DISSERTATION

VALUATION OF FRESHWATER RESOURCES AND SUSTAINABLE MANAGEMENT IN POVERTY DOMINATED AREAS

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ABSTRACT

VALUATION OF FRESHWATER RESOURCES AND SUSTAINABLE MANAGEMENT IN POVERTY DOMINATED AREAS

This study is designed to reveal the tradeoffs between anthropogenic activities and freshwater ecosystems; discuss different management options for the restoration of freshwater resources in poverty dominated areas; measure the total economic value for freshwater ecosystem services and; to evaluate alternative options in designing a contingent valuation survey in poverty dominated areas. Using a case study of river Swat in Pakistan, the study applies three steps to achieve these objectives: The first step is to study the existing and historical ecology of the river Swat; identify threats to the river system from anthropogenic activities and from climate change and; design a management plan to improve water quality and resilience of the system against floods. The next two steps are to test the economic efficiency of the designed management plan. For this purpose, a contingent valuation method is used to measure the total economic value for water quality improvement of the river Swat. Since results from contingent valuation method are sensitive to survey design and administration methods, therefore, in the second step, sensitivity of households' stated willingness to pay to payment vehicles and managing agencies is tested. In the third step, based on the recommendations from step two, a contingent valuation survey is designed to measure the total economic value (benefits) for water quality improvement of the river Swat and to test the economic efficiency of the recommended management plan.

Based on the objectives of the study and the application of three steps approach to achieve them, the whole dissertation is divided into three separate papers.

The main objectives of paper one are to identify threats to river Swat ecosystem and design a management plan to improve water quality and resilience of the system against floods due to climate change. River Swat watershed is located in the north west of Pakistan. During the past three decades, increased human population and growth in agriculture and tourism activities have severely degraded the river system. A three step approach was followed to achieve the mentioned objectives. In the first step, an interdisciplinary team randomly selected ten different sites along the main river and observed the biophysical characteristics of the river. In the second step, an oral history ecological approach was used to collect information on the dynamics of the biophysical characteristics of the system and identify threats responsible for degradation of the system. In the third step, the interdisciplinary team recommended a management plan that could improve the water quality and resilience of the river system against flood in a sustainable way.

Variations in the existing biophysical characteristics of the main river were used to divide the whole system into Rushing Water Ecology (RWE) and Sluggish Water Ecology (SWE). RWE occurs in the north part of the watershed where the valley is narrow and altitudinal variation is very high. In this part of the valley, the river and its tributaries are characterized by torrent flow, deep basin, limited width and low temperature. Most of the water comes from melting snow and glaciers. Limited water flow in winter and torrent flow in summer prevent the richness of aquatic communities. Brown Trout and Rainbow Trout are the only fish species that can be found in this zone. Riparian plants include Nasturciam officinale, Vernoica anagallis, Polygonum sps., Solanum nigrum, Cannabis sativas, Salix alba, Pyrus pashia, Quercus sps., Acer caesium, Aesculus indica and Juglans regia. SWE occurs in the central and southern parts of the watershed where the valley is wide open and the alluvial plain is flat. The river spreads to its maximum width that reduces its flow speed. Wider watercourse, sluggish flow, shallow basin and less vegetation on the river banks allow more light penetration into the water body that increase its temperature gradually downstream. Riparian plants include Potamogeton sps., Hydrilla verticillata, Paspalum sp., Marsilea minuta, Typha australis, Xanthium strumarium, Saccharam bengalense, Canabus Sativas, Populus sps and Salix species. Fish fauna include Shizothorax sps., Gara ghtyla, Channa punctatus and Puntius ticto.

Findings from oral history ecological survey indicate that SWE in the central and lower parts of the valley has been severely degraded. The river system in this zone was famous for clear and pollutants free water, the presence of riparian zones and wetlands and the abundance of native fish species. The field visits and oral history ecological survey identified the following anthropogenic activities responsible for shifts in the biophysical characteristics of the SWE: (1) disposal of wastes directly into the water body from residential, commercial and industrial areas; (2) transformation in riparian zones and wetlands for agricultural practices and clearing of forests resources and; (3) illegal fishing practices. This study also investigated the impact of global climate change on local temperature, precipitation and river's flow regime. Analysis of the metrological data for the past 40 years shows that both mean annual temperature and mean annual precipitation have increased over time. Increase in both climate factors have resulted increased average annual flow and more frequent and intense monsoon floods.

