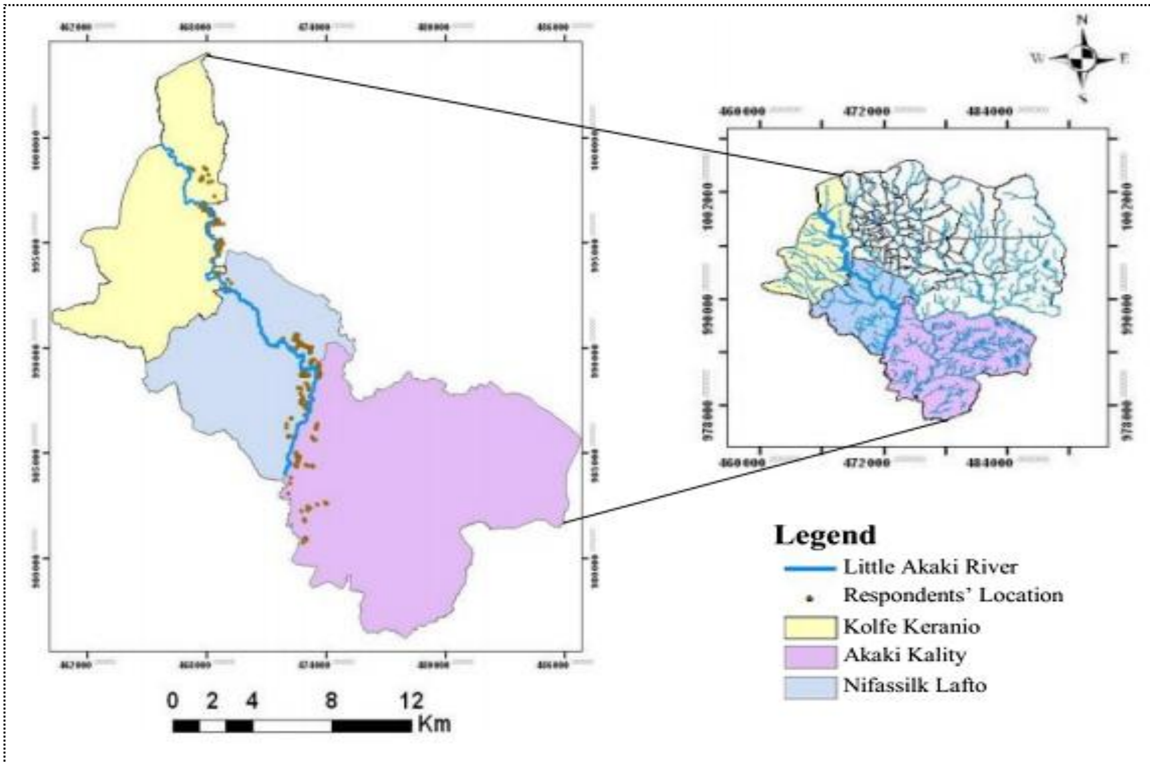
DATA AND METHODOLOGY

3.1. Description of the Study Area

Addis Ababa is located on the central highlands at the heart of the country. It is one of the fastest growing cities in Africa. Its growth has accelerated radically in the past three decades. Its population increased from 1.4 million to more than four million having the population growth rate of 3.8% which is attributed by natural growth and rural-urban migration. In addition to this the physical city also has grown extensively, more than doubling in size, since 1984, to cover an area of approximately 530 km^2 (Bjerkli, 2013).

The whole of the city lies in the upper Awash River basin which is comprised of two sub basins namely: the 'Tiliku' and 'Tinishu' Akaki Rivers. Different intermittent and perennial tributaries that cross the city stem from the Entoto Mountain and join the 'Tiliku' and 'Tinishu' Akaki Rivers in different localities. The 'Tinishu' Akaki River drains the western portion of the city and has a surface area of 950.56 square kilometers. It starts from Burayu (Northwest) and Entoto mountain (North) high lands and flows to the undulating center of the city and then to the flat lying South Western suburbs. After running for about 42 kilometers inside the city, it enters into Aba Samuel Lake that serves as pollutants sink. It flows into three sub cities namely Kolfe Keranyo, Nefas Silk-Lafto and Akaki-Kality before departing the city. The length of the river is 27.43, 14.57 and 6.92 kilometers in Kolfe Keranyo, Nefas Silk-Lafto and Akaki-Kality, respectively. But, it serves as a boundary for Akaki-Kality and Nefas Silk-Lafto for 6.92 kilometers. Hence, the total length of the river in the city is 42 kilometers.

Figure 3.1 Case Study Area-Little Akaki River



3.2. Survey Administration and Sampling Techniques

Data were collected from randomly selected households of Addis Ababa city using questionnaire. Akaki-Kality, Nefas Silk-Lafto and Kolfe Keranyo sub-cities were selected as a sample to conduct the survey, because the 'Tinishu' Akaki River crosses the sample sub cities. That the river was selected purposely for the study due to the fact that the length, the area coverage, monthly flow and quality of the water are studied which were inputs for the experimental design.

Before the commencement of the interview, enumerators with the researcher identified sampling areas using Google map for three days referencing the 'Tinishu' Akaki River. According to the census of 2007, the total number of households in the three sub cities is 223657. Then, the numbers of sample respondents in each sampled sub city were determined basing number of households. Accordingly, 89, 125 and 101 respondents were interviewed in Akaki-Kality, Nefas silk-Lafto and Kolfe Keranyo sub cities, respectively. During the survey the location of each respondent's house was registered using GPS.

The survey was administered from May to July, 2014, for eight consecutive weekends through face-to-face interview by three enumerators. Since the study targeted decision makers of the family member in financial matters, the survey was conducted on weekends. Enumerators were the researcher and two second year masters students who trained for a day how to interview before the data collection was commenced.

3.3. The Choice Experiment Model

The theoretical and empirical underpinning of choice experiment method contain: elements of the traditional microeconomic theory of consumer behavior, for instance, the definition of rational choice (Louveire *et al*., 2000), Lancaster's model of consumer choice (characteristics theory of value) that consumers derive satisfaction not from goods themselves but from the attributes they provide (Lancaster, 1966) and the random utility theory (Luce, 1959; McFadden, 1973), where as design of the survey and the analysis of data are resulted from statistics (Hoyos, 2010).

A study of choice behavior is described by the objects of choice and sets of alternatives available to decision makers, the observed attributes of decision makers and the model of individual choice and behavior and distribution of behavior patterns in the population (McFadden, 1973). From the economists' point of view, the choice problem is a problem of maximization of a utility function. The random utility model assumes that utility is the sum of deterministic (V) and random (ε) components:

$$U_j = V(\beta X_j) + \varepsilon_j \tag{3.1}$$

Where U_j is the true, but unobservable indirect utility associated with alternative j, X_j is a vector of attributes associated with alternative j including the payment, β is a vector of preference parameters, and ε_j is a random error term with zero mean.

The choice behavior is assumed to be deterministic from the perspective of the individual since each individual selects the alternative that maximizes his or her utility, but stochastic from the perspective of the researcher since the researcher doesn't observe everything about the individual. Thus, the error term in the random utility expression reflects the researcher's uncertainty about the choice (Holmes and Adamowicz, 2003).

It is usually assumed that utility is linear in parameters:

$$U_j = \sum_{k=1}^{I} \beta_k X_{jk} + \varepsilon_j \tag{3.2}$$

where β_k is the preference parameter that is associated with attribute k, X_{jk} is attribute k in alternative j.

Model estimates are based on utility differences across the alternatives comprised in the choice sets. The stochastic term in the random utility function allows probabilistic statements to be made about choice behavior. The probability that an individual will choose alternative j from a choice set containing competing alternatives can be expressed as:

$$P(j/C) = P(U_j > U_i) = P(V_j + \varepsilon_j > V_i + \varepsilon_i), \forall_i \in C \tag{3.3}$$

Where C contains all of the alternatives in the choice set; and the standard assumption in using random utility model is that errors are independently and identically distributed following a type 1 extreme value distribution (Haab and McConnell, 2002).

3.3.1. Multinomial Logit Model

An econometric choice model is specified by choosing a parametric form for the utility function and a distribution for the stochastic terms. Hence, a random utility model and a type 1 extreme value (Gumbel) distribution yield the multinomial logit model. Hoffmnan and Duncan (1988) put a distinction between MNL and CL models though both are used to analyze the choice of an individual among a set of j alternatives. According to them the central difference between the two is that the former focuses on the individual as the unit of analysis and uses the individual's characteristics as explanatory variables; whereas the latter focuses on the set of alternatives for each individual and the explanatory variables are characteristics of those alternatives, however, for Green (2003), the distinction is artificial; and even other researchers present them interchangeably (Holmes and Adamowicz, 2003).

The application of the MNL model in CE relies on several restrictive assumptions. These are: preference structure is homogeneous over respondents; choices conform to the independence from Irrelevant Alternatives (IIA), and all errors have the same scale parameters (Holmes and Adamowicz, 2003). The IIA assumption follows from the initial assumption that the disturbances are independent and homoscedastic (Green, 2003). It is an important feature in choice experiment model as far as MNL is concerned which implies that the ratio of probabilities of choosing any two alternatives is independent of the attributes of all other alternatives.

Once the operational model is derived from the utility function where a linear in the parameters specifications for the deterministic component is assumed and assumptions are made concerning the joint distribution of the error terms, then the choice probabilities are given by the MNL model as:

$$P_j = \frac{\exp(\mu \beta X_j)}{\sum_{\iota \varepsilon C} \exp(\mu \beta X_i)} \tag{3.4}$$

where μ is a scale parameter, inversely proportional to the standard deviation of the error distribution. This parameter often cannot be separately identified and is therefore typically assumed to be one (Hanley et al, 2001; Adamowicz *et al*., 1998) that implies constant error variance (Hoyos, 2010).

When the restrictions of MNL model are relaxed, introduction of extension models that have statistical complication follow suit. The relaxation of common preference brings the RPL to the stage; and the relaxation of IIA rests in the nested logit, mixed multinomial logit (RPL) and multinomial probit models (Green, 2003; Holmes and Adamowicz, 2003).

3.3.2. Random Parameter Logit Model

Recent development in analytical models accounting for random taste heterogeneity offers new powerful analytical method for discrete choice models dominated before by the multinomial logit model. According to (Alpizar *et al*. 2001), the standard MNL model is bound to have two limitations: addressing taste heterogeneity and attributes correlation in environmental valuation problems. The RPL (also referred to in various literatures as mixed logit, mixed multinomial logit, kernel logit and hybrid logit) model is considered to be the most promising state of the art discrete choice model currently available (Hensher and Greene, 2001). RPL overcomes the problem faced with MNL and can estimate any random utility problem (Train, 1998). Moreover, unlike probit, it is not limited to normal distribution rather it can be normal, lognormal, triangular etc (Hensher and Greene, 2001).

Therefore, the mixed logit model relaxes the restrictive assumptions of MNL model that are the common preference and the IIAs. Like any random utility model of the discrete choice family of models, we assume that a sampled individual ($i = 1.....,I$) faces a choice amongst J alternatives in each of C choice sets. An individual, I, is assumed to consider the full set of offered alternatives in choice set C and to choose the alternative with the highest utility. The utility associated with each alternative, j as evaluated by each individual, i in choice set, C, is represented in a discrete choice model by a utility expression of the general form as:

$$U_{ij} = V(\beta_{\iota} X_{ij}) + \varepsilon_{ij} \tag{3.5}$$

X_{ij} is a vector of non-stochastic explanatory variables that are observed by the researcher and include attributes of the alternatives and socio-economic characteristics of the respondent, β_i and ε_{ij} are not observed by the researcher and are treated as stochastic. Within a logit context we impose the condition that ε_{ij} is independent and identically distributed (IID) extreme value of type-1 (Hensher and Greene, 2001).

In other expression, we can divide the observed component of the RUM, $\beta_\iota X_{ij}$ described in equation (3.5) in to two parts- the sum of the population mean, β and the individual deviation, η_i which captures the random and unobserved type of taste heterogeneity of each random parameter (Train, 1998; Haab and McConnell, 2002; Hensher *et al.*, 2005).

Hence, the deterministic component of the random utility function which is described in the way of RPL can then be written as:

$$V_{ij} = ASC + X_{ij}(\beta + \eta_i) \qquad (3.6)$$

Where, ASC is the alternative specific constant which takes the effects on utility of any attribute not included in choice specific attributes into account.

Assuming a general distribution for η_i, and IID extreme value distribution for ε_{ij} and considering preference heterogeneity, the probability that an individual i chooses alternative j in a choice set C can be expressed as:

$$P_{ij} = \frac{\exp X_j(\beta + \eta_i)}{\sum_{n\varepsilon \mathrm{C}} \exp X_n(\beta + \eta_i)} \qquad (3.7)$$

3.3.3. Part Worth and Compensating Surplus

One of the fundamental essence of estimation using any model is measuring a walefare change. However, the CE model has an advantage of generating estimates of several attributes at a time (Alpizar *et al*., 2001). Welfare can be drawn for each individual by observing the choices made among alternatives; and it is affected by changes in prices of goods (Johanson, 1987) and quantities and qualities of environmental resources (Freeman, 2003). The change in welfare of the individual could be measured through WTP or WTA. According to the analysis of Freeman (2003), both methods approximately provide the same result; yet most of the time they don't (Horowitz and McConnell, 2002). Neverthless, small differences between the true WTP and the true WTA are accepted theoretically (Freeman, 2003). Moreover, their disparity is the logical consequence of irreversibility or adjustment costs, uncertainty and timing of the transaction, even when the individuals are rational and have neoclassical preferences (Jinhua and Catherine, 2001).

Therefore, once the parameter estimates have been obtained, a WTP compensating surplus welfare measure that conforms to demand theory can be derived for each attribute using the following formula:

$$WTP = b_y^{-1}[\ln \sum_i \exp(V_i^1) - \ln \sum_i \exp(V_i^0)] \qquad (3.8)$$

where V^0 represents the utility of the initial state and V^1 represents the utility of the alternative state; and the coefficient b_y gives the marginal utility of income .

If the utility function is linear as the DCE mostly do, the above formula can be simplified to the ratio of coefficients given in the following equation:

$$WTP = {}^{-b_c}\!/_{b_y} \tag{3.9}$$

where b_c, the coefficient of any of the attributes; and this ratio is often known as implicit price or part worth (Hanley *et al*., 2001). The formula of the implicit price represents the marginal rate of substitution between income and the marginal willingness to pay for a change in the attributes.

Compensating surplus welfare measures can also be obtained for different scenarios with multiple changes in attributes as:

$$CS = -\frac{(V^0 - V^1)}{\beta_y} \tag{3.10}$$

where CS denotes compensating surplus; and the other variables are as described above.

3.3.4. Specific Choice Experiment Model

Both the standard MNL and mixed logit models were estimated using the data that was collected from sampled households of Addis Ababa by NLOGIT 5.0 software package that could captures preference heterogeneity. Additive utility function that is linear in the parameter is assumed in RUM with respect to attributes.

The indirect utility function comprises an alternative specific constant (ASC) that take into account the systematic differences in choice patterns between alternatives. ASC is a dummy variable that takes “1” for option 1 and 2 and “0” for the status quo. Hence, the indirect utility function is expressed as:

$$V_i = ASC+\beta_1 * RWQ+\beta_2 * RWV+\beta_3 * BFZ+\beta_4 * RECR+\beta_5 * PYT \qquad (3.11)$$

Where, V_i is indirect utility associated with alternative, $i = 1, 2, 3,$ and $\beta = 1, ...5$ are coefficients of attributes. From this we can specify utility functions for the alternatives as:

$$V_1 = ASC+\beta_1 * RWQ+\beta_2 * RWV+\beta_3 * BFZ+\beta_4 * RECR+\beta_5 * PYT$$

$$V_2 = ASC+\beta_1 * RWQ+\beta_2 * RWV+\beta_3 * BFZ+\beta_4 * RECR+\beta_5 * PYT$$

$$V_3 = \beta_1 * RWQ+\beta_2 * RWV+\beta_3 * BFZ+\beta_4 * RECR+\beta_5 * PYT \qquad (3.12)$$

ASC shows the SQ bias that compares utilities of alternatives relative to the base. Its sign is negative if a respondent is worse off when moving from the status quo to the other alternatives.

The alternative specific constant term could be interacted with socioeconomic and other variables that are expected to influence households' probability to choose either of the alternatives. Therefore, the utility function can be expressed as:

$$\begin{aligned} V_i = {} & ASC+\beta_1 * RWQ+\beta_2 * RWV+\beta_3 * BFZ+\beta_4 * RECR+\beta_5 * PYT+ \beta_6 ASC*AGE+ \\ & \beta_7 ASC* HHS+\beta_8 ASC* GENDER+\beta_9 ASC* Y+\beta_{10} ASC* EDUC+ \\ & \beta_{11} ASC* PROX+\beta_{12} ASC* UAP+\beta_{13} ASC* APV \end{aligned} \qquad (3.13)$$

3.3.5. Description of Variables and Hypothesis

ASC: The alternative specific constant is comprised in the model to capture the role of the unobserved source of utility like what the constant parameter does in the ordinary regressions with a constant term. It takes a value of one in alternative 1 and 2 and zero for the SQ.

Age: Older people have long years of experience in the city and could observe the gradual contamination of the river and may easily compare the impact and more informed about the problem of river pollution. Besides, they may feel altruism and crave to pass a clean and safe environment to their children. Hence, it was expected to affect the choice probability positively.

Household size (HHS): This variable is related to the number of people in the family. On the one hand, larger house hold size is expected to spend more and have less money to contribute for river protection. On the other hand, one, a family having many members may have many hands to work and bring income to the family; two, they need to have a clean and safe water that flows in nearby areas, since the probability of contamination is high and more importantly the cost of pollution to the family might be high. Consequently, the sign of the household size was difficult to be determined in advance.

Gender: It is a dummy variable that has a value of “0” for female respondents and “1” for male counterparts. Females have less participation in the economy especially in those sectors that may bring substantial income to the family and may refrain from contributing for environmental improvement while males do. Hence, it was expected to be positive.

Income (Y): This variable stands for the total money the household earns from different activities in a year. Assuming the need to have clean river water as a normal good, households having a higher income are expected to pay more. Hence, the variable was expected to have a positive sign.