To improve the water quality and resilience of the river system against floods, the interdisciplinary team recommended a management plan that includes: (1) restoration of riparian zones in the central and southern parts of the watershed; (2) reforestation and farm-forestry on bare land/ mountains and agricultural farms along the river; (3) construction of protection walls on river sides at much needed locations to prevent land sliding and protect human settlement along the river from heavy floods; and (4) installation of sewage treatment plants, wetlands and the use of septic tanks to prevent the flow of organic and inorganic pollutants into the river.

Paper two measures the economic value for water quality improvement of the river. A contingent valuation method (CVM) was used to interview a sample of 243 households, selected from Swat valley and downstream districts through a stratified random sampling approach. Before asking respondents about their willingness to pay (WTP), the existing water quality situation and the management plan, recommended by the interdisciplinary team, were explained. Based on findings in paper three, donation to a local non-government organization (NGO) was used as payment mechanism in the designing of contingent valuation scenario for water quality improvement of the river. A payment card elicitation format was used to reveal households' WTP. Results from data analysis indicate that the mean annual WTP for water quality improvement is Rs.230 ($2.4) per household. Generalizing this value to households living in Swat valley would generate Rs.95,700,000 ($1,008,000) to Rs.51,700,000 ($544,000) per year depending on assuming the WTP for respondents who refused to pay. The present value aggregate benefit for 10 years, even from the lower bound value would be sufficient to cover the total cost on the restoration of a riparian zone, 15000 meters long and 800 meters wide, along the main river, reforestation on 8000 acres of land, installation of 2 sewage treatment plants, construction of 250 septic tanks and 20 flood protection walls and to compensate farmers on 1250 acres of land for growing native riparian plants along the main river in the central and southern parts. This paper also estimated the total economic value for water quality improvement under mandatory payment to local government. Though the present value aggregate benefit from mandatory payment to government is half of the amount from donation to a local NGO, it is still sufficient to cover the total cost on the mentioned management plan. Furthermore, a mandatory program may be more feasible than a voluntary program where payment is not assured.

Paper three explores the sensitivity of households' stated WTP to CVM survey tools. CVM is widely used for cost and benefit estimation of natural resource management (NRM) programs. However, due to questionable experiences in developing countries, additional research is needed on CVM survey design and administration and about the robustness of results to changes in survey elements. That's why this paper is designed to tests the sensitivity of household's stated WTP when payments are mandatory versus voluntary and whether they are to a government agency or a local non-government organization (NGO). To achieve these objectives, a case study of the river Swat water quality improvement was used. To design appropriate and realistic contingent valuation question scenarios, households in Swat valley were asked about their opinion on the provision and management of public goods. Based on their response, the following scenarios were selected to design three different WTP questions: (1) mandatory payment (increase in electricity bill charges) to government; (2) donation to government and (3) donation to a local NGO. A payment card (PC) elicitation format was used to ask respondents about their WTP for water quality improvement. Using a stratified random sampling approach, a sample of 243 households was selected from Swat valley and downstream districts. Results from maximum likelihood regression analysis show that donation payment to a government agency has insignificant impact on households' stated WTP for water quality improvement. It means, under government management, households' WTP for water quality improvement is not sensitive to choice of payment mechanism. However, under NGO management, donation is the single most preferred payment mechanism. A combined analysis of data sets on all three scenarios shows strongly positive and significant impact of donation to a local NGO on households' stated WTP. The estimated mean-WTP from donation to a local NGO of $2.4 per household is almost double the amount of mean WTP from mandatory payment and voluntary payment to government. These results reveal people's lack of trust on payment to government for water quality improvement, possibly because of inefficiency in funds allocation and high corruption. Another possibility might be a strategic behavioral response by the households. In replying to donation to a local NGO for water quality improvement, respondents know that they will not be required to donate to NGO; therefore, they can state a fairly high value.

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CHAPTER 1: VALUATION OF FRESHWATER RESOURCES AND SUSTAINABLE MANAGEMENT IN POVERTY DOMINATED AREAS

1.1. Background and objectives: Terrestrial freshwater resources provide a number of ecological, social, and economic benefits (Postel and Carpenter 1997). They can be categorized into extractive and non-extractive benefits. Extractive benefits include provision of water for irrigation, drinking, and industrial use and for the production of fish and waterfowl. Non-extractive or instream benefits include habitat for terrestrial and aquatic wildlife animals, waste processing and water purification, flood control, transportation, recreation, etc. Despite providing such vital services to human health and livelihood, unfortunately, most of these resources have been severely degraded by human activities. Increased human population, extensive and intensive agricultural practices and industrial development are considered the main reasons for degradation of freshwater resources (Gleick 1993, Jackson et al 2001, Baron et al., (2002)). A question now arises: why do people allow activities that affect freshwater ecosystems heath and the flow of services provided by them? This might be due to: (1) their limited understanding about the functioning of freshwater ecosystems and the trade-offs between human activities and ecosystem functioning and; (2) institutional and market failure for freshwater resources that provide incentives for unsustainable use of these resources.

For sustainable management of freshwater resources, it is highly important to reveal the hidden trade-offs between human activities and freshwater ecosystems functioning and to internalize the cost of threatening freshwater ecosystems into the economic decisions of different users. For this reason, the Millennium Ecosystem Assessment (2005) recommended economic valuation of freshwater ecosystems services. Economic valuation of freshwater resources help policy makers and managers to: estimate the marginal social cost (benefits) of negative (positive) externalities produced by different stakeholders; set policy instruments, such as taxes and prices, for controlling degradation of environmental and natural resources and; estimate cost and benefits for natural resource management (NRM) projects to test their economic efficiency.

This study is designed to reveal the tradeoffs between anthropogenic activities and freshwater ecosystems in poverty dominated areas; to design different management plans for the restoration of healthy freshwater systems and; to test the economic efficiency of management plans based on economic valuation of services provided by freshwater ecosystem. Using a case study of river Swat in the Swat valley of Pakistan, the study applies three steps to achieve the mentioned objectives: The first step deals to study the existing and historical ecology of the river Swat, identify threats to the river system and design a management plan to improve water quality and resilience of the system against floods, which is presumed to have a positive impact on poverty alleviation. The next two steps test the social acceptability and economic efficiency of the designed management plan. For this purpose a contingent valuation method (CVM) is used to measure the total economic value for water quality improvement of the river Swat. Since, CVM results are sensitive to survey design and administration, in the second step, the sensitivity of households' stated willingness to pay (WTP) to different payment vehicles and managing agencies is tested. In the third step, based on findings in step two, a CVM survey is designed to measure the total economic value (benefits) for water quality improvement of the river Swat. Results from this analysis are further used to test the economic efficiency of the designed management plan.

Based on the three steps procedure, this PhD dissertation is divided into three separate chapters (papers) to discuss each in more detail.

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CHAPTER 2 – PAPER ONE

THREATS TO FRESHWATER RESOURCES AND MANAGEMENT OPTIONS IN A POVERTY DOMINATED AREA: A CASE STUDY OF RIVER SWAT (PAKISTAN)

2.1. Introduction and objectives: Terrestrial freshwater resources, such as rivers and lakes, are 0.26% of the total global freshwater reserves and less than 0.01% of the total stock of water in the hydrosphere (Gleick, (1993)). Despite their limited amount, they are the main source for human water consumption and provision of goods and services that are vital to human health and economic well-being. The services they provide can be categorized into: (1) extractive services such as the provision of water for drinking, irrigation, industrial use and hydropower generation; (2) regulating services such as the purification of water, pollutants filtration and floods control; (3) provision of fish and aquatic birds; (4) habitat services for wildlife animals; and (5) cultural services (Postel et al., (1997), MES (2005)). The flow of these services depends on the health of the freshwater ecosystem. A healthy freshwater ecosystem is more likely to sustain the provision of ecological services and retain the adaptive capacity of the system to respond to future environmental alterations, such as climate change (Baron et al, (2002)).