Education level (EDUC): The level of education refers to the number of years a respondent spent in formal education. Households with higher level of education have more exposure to the problem of the environment in general and more cognizant to the solution of the problem, so that they are expected to be activists to the improvement of the river water pollution. Thus, it was expected to have a positive sign in the model.

Proximity to the river (PROX): The polluted river has direct and indirect impact on the residents of the city. Those households that live near to the river are highly affected by both impacts and may have a positive reaction to the protection of the river. However, the impact of the river minimizes for respondents living far to the river and hence expected to have a negative sign.

Participation in urban agriculture (UAP): It is comprised in the model to take in to account farm households in the city. So, it is a dummy variable which has "1" value for farm household and "0", otherwise. It was expected to have a positive sign.

Awareness of the Impact of Water Pollution on the production of Vegetables (APV): this explanatory variable is included in the model to capture the level of respondents' awareness of the impact of polluted water on the environment and health of the society. More aware people were expected to respond positively so did the sign of the variable.

Quality of the river water (RWQ): This variable is an attribute for protection of urban river water pollution. The improvement of the quality of the water increases the utility of households and, therefore, it was expected to have a positive sign.

Quantity of the river water (RWV): In the literature, the protection of streams could be also manifested by increment of the volume of river water. The variable was expected to have a positive sign.

Riparian buffer zone (BFZ): River protection doesn't only involve the river water but also resources of the river banks. Developing biophysical structures, planting trees and terracing, along the river banks has policy relevance, which uses for carbon sequestration that is emitted by vehicles and industries in the city and fence to block flooding. It was expected to increase the utility of the respondents and thereby carry a positive sign.

Recreational facilities (RECR): This attribute is included in the model to capture the recreational value of urban rivers. Most of the time people go to rivers for the purpose of swimming, boating, fishing; and scenic amenities via walking along the river banks. All of these recreational activities are impossible at the current circumstances since the river is highly polluted. Thus, improving the status of the river for the residents of the city to enjoy themselves along the streams will increase their utility. Hence, it was expected to hold a positive sign.

Payment (PYT): It is a monetary attribute representing the annual payment a respondent has to contribute for the protection of the river water pollution. Since an increase of the attribute level reduces the utility of the respondent, the payment attribute was expected to have a negative sign in the model.

3.3.6. Choice Experiment Design

In the CE valuation technique the experimental design play a paramount importance in the development of scenarios. The strength of the model is that it allows the researcher to manipulate the set of explanatory variables associated with the attributes of the environmental valuation problem. However, without a proper consideration of experimental design this asset can be a liability. There is no common rule that determines the number of attributes for an alternative, alternatives per choice set, replications and randomization of choice sets. The optimal combination of these terms is still a subject of substantial research (Holmes and Adamowicz, 2003; Rose *et al*., 2011).

Although it is free to choose as many attributes as desired, the larger the number of attributes the more difficult the choice for the respondent. On the other hand, increases in the number of attributes raise the effective sample size required to obtain a given level of precision on parameter estimates. Concerning to alternatives, they should be constructed in the way that respondents are forced to make trade-offs. Competing scenarios must be given equal opportunity and one scenario should not dominate the others in the choice set in possessing more of all good attributes and less of all the bad attributes. Though increasing the number of alternatives per choice set enhances the precision of parameter estimates, forcing respondents to make choice among too many alternatives may lead to a less meaningful result unless they are familiar with the attributes of the alternatives (Haab and McConnell, 2002).

There is also advantage and disadvantage in increasing replication of choice sets. Adding another choice set is similar to obtaining a bigger sample size with parsimony. However, if excess burden is imposed on the cognitive ability of respondents in increasing the number of replications, they may exhaust and adopt a simpler choice method that they may not reveal their true preference (Haab and McConnell, 2002).

Experimental design goes beyond determining the optimal number of attributes, alternatives and choice sets. A good experimental design considers whether to use labeled or unlabeled choice tasks, since the decision has impact on the number of parameters to be estimated (Rose *et al*., 2011). Moreover, the brand name may be collinear with attributes omitted from the choice problem and result omitted variable bias (Holmes and Adamowicz, 2003). The other argument is whether to include opt-out or SQ options or not. The inclusion of the SQ will let the model mimic an actual market situation (Holmes and Adamowicz, 2003). Besides, when one of the alternatives is the opt-out option, the calculation of implicit price relative to the SQ is easily done (Haab and McConnell, 2002). Imposing the attribute level balance where each attribute level appears an equal number of times for each attribute over the design; the number of attribute levels, inclusion of interaction effects and attribute level range are important considerations in experimental design procedures. The first three have impact on the number of choice tasks required of a design. Using a wide attribute level range is statistically preferable which lead to parameter estimates with smaller standard errors. But, having too wide range results a choice set with dominated alternatives, whereas, too narrow range is inappropriate that results indistinguishable alternatives (Rose *et al*., 2011).

3.3.6.1. Definitions of Attributes and Assignment of Levels

The development of attributes and attribute levels should pass several steps in CE method. They can be developed through literature reviews, expert consultation, focus-group discussions and pre-tests before the final survey is conducted. In this study five attributes were identified corresponding with their attribute levels including the monetary payment attribute via literature reviews, pilot survey, expert consultation, peer-group discussion and pre-testing. The attributes are quality of the river water, volume of the river water, riparian buffer zone, recreational facilities and the monetary payment.

The quality of the river water is the first attribute. Studies indicated that the 'Tinishu' Akaki river water is highly polluted; however, it is being used for different purposes like for irrigation to grow different vegetables which are marketed in the city, washing clothes and vegetables which have health risks. Besides, the river emits bad odor that causes respiratory diseases. The sources of pollution are municipal, industrial and service providing organizations effluents and solid wastes dumped on open sites and rivers. The quality of the water could be improved by controlling solid wastes and effluents dumped into open ditches through awareness creation and law enforcement; disposing municipal sewages appropriately in privately and communally constructed septic tanks; increasing the capacity of central treatment plants; and treating industrial effluents.

The quality of the river water has three levels: moderate, good and very good. However, water quality is subjective and has different criteria; and, thus, difficult to standardize as such. To avoid the difficulty, the measurement of river water quality was approached from the economic importance it provides. For such purpose six economic activities which are being practiced using the 'Tinishu' Akaki River were identified. These economic activities are irrigation, animal drinking, washing clothes and vegetables, swimming or bathing and home consumption. They need different water quality depending on their sensitivity and nature of filtration process. Therefore, the river water that can be used for irrigation only; irrigation and animal drinking only; irrigation, animal drinking, washing clothes and vegetables and bathing was leveled as moderate, good and very good, respectively.

The second attribute is the volume of the river water. Some of the tributaries of the 'Tinishu' Akaki River are intermittent which dry during winter season that reduces the volume of the water. The entire tributaries stem from the Entoto Mountain located northern part of Addis Ababa at 3200 meter above sea level. The Entoto Mountain chain stretches from North West to North East of the city. The northern rim is used as a watershed for the Nile River whereas the southern rim contributes for the Awash River. Most of the area of the mountain is covered by eucalyptus trees Eucalyptus tree has been the back bone of the city in responding for the demand for fire wood and housing construction. However, it is controversial as far as ground water and soil erosion are concerned. Most foresters argue that Eucalyptus trees are alleged to impede the establishment of other plants in their understory by outcompeting them for the available soil moisture and nutrients, as well as by direct inhibition through phototoxic exudates of their leaves and litter. Furthermore, the trees do not provide organic matter and deplete soil nutrients and water resources and suppresses ground vegetation and resulting unsuitability to soil erosion control. The leaves of Eucalyptus species have allelopathic effect. Hence, it increases flooding during the rainy season through preventing the percolation of rain in to the ground (Fekadu, 2008).

The forest is administered by the Addis Ababa city administration and the Oromia Regional State. The former has already started replacing the area by coniferous trees while the latter has planned to replace it in the future. This is a good opportunity to increase the volume of the water. The volume of the water can also be enhanced by terracing, water shade management, and planting trees on the degraded part of the mountain. Therefore, to increase the quantity of the river water, two activities are proposed. The first one is to replace the eucalyptus with indigenous trees. The second activity is to plant trees on degraded areas and terracing in addition to replacement so that the area will be transformed in to a Semi-Afro Mountain Temperate Forest. On account of these, there will be a partial and substantial improvement of the volume of the river water, respectively.

River protection doesn't only involve the river water but also resources of the river banks. So, riparian buffer zone is the third attribute that has three levels. The Addis Ababa Environmental Protection Authority has prepared a master plan for greening the city. One of the targets is preparing a buffer zone along the river banks of the city. Developing a buffer zone has several advantages. Planting trees is one criterion for being a good city. That is why the administration is planning to cover 41 % of the city with trees. Planting trees on the river banks will reveal the other areas to be used for other projects as there is a shortage of land in the city. Trees that are grown on river banks could be useful for carbon sequestration since carbon dioxide emission is escalating in the city attributed mainly by increasing number of vehicles and industries; and some trees have the ability to purify toxic elements emitted from industries. The other advantage of riparian buffer zone is avoiding unpredicted floods on the nearby houses. Hence, the attribute levels are 10, 20 and 30 meters wide on average.

The fourth attribute is the recreational facilities. Addis Ababa is a big city having more than four million residents and hosts different international and continental organizations and more than hundred embassies. Now days, it is common to observe conferences being hosted in the city. It is a good opportunity for expanding conference tourisms. Besides, international and local tourists use the city as a transit to other tourist destination sites. For that, there should be open air recreational facilities in addition to infrastructural and hotel developments. Nevertheless, the city has very limited recreational facilities. There are only few parks. Most of the time residents of the city complain on the accessibility of recreational facilities. Addis Ababa is not located to seas naturally and there are no beaches for recreation for the residents. So what the city has is the rivers and hence, it is possible that the rivers can be recreational sites for the residents if they are protected from pollution so that the rivers can compensate the unavailability of beaches. By improving the status of the river, it is possible to make it a recreational site. Hence, this attribute has three levels- planting trees and constructing pedestrian roads so that people can walk on river banks. The second level is planting trees, constructing pedestrian roads and preparing chairs on river banks so that people can spend some time sitting there and enjoying the scenery. The third level is planting trees, constructing pavements, preparing chairs and building resorts that have swimming pools and play grounds.

The last attribute is the monetary payment. The payment will be per annual for five consecutive years that is going to be added to water bills. There are six payment attribute levels. Currently, residents are polluting rivers, yet they are paying zero birr. So, the payment levels are 10, 25, 50, 100, 150 and 200. Moreover, the project will be managed by AAEPA, collaborating with stakeholders, AAWSA, City Government of Addis Ababa Beautification, Park and Cemetery Development and Administration Agency, Gulelle Botanical Garden, Oromia Forest and Wild Life Protection and Development Enterprise, City of Addis Ababa Solid Waste Management Agency, Addis Ababa Urban Agriculture Bureau and Non-Governmental Organizations. Attributes and attribute levels are summarized in the following table.

Table 3.1 Summary of attributes and attribute levels

Attributes	Description attributes	Attribute levels
River water quality	Improving the quality of the river water	**SQ:** poor **Improvement plan:** ✓ Moderate, ✓ good and ✓ very good
River water volume	Improving the volume of the river water	**SQ:** weak flow **Increment plan:** ✓ Partial improvement and ✓ Substantial improvement
Riparian buffer zone	Developing biological and physical structures on rivers and river banks.	**SQ:** No buffer zone **Development of buffer zone on average:** ✓ 10 meters, ✓ 20 meters and ✓ 30 meters wide
Recreational facilities	Planting trees Constructing roads, preparing out-door chairs and building resorts across rivers	**SQ:** no recreational facilities **Preparing recreational centers that have different facilities:** ✓ Trees + Pedestrian Roads, ✓ Trees + pedestrian Roads + Chairs ✓ Trees + Pavements+ Chairs + Resorts
Monetary payment	Annual payment for the implementation of the plans	**SQ:** Birr 0 **Monetary payment:** ETB 10, 25, 50, 100, 150 and 200

3.3.6.2. Experimental Design

In experimental design alternatives are described by a number of attributes and differentiated by independent attribute levels. The combination of alternatives, factors and factor levels are known as choice sets. A full factorial design creates an alternative for each possible combination of all factors (Haab and McConnell, 2002). It contains all possible different choice tasks. However, for practical reasons, the number of choice tasks in a full factorial design is too large which is impossible for respondents to reveal their preference; and computational complexity of estimation is a huge burden (Hensher *et al*., 2005; Garrod and Willis, 1999; Rose et al, 2011). Therefore, to reduce the cognitive burden and computational complexity, most researchers rely on fractional factorial design (Rose et al, 2011). However, the loss of information is inevitable (Holmes and Adamowicz, 2003). Hence, the key design issues stem from selecting the appropriate fractional design (Haab and McConnell, 2002).

Different classes of fractional factorial designs exist in the literature. Among them, the best known fractional factorial design type is the orthogonal design (Rose *et al*., 2011). Orthogonality has been the principle of an efficient design, which aims to minimize the correlation between the attribute levels in the choice set (Alpizar *et al*., 2001; Rose et al, 2011). Several methods for constructing an orthogonal design prevail in the choice experiment literature. The L^{mn} orthogonal fractional factorial design is the most practiced orthogonal design type where L is the number of attribute level, m is the number of non-SQ alternatives; and n is the number of attributes (Rose *et al*., 2011). Unlike a binary choice model, a version of dichotomous used in contingent valuation, where the full factorial design in CE reduces from L^{mn} to L^{n} , the design of choice experiment is complicated in which respondents will be required to compare two or more alternatives simultaneously (Holmes and Adamowicz, 2003).

From the five attributes with their corresponding attribute levels that are the quality of the river water, volume of the river water, riparian buffer zone, recreational facilities and monetary payment; the numbers of complete combinations of profiles are $324\left(3^3 * 2 * 6\right)$. From this 18, 100 % D-Efficient, choice sets were produced using a fractional factorial orthogonal design method. The 18 choice sets were blocked in to three and randomized five times. Each respondent was presented six consecutive choice sets with three alternatives, two with different combinations of attribute levels and the SQ which is the same in all the choice sets. Colored choice cards that contain images of attribute levels were presented to respondents to make the choice set more vivid.

3.3.7. Questionnaire Development

The English version of the questionnaire was translated into Amharic version. The survey questionnaire comprised four parts. The first part of the questionnaire was devoted to collect respondents' attitude, observation and opinion about pollution and protection of rivers in the city. Then, different choice sets of the choice experiment scenarios were presented to respondents. In the third part of the questionnaire, respondents were asked a follow up questions after the choice sets which were assumed to be helpful understanding his or her reasoning of choosing a particular alternative. In the final part of the questionnaire, information on respondents' socio-economic characteristics were gathered.

CHAPTER FOUR

ANALYSIS AND RESULTS

4.1. Descriptive Analysis

4.1.1. Socio-Economic Characteristics of Respondents

Under the choice experiment questionnaire respondents were interviewed about their socioeconomic conditions. As it is revealed in the following tables among the 315 households interviewed 52% are female respondents. The average age of respondents is 41 and the minimum and maximum is 18 and 85 years old, respectively. All of them were decision makers, since the study mainly focused on the interviewers' decision making ability rather than aged member of the family. The minimum and maximum number of family members is 2 and 12, respectively while the average is 5.27. The mean educational attainment of respondents is 8.46 years. When the minimum education is 0, the maximum educational achievement is 19 years (master level). 8.89 % did not attain basic education from which 75 % are female respondents and 6.67 % from the whole samples. 60 % completed primary education, i.e., eight years, and 12.38 % are either first or second degree holders.

Most of the time people do not provide accurate information about their income. For this reason, respondents were presented different questions that are proxy to income such as number of workers in the family, interval of monthly income of the family and monthly food expenditure of the family. All of the information gathered was compared with the monthly income of the family. The income of the total family was taken rather than the monthly income of the respondent. Accordingly, based on the survey the minimum annual income of the households is 3600 and the maximum annual income is 300,000 birr. The average annual income of the family is ETB 33,613.6.

Table 4.1 Qualitative Socio-Economic Characteristics of Respondents

Qualitative variables	Frequency	%
Gender (Female)	164	52.06
No education	28	8.89
No education and female	21	6.67
Primary education completion	189	60.00
BA/BSc and MSc	39	12.38
Urban agricultural practice	27	8.57
Use the river for irrigation	20	6.35

Respondents were also asked if they practice urban agriculture. Around 9% of them do base their lives mainly on the production and supply of fresh vegetables to the surrounding communities. Among those urban farmers 74% (6.35% from the whole sample) irrigates the Little Akaki River while the rest 26% of respondents use other options like dug wells and pipe water. The proximity of the house of the respondents to the Little Akaki River ranges from 10 meters immediate to the river to 3 kilometers. The average distance of houses from the river is approximately 0.6 kilometer. Moreover, respondents were interviewed on dejure bases that the minimum living experience of the individual in that particular area is one year while the maximum is 85 years.

Table 4.2 Quantitative Socio-Economic Characteristics of Respondents

Quantitative variables	Mean (Std.Dev.)	Minimum	Maximum
Age	41.03 (13.11)	18	85
Household size	5.27 (1.99)	2	12
Education (all samples)	8.46 (4.68)	0	19
Household income (ETB/annum)	33613.6 (30894.48)	3600	300000
Proximity to the river (kilo meter)	0.57 (0.61)	0.01	3
Living experience in Addis Ababa	30.42 (14.89)	1	85

4.1.2. Awareness and Perception of Respondents on the Impact of River Water Pollution

Interviewees were asked about their opinion on who is more responsible for the protection of the Little Akaki River. Accordingly, more than 60 % of respondents believe that those who pollute the river should take the main responsibility to protect the river from pollution. Whereas, nearly 40 % argue that those who use the river should take the responsibility. Concerning the effluent disposal options, almost 26 % dispose effluent wastes in septic tanks that are either directly connected to the tube which takes the effluent to Akaki treatment plant or deposited and taken by vehicle later. Whereas, 74 % use either open ditches (43 %) or open spaces (31 %) that in any way eventually end up in to the river. Almost all households- 99.4 %, separate solid wastes from effluents before disposing. For the solid wastes there are private enterprises that collect on weekly bases.