In the past few decades, most terrestrial freshwater resources have been severely degraded (Gleick 1993, Jackson et al., 2001). This situation could be worse in poverty dominated areas. In Pakistan, where more than 32 percent of the total population is below the poverty line (Govt. of Pakistan, 2001) and where people depend heavily on freshwater and other natural resources for their basic needs, the emission of wastes and pollutants from residential areas, industries and agricultural fields into the freshwater systems has degraded water quality severely (WWF, 2007). Furthermore, water management policies are clearly unable to meet the goal of sustaining freshwater ecosystems. Diversion of more than 90% of the country's total freshwater for irrigation (Bhatti et al., (2009)) has affected the functioning of most freshwater ecosystems and the flow of ecological services (WWF, 2007). The main objectives of this study are to identify threats to a freshwater resource in a poverty dominated area of Pakistan and design a management plan to sustain its heath. To achieve these objectives a case study of river Swat in the Swat valley of Pakistan was used.

Like most freshwater resources, the river Swat and its tributaries in the Swat valley of Pakistan, have been polluted to a level that is a serious threat to people's health and the river's associated biodiversity (Khan, 2003). The Swat River, which drains the entire Swat valley, plays an important role in the economic life of the people. The valley is famous for tourism and for the production of best quality fruits and offseason vegetables. River Swat provides water for irrigation, fisheries, marble industries, running of water mills, drinking and hydroelectric power generation. The esthetic beauty of the river is the main source of attraction for tourists.

The paper is organized as: section 2 discusses the methodology used to achieve the objectives of this study; section 3 and 4 describe the river Swat watershed, the existing and historical ecology of the river system shifts in its biophysical characteristics over time; section 5 discusses threats to the river Swat and; section 6 presents the management plan designed by an interdisciplinary team.

2.2. Methodology: An interdisciplinary team (Appendix 2.8.2) was assembled first to implement a three steps approach for the achievement of the study objectives. In the first step, the team visited different sites along the river (Appendix 2.8.3) and observed the existing biophysical characteristics of the main river system. In the second step, the temporal dynamics of the biophysical characteristics of the river system were studied and threats from anthropogenic activities and climate factors were identified. For this purpose the existing ecology of the river system was compared with its natural state (reference state), characterized by less human intervention. Due to lack of historical information, an oral history approach was followed and a questionnaire was designed to collect information on historical ecology of the river from older and learned people in the valley. In the third step, based on the geophysical characteristics of the watershed, biophysical characteristics of the river system and threats from anthropogenic activities and climate change, the interdisciplinary team designed different management plans that could improve the water quality and resilience of the river system against flood. A final management plan was recommended based on the ability to achieving the desired objectives in an ecologically viable, socially acceptable and economically efficient way.

A similar approach was used by the Environmental Protection Society (EPS) for the River Swat Conservation Project (2001 – 2002). However, the project totally ignored the impacts of climate change on freshwater ecosystem and challenges for sustainable management of the system. This study used metrological data for the past 40 years to evaluate the impacts of global climate change on the river system, highlighted the importance of integrated water resource management (IWRM) approach for sustainable management of the system and discussed different challenges that could be faced during its implementation.

2.3. River Swat watershed: River Swat watershed, also called Swat valley, is located in the north west of the Khyber Pakhtunkhwa Province of Pakistan (Appendix 2.8.5 – River Swat watershed) under the geographical limit 34°-36° North Latitude and 71°-73° East Longitude. The valley is narrow and steep in the north and is bounded by Hinduraj Hindokush Mountains. Down towards the south, it becomes increasingly wider and flatter. Altitudinal range varies from 567m in the south to around 6000m in the north. The total area of the valley is over 6288km^2 (Nafees et al, 2008) out of which around 75-80 percent is hilly and the remaining 20-25 percent is plain area (Appendix 2.8.5). Administratively, the valley is a combination of three districts: (1) Swat District; (2) Lower Dir; and (3) Malakand Agency. District Swat constitutes 81 percent of the total valley, whereas Lower Dir and Malakand Agency are 12 percent and 6 percent, respectively (Nafees et al, 2008).