Table 4.3 Awareness and perception of households on the impact of river water pollution

Variables		Frequency	%
Responsibility	Polluters	191	60.63
	Users	124	39.37
Effluent disposal options	Toilets (septic tanks)	83	26.35
	Open ditches (canals)	135	42.86
	Open spaces	97	30.79
Segregate wastes (yes)		313	99.37
Habit of eating raw vegetables (yes)		222	70.48
Awareness on the production of vegetables (yes)		255	80.95
Awareness	Aware but eat	183	58.09
	Aware and don't eat	72	22.86
	Don't aware and eat	39	12.38
	Don't aware but don't eat	21	6.67
Awareness on health risk (yes)		285	90.48
Aware on production and health risk, and eat		174	55.24
Incidence of water born diseases in the family (yes)		97	30.79
Incidence of respiratory diseases in the family (yes)		190	60.32
Experience of odor (yes)		281	89.21

Respondents were also asked about the habit of eating raw vegetables like tomato and lettuce. Around 29.5 % never eat vegetables unless well cooked, while the rest, 70.5 %, have the habit especially during fasting seasons. However, they use different cleaning mechanisms like washing, using lemons and slight heating. They were also interviewed whether they are aware of the production of vegetables marketed in their area using polluted water. Nearly 81 % of respondents have awareness, while 19 % haven't. Particularly 58 % of respondents have habit of eating raw vegetables though they are aware of the production condition of the vegetables. 22.86 % do not eat raw vegetables because they are aware of the production. Around 12.38 % eat but not aware, whereas, 6.67 % do not eat raw vegetables and also not aware of their production.

Regarding the health risk of vegetables produced using contaminated water, 90.5 % have awareness on the potential health risk. Those who eat raw vegetables even if they know that vegetables are produced using polluted water and have health risk are 55.24 %. At a point of time across households, the habit of eating raw vegetables reduces as awareness increases.

More than 89 % of respondents experience bad odor whenever they cross river bridges and live near to the river. Nearly 31 % of respondents' family members are affected by water born diseases. In the case of respiratory diseases the percentage increased to more than 60 %, almost double. Although it is difficult to differentiate whether the sole cause of these diseases is the pollution of the river, its impact is undeniable.

4.2. Analysis of the Choice Experiment Results

The 18 choice sets obtained from 100 % D-efficient experimental design were blocked in to 3 and each block was randomized 5 times to increase the variability of the choice sets so that only 21 respondents were assigned to complete the same choice sets. Hence, 315 respondents were interviewed to complete six consecutive choice sets. The 315 respondents completing six choice sets resulted with a total of 1890 observations available for the final estimation. Moreover, the attribute levels were appropriately coded to be entered in NLOGIT 5.0 econometrics software package for estimation.

Thus, the attribute levels of the quality of river water; moderate, suitable only for irrigation, was coded as "1", good, that can be used for animal drinking and irrigation was coded as "2"and the very good level that is conducive for irrigation, drinking animals, swimming and washing clothes and vegetables was coded as "3". The volume of river water attribute has two levels, partial and substantial improvements and they were coded as 1 and 2, respectively. The riparian buffer zone has also three attribute levels: 10, 20 and 30 meters wide. They were entered directly as they are. The attribute levels of recreational facilities: trees and pedestrian road was coded as "1", trees, pedestrian road and chairs was coded as "2" and trees, pavements, chairs and resorts was coded as "3". The payment attribute levels 10, 25, 50, 100, 150 and 200 were entered directly. Moreover, the SQ in all attributes took a value of zero.

4.2.1. The Multinomial Logit Results

To begin with, the basic MNL model was estimated. As it is presented in table 4.6 (column one), all parameters are significant at 5% and 1%. Particularly, the parameters of river water quality, volume of the river water and the recreation facilities were significant at 1% and have the expected sign indicating a positive preference towards the new proposed options. The parameter of riparian buffer zone is significant at 5% with the expected positive sign. The payment coefficient is also significant at 1% and has the expected negative sign that showed the negative preference of respondents as the payment level increases. The ASC is significant at 5% and carries a negative sign which is not expected. It was expected that respondents' utility will increase as they move from the SQ to the new alternatives. But, the significant and negative sign of ASC confirmed that they are hesitant to move away from SQ.

However, the estimates of the MNL model are based on the IIA assumption. The IIA assumption is restrictive and results might be spurious. Therefore, the Hausman-McFadden test or the IIA test, (Hausman and McFadden, 1984), is conducted to check the reliability of the MNL estimates. To do so, first of all, the MNL model that contains all three utility functions (Equation 3.12) was estimated (Hensher *et al.*, 2005). Then, by dropping out alternative one followed by alternative two, restricted models were estimated. The result of the last two estimations is presented in table 4.4 below.

Table 4.4 The Hausman-McFadden test for IIA in basic MNL model

Alternatives excluded	Chisqrd	Degrees of freedom	Pr(C>c)
Alternative one	25.6067	6	.000264
Alternative two	14.3789	6	.025678

According to table 4.4, the IIA assumption is rejected at 1% and 5%. Hence, estimation of the basic MNL could generate misleading results. Besides, the log likelihood function is -1561.487, higher than the other models in table 4.6, and the adjusted McFadden Pseudo R^2 is 0.1308 that the explanatory power of the model is very low. As a rule of thumb, the Pseudo R^2 or log likelihood ratio index (LRI) greater than 0.2 is termed as adequate model (Hoyos, 2010).

The next procedure was to estimate the extended MNL model. Therefore, the extended MNL was estimated by introducing the socioeconomic characteristic and awareness variables interacting with an ASC. The interaction variables control the observable heterogeneity of respondents.

The Hausman test for IIA assumption for the MNL model with interactions was also conducted to check the reliability of estimates when socioeconomic and awareness arguments included in the model. Based on table 4.5, we fail to reject the IIA assumption that states the ratio of two alternatives is not affected by the inclusion or exclusion of another alternative (Hensher *et al.*, 2005). Hence, the extended MNL model is appropriate from the perspective of the IIA assumption.

Table 4.5 The Hausman-McFadden test for IIA in extended MNL model

Alternatives excluded	Chisqrd	Degrees of freedom	Pr(C>c)
Alternative two	15.0244	12	.240105

Therefore, as it is revealed in table 4.6 (column two), the sign of ASC is negative, but it is not significant even at 10%. The parameters of river water quality, river water volume, recreational facilities and payment are significant at 1% and have the expected signs. The riparian buffer zone is significant at 5% and has the expected sign. All of the attributes are important determinants for the choice of improvement scenarios.

In the extended MNL model, eight socioeconomic and awareness variables which are proximity to the river, gender, age, education, urban agricultural practice, household size, annual income of the household and awareness on the production of vegetables were interacted with the ASC. Accordingly, proximity to the river, gender, age, urban agricultural practice, annual income and awareness on the production of vegetables were significant at 1%, while education and household size are significant at 5% and 10%, respectively. All interaction variables have the expected sign except the participation in urban agriculture and age; and the sign of household size was left to be determined by the model. So, the household size affects the probability of choosing the new options negatively. Those respondents who practice urban agriculture were expected to prefer the new improved options. Concerning the age of the respondents, those who are older were assumed to be altruist and have more experience about the pollution of the river so that they could prefer the improvement scenarios. However, practically as age of the respondent increases, preference for the new options decreases.

The log likelihood function and the adjusted McFadden Pseudo R^2 for the extended MNL model are -1403.640 and 0.2170, respectively. Even though the goodness of fit of the model is relatively better than the basic MNL model, it is very poor compared with the RPL models, (see table 4.6). This might be due to the fact that the MNL model has another restrictive assumption other than IIA that preference structure is homogeneous over respondents (Holmes and Adamowicz, 2003). Therefore, another DCE model that considers random taste heterogeneity (Alpizar *et al*., 2001) and captures the unobservable heterogeneity of respondents should be introduced to the analysis. That model is the mixed logit or RPL model since it is becoming increasingly accepted (Hanley *et al*., 2006).

4.2.2. The Random Parameter Logit Results

In the estimation of both the basic and the extended RPL models a standard Halton sequence was applied and 400 replications were used in the simulated draws. Besides, to avoid potential misspecification, a robust standard error was employed. The ASC, river water quality and quantity, riparian buffer zone and recreational facilities are specified as random parameters drawn from a normal distribution though the appropriateness of distributional assumptions of the random parameters comprised in RPL model is not yet tested (Hoyos, 2010). The parameter of the payment attribute is assumed to be fixed.

The basic RPL parameter estimates are presented in table 4.6 (column three). The random parameter estimates of ASC, river water quality and recreational facilities are significant at 1% and the riparian buffer zone is significant at 5%, whereas, the random parameter estimate of river water volume is insignificant. All of the parameters have the expected sign. The parameter of the payment attribute is significant at 1% and has the expected sign. Furthermore, all the derived standard deviations of the random parameters except the river water volume are statistically significant at 1%. The insignificant parameter estimate of the river water volume for derived standard deviation indicates that the dispersion around the mean of the volume of the river water is statistically equal to zero so that all information in the distribution is captured by the mean and a single parameter is representative of all sample population (Hensher *et al*., 2005). To solve the problem, it is possible either to make the variable fixed or to introduce more information like interaction terms. Therefore, the RPL model with interaction is estimated.