2.3.1. Climate zones: Based on climatic conditions and geographic characteristics, the Swat valley can be divided into four zones: (1) Swat Kohistan; (2) Upper Swat; (3) Central Swat; and (4) Lower Swat (Khan et al.,(2003)). The Swat Kohistan is the extreme north part of the watershed extending from Madyan village in the south to Falakser valley in the northeast and Gabral valley in the northwest. This zone is characterized mostly by dry temperate climate and huge altitudinal variation. Alpine (3600m – 4600 m altitudes) and Cold Desert zones also exist in some sides valleys (see Appendix 2.8.5). The altitudinal rang varies from 1500m in the south at Madyan to 6000m in the north at Falaksair valley (Appendix 2.8.5). Unlike southern parts of the Himalayas, this zone receives little monsoon rains in summer, while in winter heavy snowfall occurs from mid-December to late March. The Upper, Central and Lower Swat valleys lie towards the south of the Swat Kohistan. The Upper Swat includes Matta, Khwazakhela and Charbag villages, where altitudinal range varies between 1000m to 2300m and is characterized by Moist-Temperate climate. The Central and Lower Swat are wide open, and are flanked by ranges descending from 1400m in the north to 600 m in the south. Sub-Tropical climate, flat alluvial plain and sufficient water for irrigation encourages bi-crops agricultural practices. That's why most of the densely populated settlements (Mingora, Barikoak, Thana, Chakdara, and

Barikoat) are located in these parts of the valley. Details about altitudinal variation, temperature, precipitation, vegetation and agriculture for each zone are given in Appendix 2.8.5.

2.3.2. Demographics: According to the population census report 1998, the total population of Swat valley was 2,420,000 individuals with an average density of 308 people/Km^2 and annual growth rate of 3.38% (for the years 1981-1998). Most of the people (89 % of the total population) were settled in rural areas located mostly along the river banks. There were 268,000 housing units in the valley and the average family size was 9 people. Literacy ratio for 10 years and above population was 33% - male represented 49 % while female were 16% of the total. According to the same census report, around 19% of the district Swat population was employed, half of which was involved in agriculture, forestry and fishing trades; while, 14% in services. Only 12% of the total was involved in restaurant, hotel businesses and wholesale trade.

2.3.3. Ethnic groups - their linguistics, economy and distribution in the area: The inhabitants of Swat valley can be divided into the following three major ethnic groups based on the linguistics and economy: (1) Kohistanis are characterized by the usage of Kohistani language. They are considered the ancient inhabitors of Swat valley (Barth, (1956)) and practice one crop agriculture and transhumant herding; (2) Pathans are the Pashto speaking largest group in the area. Their economy is based on double-crop agriculture in the lower and central parts of the valley; and (3) Gujars are nomadic herders grazing their livestock in the alpine and sub-alpine zones in the valley. They speak Gujari language. The social system for each ethnic group is significantly different from others and this affected their distribution in the area. According to Barth (1956) '*the distribution of each group in the valley is not controlled by natural area but by the distribution of specific ecologic niches, which each group with its particular economic and political organization is able to exploit'* (Barth (1956), p. 1088). He further explained that the different tribes of the Pathans, who initially entered the area during A.D. 1000-1600, settled in the central and lower parts of the valley. Their economy and social organization was based on double-crop agriculture, which constrained their settlement in the Swat Kohistan, characterized by harsh climate, limited plains and short summers. Kohistanis, when pulled out by the Pathans from the Lower and Central valleys, efficiently occupied the Swat Kohistan. Gujars are distributed throughout the valley and they have established symbiotic relations with the Pathans and Kositanis' (Barth (1956), pp. 1081-1087). During the past forty years, with development in road infrastructure, Pathans, Punjabis and Kashmiries from other parts of the country migrated into the Central, Upper and Swat Kohistan areas and invested in the tourism sector. That investment not only resulted growth in the tourism industry and jobs creation for local people but also boosted the agriculture and property businesses in the area. This process was affected badly by the Taliban activities in the valley and the war against them in 2009. More than half of the total human population migrated to Mardan and other districts.

2.4. Ecology of river Swat: To study the ecology of the river Swat, the interdisciplinary team divided the whole watershed into four zones (Appendix 2.8.4) and randomly selected 10 different sites along the main river (Appendix 2.8.3), having at-least one site from each zone. The team then visited each site to observe the biophysical characteristics of the river system. Based on characteristics of each site, the whole river system was divided into Rushing Water Ecology (RWE) and Sluggish Water Ecology (SWE). These zones were first identified in a study conducted by the EPS and the United Nation Development Program (UNDP) on the ecology of the river Swat (2001 – 2002).

2.4.1. Rushing Water Ecology (RWE): RWE occurs in the area of Swat Kohistan. The river Swat originates with the confluence of river Utror and river Ushu at Kalam, a main village in the northern Swat Kohistan. The river Utror and its tributaries (Gabral, Batal, etc.) drain the western and the northwestern sub-valleys of the Swat Kohistan. The river Ushu emerges from lake Maho Dand in the north and drains Mathaltan and Ushu valleys. These rivers are fed by melting of snow and glaciers. Downstream Kalam, the river enters a deep narrow canyon where its width reduces and its flow speed increases due to huge altitudinal variation. That's why this zone is called rushing water zone. A number of streams (Gahil, Mankial, Daral and Chail streams) also join the river while it flows through the canyon. Downstream Madyan, the southern boundary of Swat Kohistan, the narrow canyon ends and the river enters the Upper Swat valley. In the RWE, river Swat and its tributaries are physically characterized by torrent flow, deep basin, limited width and low temperature. Torrent water flow erodes soil from side rocks and thus prevents higher plants to establish. Only *bryophytes* (*Marchantia* and *Funaria*), *ferns* (*Adiantum capillus*) and *pteridophytes* were found on moist rocks. However, in the riparian zones downstream Madyan and in the Utror valley the following riparian plants were frequently observed: *Nasturciam officinale, Vernoica anagallis- aquatic, Polygonum amphibium, Polygonum hydropiper, Ranunculus sps., Eruca Sativa, Rumex hastatus, Amaranthus spinosus, Cannabis sativas, Salix alba, Populus alba, Pyrus pashia, Juglans regia, Quircus sps., Diospyrus lotus, Acer caesium, Aesculus indica and Prunus cornuta* (Appendix 2.8.6). *Brown Trout (Salmotrutta ferio)* and *Rainbow Trout (Salmotrutta gairdneri)* are famous fish species of the RWE.

2.4.2. Sluggish Water Ecology (SWE): SWE occurs in the areas of Lower, Central and Upper Swat valleys. Downstream Madyan the river enters an open valley where its width increases and its flow speed reduces gradually southwards. In the Central and Lower part, where the valley is wide open and flat, the river spreads to its maximum width and its flow speed becomes sluggish. That's why this zone is called the sluggish water zone. Wider course, sluggish speed, shallow basin and sub-tropical climate allow more light penetration into the water body and gradually increase its temperature downstream. Deposition of sediments from upland areas occurs in the alluvial plains of the central and lower valleys where most of the land is flat and suitable for agriculture. Intensive bi-crops agricultural practices are common. Rice, onion, tomatoes, peaches, apple and persimmons are the main cash crops. Riparian plants include *Potamogeton sps., Hydrilla verticillata, Chara, Paspalum dilatatum, Marsilea minuta, Typha australis, Cyprus sps., Xanthium strumarium, Saccharam bengalense, Calatropis procera, Canabus Sativas. Salix babylonica, S. alba, Populus sps., Morus alba, Morus nigra, Ficus religiosa, Alnus nitida etc* (Appendix 2.8.6). Fish fauna include *Golden Mahseer (Tor pitora), Shizothorax sps., Gara ghtyla, Channa punctatus, Glyptothorex stocki, Puntius ticto and eels.*

In the extreme south of the valley the river once again enters a narrow canyon and joins with river Punjkora. At Chakdara (Lower Swat), a substantial amount of water is diverted through the Upper Swat Canal for hydroelectric power generation and irrigation.