As it is also presented in table 4.6 (column four), all the random parameter estimates are significant below 10%. Specifically, river water quality and recreational facilities are significant at 1%; and ASC and riparian buffer zone are significant at 5%, while river water volume is significant at 10%. Moreover, the expected sign of all random parameters is as expected. The positive sign of the ASC indicates that the utility of respondents on average increases as they move from the current situation to the proposed scenarios unlike the results of the MNL models. The probability of choosing the new options increases as the attribute levels of river water quality and quantity, buffer zone and recreational facilities improves. Regarding the non random parameter of the payment attribute, it is significant at 1% and posses the expected sign. The negative sign of the payment coefficient indicates that choosing an alternative with higher payment level reduces utility of respondents. This argument is consistent with the theory of demand which states that options with lower payment level are more preferred to options with higher payment levels, ceteris paribus. These results confirmed that positive and significant economic values prevail for higher attribute levels for the protection scenarios, yet respondents don't want to be charged higher amounts of payment.

Moreover, all the derived standard deviations of the random parameters are statistically significant at 1%. Significant parameter estimates for derived standard deviations for random parameter implies the existence of heterogeneity in the parameter estimates over the sampled population around the mean parameter estimates. Hence a single parameter estimate like that of the MNL model is insufficient to represent all sampled respondents.

In the RPL model with interactions, eight socioeconomic and awareness variables mentioned in the extended MNL model were introduced. Accordingly, proximity to the river, gender, age, education, urban agricultural practices and annual income are significant at 1%. Awareness of respondents on the production of vegetables is significant at 5%, whereas household size is insignificant even at the generous 10%. Regarding the expected sign, except age and urban agricultural practices, all of the socioeconomic and awareness variables have the expected sign. The probability of choosing the new options decreases as the respondent lives far from the river due to the fact that the impact of the pollution reduces as one move away from the river. Male respondents prefer the proposed options. The higher the educational achievement is, the higher the awareness of the problem of pollution and the deeper the understanding of the impact of pollution on the environment beyond the society so that the higher is the probability of choosing the proposed scenarios. Respondents who have higher annual income are more prefer improved scenarios because higher income respondents may have enough money to contribute for protection. Most of vegetables supplied to the market of Addis Ababa are produced using the polluted urban rivers. Hence, respondents who are aware of this preferred improvement.

The sign of age was expected to be positive. Ideally, it was assumed that older respondents live in the city longer than younger one so that they have observed the gradual contamination of the river and may easily compare the impact of river pollution in their area. Moreover, they might be tempted to pass clean river for their children. However, practically, older respondents are less educated, have less annual income and have more family size so that less preferred the improvement scenarios which cost the respondent. The other unexpected sign is participation on urban agriculture. Urban agricultural practice has expected to have positive sign due to the fact that urban farmers have immediate contact with polluted river water and they don't use safety protection. Hence, the contaminated water cause illness during the production process (Alebel *et al*., 2011) in addition to the health risk caused by consumption. However in the model it negatively affects respondents' preference for the attributes. The reason might be that their land is located near to the river. If they prefer the new options, they may lose their land due to the expansion of the buffer zone. The other reason might be also the nature of the current river water. The river is polluted by municipal, service providing organizations and industrial liquid wastes. These effluents have fertilizers that are conducive for vegetable growing. When the quality of the water is improved they lose the fertilizer and they will be expected to purchase inorganic fertilizers from the market.

This is possibly unwanted expenditure by farmer respondents so that less preference for the new scenarios.

The log likelihood function of the extended RPL model is -1040.594 which is relatively the nearest to zero (see the summary statistics in table 4.6). Moreover, the adjusted Pseudo R^2 is the highest, 0.499. Therefore, the model best explains the data. Moreover, the chi squared of RPL model with interaction, 2071.57 significant at 1% is higher than the basic RPL model having chi squared 2018.64 at 1% significant level.

Table 4.6 Results of the MNL and RPL models

Variables	MNL Coef(St.Err.)	Extended MNL Coef(St.Err.)	RPL Coef(St.Err.)	Extended RPL Coef(St.Err.)
			Random parameters	
ASC	-.44002** (.18773)	-.63886 (.43317)	9.20470*** (1.97844)	8.09100** (3.60573)
RWQ	.60813*** (.03875)	.61928*** (.03931)	1.56694*** (.28738)	1.58459*** (.22710)
RWV	.26470*** (.05934)	.26685*** (.05988)	.15921 (.12994)	.22607* (.13636)
BFZ	.00896** (.00372)	.00913** (.00375)	.02585** (.01041)	.02600** (.01145)
RECR	.28987*** (.03868)	.29642*** (.03919)	.42553*** (.11348)	.48892*** .11839
			Nonrandom parameters	
PYT	-.00651*** (.00054)	-.00667*** (.00055)	-.01655*** (.00285)	-.01754*** (.00255)
PROX		-.97020*** (.12845)		-5.44839*** (.91543)
GENDER		.58140*** (.19318)		6.60035*** (1.47944)
AGE		-.03570*** (.00670)		-.20183*** (.07157)

EDUC		.05661** (.02281)		.28741*** (.10489)
UAP		-.93348*** (.27244)		-3.22473*** (.91976)
HHS		-.08874* (.04785)		.13548 (.23497)
Y		.78509D-04*** (.8818D-05)		.00015*** (.3146D-04)
APV		.57308*** (.20236)		2.66893** (1.29595)
Derived standard deviations of parameter distributions				
NsASC			11.0386*** (2.67333)	8.67639*** (1.44575)
NsRWQ			2.20195*** (.37554)	2.26265*** (.28690)
NsRWV			.47693 (.62661)	.85704*** (.28319)
NsBFZ			.12931*** (.02328)	.14454*** (.03262)
NsRECR			1.04951*** (.21858)	1.14741*** (.22410)
Summary statistics				
N (Observations)	1890	1890	1890	1890
Respondents	315	315	315	315
K	6	14	11	19
LLF	-1561.487	-1403.640	-1067.059	-1040.594
Adjusted R^2	.131	.217	.486	.499
AIC (AIC/N)	3135.0(1.659)	2835.3 (1.5)	2156.1 (1.141)	2119.2 (1.121)
Iterations	5	8	41	60
Chi squared [significance level]	-	-	2018.63602 [.00000]	2071.56655 [.00000]

Note: nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.

***, **, * ==> Significance at 1%, 5%, 10% level.

4.2.2.1. Estimation of Marginal Willingness to Pay

The marginal willingness to pay or part worth (implicit price) (Hanley *et al*., 2001) represents the marginal rate of substitution between the payment attribute and the other attributes. Thus, implicit price reflects respondents' willingness to pay for an additional unit or/and level of an attribute of interest to be present, other attributes remaining constant. When parameter estimates are obtained from a linear utility function, the marginal utility function can be calculated as the ratio of river protection attributes and the monetary payment as depicted in equation (3.9). Results of the implicit prices in table 4.7 are manipulated using the attribute coefficients estimated using the models of MNL and RPL with interactions in table 4.6, in column two and four, respectively.

Table 4.7 Marginal willingness to pay results for attributes

Variables	MWTP (ETB/Year) for MNL	MWTP (ETB/Year) for RPL
RWQ	92.85	90.34
RWV	40.01	12.89
BFZ	1.37	1.48
RECR	44.44	27.87

The marginal willingness to pay results are obtained from the ratio of significant and normally distributed attributes and fixed monetary payment as numeraire. Thus, the distribution of the marginal willingness to pay is normal (Carlsson *et al*., 2003). Marginal willingness to pay results obtained from the MNL and RPL models are quite different for the attributes of river water volume and recreational facilities that the MWTP results obtained from MNL model are higher than the results obtained from the RPL model though the results of river water quality and buffer zone are relatively similar. Due to the existence of preference heterogeneity which is not captured in the MNL, reporting the MNL model results for policy decision is misleading.

The interpretation of the results found in the RPL model is as follow, ceteris paribus: as it is reported in the above table (third column), respondents attached the highest value to the quality of the river water. They are on average willing to pay around 90 birr per year for additional water quality level. The second highest value attached by the respondents is the attribute of recreational facilities. That is, on average they are willing to pay around 28 birr per year for extra level. Respondents are also willing to pay approximately birr 1.5 per year for additional meter of buffer zone. The least value is attached to the volume of the river water that is around 13 birr per year.

4.2.2.2. Estimation of the Compensating surplus

Compensating surplus is an economic welfare measure. It is the change in income which makes an individual indifferent between the SQ and the new scenarios that contain improved river protection attributes. So, the change in income indicates individual's WTP for higher improvement scenarios. Based on the indirect utility functions, the compensating surplus can be calculated using equation (3.10). Thus, for the purpose of computing the compensating surplus, the following improvement scenarios were arranged:

1. **Current situation (SQ):** in this scenario the river water is badly polluted and should not be used for any economic activities. The river has a weak flow especially during dry season. There is no buffer zone and houses are built immediate to the river. Recreational facilities are not built around the river banks.
2. **Scenario one (low impact improvement scenario):** in this scenario the quality of the river water is improved to moderate to be used for irrigation purpose. The volume of the river water is partially improved. The riparian buffer zone is expanded by 10 meters on average. Trees are planted; and pedestrian roads are constructed.
3. **Scenario two (medium impact improvement scenario):** in the second scenario the quality of the river water is good enough to be used for irrigation and animal drinking. The quantity of the river water is substantially improved. The riparian buffer zone is expanded by 20 meters on average. Trees are planted; pedestrian roads are constructed; and chairs are prepared.
4. **Scenario three (high impact improvement scenario):** in the third improvement scenario, the quality of the river water is very good that it can be used for irrigation, animal drinking, washing clothes and vegetables and swimming or/and bathing. The volume of the river water is substantially improved. The riparian buffer zone is widened to 30 meters on average. The recreational facilities are equipped with trees, pavements, chairs and resorts that have swimming pools and play grounds.

Using the parameter coefficients estimated in the random parameter logit model with interactions, the results of the compensating surplus from the above scenarios are presented in table 4.8 beneath.

Table 4.8 Compensating surplus

Scenarios	Compensating surplus (ETB/Year)
Scenario one	607.2
Scenario two	753.2
Scenario three	886.2

As it is shown in the above table, the value of compensating surplus increases as one moves from scenario one to scenario three. This is due to the fact that attribute levels are improved in the high impact improvement scenarios. Accordingly, on average, respondents are willing to pay 607.2, 753.2 and 886.2 for scenario one, scenario two and scenario three, respectively.

4.3. Analysis of Follow up Questions

Respondents were presented with three consecutive follow up questions beneath the choice sets that reveal reasons of prioritizing their preference regarding alternatives. As presented in table 4.9, in the first question, respondents were asked why they chose the SQ option if they did. The majority from those who opted for SQ, 13.97 %, explained that they have no enough money to contribute for the protection of the river even if they need the project to be realized. While 1.27 % of respondents refused to pay because they have doubts about the money they contribute will be for the implementation of the project. About 0.95 % chose the SQ because they believe that they are not responsible for the pollution of the river. 0.32 % preferred the do nothing option, for she argued that protecting the river is the sole responsibility of the government.

The purpose of the second follow up question was to disclose the first priority of the respondents in preferring the new proposed options. Accordingly, 56.51 % preferred the new options because of the quality of the river water followed by 25 % for the recreational facilities. 8.89 % of respondents prioritized the riparian buffer zone, whereas, for 2.86 % is the volume of the river water.

Respondents were also asked about their first criterion for choosing either of the new proposed options in the third follow up question. Hence, 38.73 % chose the alternative that contains higher water quality whatever the amount of the payment, while 25.71 % always opted for the least cost protection option. About 18.73 % chose the alternative that has better recreational facilities, and 2.22 % opted for the alternative that has higher quantity of river water. Nearly 4 % of respondents chose the alternative that has wider buffer zone, but 4.44 % chose the alternative that has narrow buffer zone.

In general, 6.67 % of respondents chose the SQ in all six consecutive choice sets, while 83.49 % chose only the new proposed options. Around 9.84 % chose both the SQ and the new options depending on the amount of the payment attribute.

Table 4.9 Follow up questions

Follow up questions		Frequency	%
Reasons for choosing the SQ option			
1	I don't believe that the money that I will contribute will actually go to protection of the river	4	1.27
2	Protecting urban rivers is the sole responsibility of the government	1	0.32
3	I have no money left for river protection	44	13.97
4	I don't want to pay since it is polluted by other bodies	3	0.95
Total		52	16.51
The number one priority to choose alternatives other than the SQ			
1	The quality of the river water	178	56.51
2	The volume of the river water	9	2.86
3	The riparian buffer zone	28	8.89
4	The recreational facilities	79	25.00
Total		294	93.33
The immediate criterion to choose either of the new proposed alternatives			
1	I always opted for the least cost protection option	81	25.71
2	I chose the alternative that contains higher water quality	122	38.73
3	I opted for the alternative that has a wider buffer zone	11	3.49
4	I chose the alternative that has better recreational facilities	59	18.73

5	I opted for the alternative that has higher quantity of river water	7	2.22
6	I chose the alternative that has a narrow buffer zone	14	4.44
Total		294	93.33
Respondents who chose SQ in all six consecutive choice sets		21	6.67
Respondents who chose both the SQ and the new options		31	9.84
Respondents who chose only the new options		263	83.49

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATIONS

5.1. Conclusion

River water pollution is a pressing issue in Addis Ababa. Perennial and intermittent rivers are grossly polluted by effluents which carry toxic chemicals, pathogens and heavy metals. The wastes of municipal, service providing organizations and industries are point and non point sources of effluents. Previous measures taken by stakeholders are not satisfactory to mitigate the problem. Nevertheless, households living nearby the rivers are highly affected during growing vegetables and consumption. The residents of the city in general are affected by the problem as they are the sole consumers of vegetables produced using the polluted river water.

Therefore, the aim of the study was to analyze households' participation in mitigating the problem which is revealed by their WTP for protection of river water pollution that in turn attaches an economic value to the river. For this purpose a data from CE survey questionnaire was collected from 315 households. The collected data was analyzed carefully using MNL and RPL models by conducting appropriate tests. Accordingly, the basic MNL model couldn't pass the IIA test. Though the extended MNL model passes the IIA test and parameters of attributes, socioeconomic characteristics and awareness are highly significant, from its nature, it fails to capture taste heterogeneity so that its results are suspected to be misleading. The basic RPL model was also tried, but it was not the good model fit. For these reasons, the extended RPL model was estimated; and random and non random parameters are found to be significant and have the expected sign except the parameters of age, urban agricultural practice and household size that the former two parameters are negative and household size is insignificant. It was also proved that heterogeneity, indeed, prevail among respondents.

Based on the results obtained from the extended RPL model, respondents are willing to pay on average 90.34, 12.89 and 27.87 ETB/respondent/year for additional attribute levels for river water quality and volume and recreational facilities, and 1.48 ETB/respondent/year for additional meters for the riparian buffer zone. Respondents attached the highest value to the river water quality. This indicates that the impact of river water pollution is high. They are also willing to pay on average 607.2, 753.2 and 886.2 ETB/respondent/year for low, medium and high impact improvement scenarios. The results of the compensating surplus have shown that respondents are keen for higher levels and units of attributes.

5.2. Policy Implications

Based on the main findings of the study the following policy implications are forwarded:

- Respondents attached the highest value to river water quality. Therefore, the authority cooperating with stake holders should give priority for water quality improvement so long as it is difficult to finance different sub projects at a time.
- Respondents have shown interest in the expansion of riparian buffer zone. However, many households live on river banks. The buffer zone undoubtedly touches those households. Hence, displacement of households who live immediate to the river is unavoidable. However, the process should be efficient that improvement in utility of the residents due to elimination of the bad good-pollution shouldn't be offseted by disutility due to displacement. Therefore, they should be reallocated properly so that they don't be affected by the project.
- Farm respondents have shown reluctance for the protection of the river water pollution. Therefore, intensive awareness must be created by Addis Ababa Urban Agricultural Bureau and Non-Governmental Organizations in application of safe technologies in the production of vegetables.

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Appendices

Appendix I: Questionnaire Used for the Survey with Sample Choice Sets

Addis Ababa University

Department of Economics

Choice Experiment Questionnaire Designed for Households in Addis Ababa

Name of the interviewer: ____

Date of the interview: _______________ Code of the interview: _________________

Starting time: _____________________ Ending time: ________________________

*Dear respondent, my name is Gebretsadik Teshager. I am a final year MSc student at Addis Ababa University. Currently, I am conducting research on "**Economic Valuation of Protecting Urban River Water Pollution in Addis Ababa, Ethiopia: a Choice Experiment Approach**". You are randomly selected to provide accurate information on your observation, perception and attitude on the pollution of 'Tinishu' Akaki River. Your information will be used as an input for policy making. Hence, it is very important to give your genuine preference on the protection options. Your information will be strictly confidential and will only be used for this study purpose. Please, tick in the boxes and circle the numbers to show that it is your best choice.*

Part I: Questions on Respondents' Observation, Perception and Attitude on pollution and protection of 'Tinishu' Akaki River

2.1. For what purpose you use the river? (You can choose more than one)

A. Irrigation C. Washing vegetables E. I don't use it.

B. Disposing solid wastes D. Disposing effluents via open ditches

2.2. In your opinion, who should take the responsibility to clean the river?

A. Polluters B. Users

2.3. Where do you spill effluents most of the time?

A. Toilets or septic tanks B. Open ditches or canals C. Open spaces

2.4. Do you separate solid wastes from effluents before spilling? A. yes B. No

2.5. Does the family eat raw vegetables frequently? A. Yes B. No

2.6. Do you know that most of the vegetables supplied to Addis Ababa's market are produced using the rivers that flow in your area? A. Yes B. No

2.7. Do you know that eating vegetables that grow using polluted water have potential health risk? A. yes B. No

2.8. Have you ever participated in river cleaning campaign? A. Yes B. No

2.9. Will you participate in terracing and planting trees campaign in Entoto Mountain for free if you are asked? A. Yes B. No

2.10. How many parks are there in your areas? ______________

2.11. Do you take your family to any parks? A. Never B. Once a week D. often

2.12. Does your family member experience water born disease? A. Yes B. No

2.13. Does your family member experience respiratory disease? A. Yes B. No

2.14. Do you experience bad odor when you cross river bridges? A. Yes B. No

Part II: The Choice Experiment Scenario

In this particular section of the questionnaire, I will provide you two alternatives with attributes of the river and attribute levels intending to protect the river; and the SQ, i.e. alternative of 'do nothing'. These alternatives have no "right" or "wrong" answers. You are expected only to choose your best preference considering the different levels each attribute takes in each alternative. Feel free to ask the interviewer questions when you get difficulty or confusion. You are also allowed to change your choice if you decide that is not your best answer.

Now assume AAEPA, collaborating with stakeholders; AAWSA, City Government of Addis Ababa Beautification, Park and Cemetery Development and Administration Agency, Gulelle Botanical Garden, Oromia Forest and Wild Life Protection and Development Enterprise, City of Addis Ababa Solid Waste Management Agency, Addis Ababa Urban Agriculture Bureau and Non-Governmental Organizations has a plan to protect the 'Tinishu' Akaki River. The river has already given a water quality standard as 'very badly polluted' so that it should not be used for any economic activities. Therefore, to protect the river, the authority has identified the following river attributes with their corresponding levels.

Quality of the river water: *The quality of the Tinishu' Akaki River water is very poor. There are different factors for its pollution. Households and service providing organizations dispose effluents to open ditches. But, these ditches are automatically connected to the nearby river. So, all effluents mixed with solid wastes join the river. Almost all of the industries have no treatment plants. Hence, their liquid wastes flow to* *the river. Some households connect their toilets to the river. People also dump solid wastes on the river.*

Despite its pollution, different people use the river for growing vegetables, washing clothes and vegetables, drinking animals, home consumption and swimming. The market destination of those vegetables is Addis Ababa. Now, the river pollution is becoming a great impact on the environment. Toxic chemicals degrade the nutrient of the soil; absence of oxygen inhibits aquatic habitats; and the incremental concentration of heavy metals on the leafy vegetables has a health risk on the consumer. Moreover, beyond the reduction of the amenity value of the river and distortion of the image of the city, people are getting difficulty crossing bridges due to the bad odor emitted from the polluted river water. Consequently, it is causing respiratory and water born diseases.

So, the proposition of the authority is to enhance the quality of the river water through awareness creation, law enforcement; and constructing private and communal septic tanks in the short run and well organized sewerage systems and treatment plants in the long run. The first alternative is to improve the water from very badly polluted to moderate so that it will allow irrigation. The second option is to improve it to good quality and irrigation and drinking animals will be safe. And the third option is to enhance the quality of the water to very good status. This improvement will allow irrigation, drinking animals, washing vegetables and clothes and swimming or/and bathing.

Volume of River Water: *The 'Tinishu' Akaki River has several tributaries possessing the eastern catchment having a surface area of around 950 sq. km. The source of the* *tributaries is the Entoto Mountain which is covered by eucalyptus trees. As far as the volume of the river water is concerned, eucalyptus tree has a negative impact. During raining, it prevents percolation of water into the ground and then increases flooding which is another threat to the city. Therefore, to increase the quantity of the river water, two activities are proposed. The first one is to replace the eucalyptus with indigenous trees. The second activity is to plant trees on degraded areas and terracing in addition to replacement so that the area will be transformed in to a Semi-Afro Mountain Temperate Forest. On account of these, there will be a partial and substantial improvement of the volume of the river water, respectively.*

Riparian Buffer Zone: *The 'Tinishu' Akaki River banks are not protected. Houses are built immediate to the river, which are encountered with a potential flooding risk. People wash cars on river banks. Open spaces on the river banks are waste dumping sites. Thus, development of biological and physical structures is planned. Three buffer zone widths are proposed. These are on average 10, 20 and 30 meters wide.*

Recreational Facilities: *the existence of a river in a city is an opportunity rather than a liability. However, this is not the case in Addis Ababa that there are no recreational centers built on the 'Tinishu' Akaki River. Therefore, three types of park options are proposed depending on their recreational benefits. The first option is to plant trees and construct pedestrian roads so that people can walk along the river banks for hiking and picnic. The second one is planting trees, building pedestrian roads and preparing chairs, and then people can spend sometimes gazing the panorama. The third option is planting trees, constructing pavements, preparing chairs and building resorts that have play grounds and swimming pools.*

Now, to implement the plans, the authority will collect the money you wanted to contribute adding into your water bill. The contribution will last for five years i.e. from 2008-2012 E.C. The authority will use the contributed money with the existing budget to execute the plan.

You are now asked to choose your preferred alternative in each of the following six consecutive choice sets.

1. Choice Set-1

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Very good	Moderate	Poor
Volume of the River water	Partial improvement	Substantial improvement	Weak flow
Riparian Buffer Zone	30 meters	20 meters	No buffer zone
Recreational Facilities	Trees + Roads +chairs	Trees + Roads	No recreational facilities
Monetary Payment	25	100	0
I prefer (please tick in the box)	☐	☐	☐

2. Choice Set-2

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Very good	Moderate	Poor
Volume of the River water	Partial improvement	Partial improvement	Weak flow
Riparian Buffer Zone	10 meters	20 meters	No buffer zone
Recreational Facilities	Trees + Roads	Trees + Roads +chairs	No recreational facilities
Monetary Payment	150	10	0
I prefer (please tick in the box)	☐	☐	☐

3. Choice Set-3

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Very good	Moderate	Poor
Volume of the River water	Partial improvement	Substantial improvement	Weak flow
Riparian Buffer Zone	20 meters	30 meters	No buffer zone
Recreational Facilities	Trees + Roads +chairs	Trees +Roads +Chairs +Resorts	No recreational facilities
Monetary Payment	100	150	0
I prefer (please tick in the box)	☐	☐	☐

4. Choice Set-4

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Good	Very good	Poor
Volume of the River water	Partial improvement	Substantial improvement	Weak flow
Riparian Buffer Zone	10 meters	30 meters	No buffer zone
Recreational Facilities	Trees + Roads	Trees + Roads +chairs	No recreational facilities
Monetary Payment	25	10	0
I prefer (please tick in the box)	☐	☐	☐

5. Choice Set-5

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Good	Very good	Poor
Volume of the River water	Partial improvement	Substantial improvement	Weak flow
Riparian Buffer Zone	10 meters	20 meters	No buffer zone
Recreational Facilities	Trees + Roads +chairs	Trees +Roads +Chairs +Resorts	No recreational facilities
Monetary Payment	100	150	0
I prefer (please tick in the box)	☐	☐	☐

6. Choice Set-6

Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Very good	Moderate	Poor
Volume of the River water	Partial improvement	Substantial improvement	Weak flow
Riparian Buffer Zone	20 meters	30 meters	No buffer zone
Recreational Facilities	Trees +Roads +Chairs +Resorts	Trees +Roads	No recreational facilities
Monetary Payment	200	10	0
I prefer (please tick in the box)	☐	☐	☐

Part III: Follow up Questions

4.1. Which one of the following best explains why you chose status quo (if you did)?

1. I don't believe that the money that I will contribute will actually go to protection of the river
2. Protecting urban rivers is the sole responsibility of the government.
3. I have no money left for river protection
4. I don't want to pay since it is polluted by other bodies
5. Urban river protection should not be a priority at this time

4.2.What was your number one priority to choose alternatives other than the status quo?

1. The quality of the river water
2. The volume of the river water

3. The riparian buffer zone

4. The recreational facilities

4.3.What was your immediate criterion to choose either of the new proposed alternatives?

1. I always opted for the least cost protection option

2. I chose the alternative that contains higher water quality

3. I opted for the alternative that has a wider buffer zone

4. I chose the alternative that has better recreational facilities

5. I opted for the alternative that has higher quantity of river water

6. I chose the alternative that has a narrow buffer zone

Part IV: Socio-economic Characteristics of the Household Head

4.1.Gender : A. male B. Female

4.2.Age: __________.

4.3.Marital status: A. Married B. Single C. Other, specify: _______

4.4.Maximum level of educational attainment: _____________

4.5. Do you practice urban farming? A. Yes B. No

4.6.If your answer for 4.5 is ‘A’, do you use ‘Tinishu’ Akaki River for irrigation?

A. Yes B. No

4.7.How many family members do you have including you?

<20 _________, 20-65 __________and>65 ________years old.

4.8.Sub-city where you live:

A. Akaki-kality B. Nefas Silk-Lafto C. Kolfe-Keranyo

4.9. How far is the ‘Tinishu’ Akaki River from your house? ________ meter/km.

4.10. For how many years you live in Addis Ababa? _________ Years.

4.11. How many member of the family earn income including you? _______________.

4.12. In which level your family's estimated monthly income lies?

A. <=150 B. (150-650] C. (650-1400] D. (1400-2350]

E. (2350- 3550] F. (3550-5000] G. >5000

4.13. How much is your family's monthly food expenditure? _______________

4.14. How much is your family's monthly income? __________________

Thank you for your cooperation!

Appendix II: The Choice Set Card

Choice Set 1			B1R1
Attributes	Option 1	Option 2	Status Quo
Quality of the River Water	Very Good	Moderate	Poor
			
Volume of the River water	Partial Improvement	Substantial Improvement	Weak Flow
			
Riparian Buffer Zone	30 meters	20 meters	No buffer zone
			
Recreational Facilities	Trees + Roads + Chairs	Trees + Roads	No recreational facilities
			
Payment	25	100	0
I prefer (please tick in the box)			

Declaration

I, the undersigned hereby declare that, this thesis is my original work and has not been presented nor is being currently submitted for a degree in other Universities or publication. All sources of materials used have been duly acknowledged.

____________________________ ____________________

Gebretsadik Teshager Date

This thesis has been submitted for examination with the approval of University main advisor.

____________________________ ____________________

Zenebe Gebreegziabher (PhD) Date

October, 2014

Addis Ababa, Ethiopia