2.4.3. System dynamics: To study the temporal dynamics of the system, the existing biophysical characteristics of the system were compared with its natural state. For this reason an oral history ecological approach was followed to collect information about the reference state and historical ecology of the river system. A questionnaire was designed (see Appendix 2.8.8) and used to personally interview older and learned people in the area. Some historic information on biophysical characteristics of the river system were provided by the Irrigation Department Malakand and the Fishery Department Chakdara.

On the basis of collected information the life history of the River Swat was differentiated into the following three periods: (1) natural state or reference state (1926 – 1960); (2) period before the 2010 floods (1970 – 2008); and (3) period after the 2010 floods (2011 – Nov. 2012). The reference state was characterized by natural freshwater ecosystem with less human intervention. Though, during the first quarter of 19th century, some changes had been done to the natural flow of the river at Chakdara (Lower Swat) by diverting water through an Upper Swat Canal to generate hydroelectric power and irrigate Mardan, Charsada and Swabi districts. The field observations reveal that the diversion of water through the Upper Swat Canal significantly reduces the main river flow downstream Chakdara, particularly during the winter season when the water flow reduces to its minimum. The period before 2010 floods is characterized by increased human population, growth in agricultural and tourism activities in the valley and over exploitation of natural freshwater resources. The period after the 2010 flood is the existing ecology of the river system, discussed in the previous sections under the RWE and SWE.

Based on historical ecological information and field observations, the river system in the central and lower parts of the valley was found to be severely degraded. During the reference period (1926–1960), it was famous for clear and pollutant free water, the presence of riparian zones and wetlands along the river, and the abundance of native fishes, such as the *Shizothorax*, and the *Mahseer*. Native plant species, such as *Potamogeton indicus, Potamogeton pectinatus, Potamogeton perfoliatus, Hydrilla verticillata, Paspalum dilatatum, Marsilea minuta, Typha australis, Segittaria trifolia, Xanthium strumarium, Saccharam bengalense, Reptonia buxifolia, Ricinus communis, Salix babylonica and S. alba, Morus alba, Morus nigra, Alnus nitida* and *Ficus religiosa*, also were abundant in the riparian zones and wetlands of the SWE. Since then, with the increase in human population and growth in agriculture and tourism, the regimes were shifted to turbid and polluted water (Table 2.1), transformation of the riparian zones and wetlands into rice fields and substitution of ecologically important native trees with high-value, fast growing *Popular* plants (Table 2.2), and a decrease in the population of *Tor putitora (Mahseer)* and the *Shizothorax labiatus* (Table 2.3). The 2010 flood further destroyed the river system. The floods completely washed away around 31,000 hectares of agricultural land; heavily damaged *poplar* plantations on agricultural fields along the river banks and its tributaries, completely removed the *Brown Trout* population from the RWE at Swat Kohistan and severely affected native fishes in the SWE (Khan et al., 2010). Field observations and the oral history ecological information show that most native fishes and riparian plants have successfully recovered after the flood (Table 2.3). This means that they have developed resistance to floods due to climatic disturbances (Table 2.3).Details about shifts in physical and biological regimes and their causal factors are discussed in the next section of this paper.

Table 2.1. River Swat - changes in physical characteristics of SWE over time

Physical Characteristics	Temporal dynamics		
	Reference state (1926 – 1960)	**Before 2010 floods (1970 -2008)**	**After 2010 floods (2010 – 2011)**
Water color	Crystal clear	Turbid	Turbid
Silt load	Low	High	High
Pollutants	Low	Medium	Medium
Ave. annual water discharge at Chakdara	5641 cusecs	6814 cusecs	7760 cusecs

Source: Historical ecology survey (2012), field visits (July-Dec., 2012), Irrigation Department (Malakand),

Table 2.2. River Swat – dynamics of native riparian plants in the SWE

Native plants (WWE)		Temporal dynamics		
Category	**Species**	**Reference state (1926 – 1960)**	**Before 2010 floods (1970 -2008)**	**After 2010 floods (2010 – 2011)**
Aquatic plants (SWE)	*Hydrilla, Potomageton, Marsilea, Paspalum, Thypa, etc.*	Abundant (less human intervention)	Decreased (habitat loss-converted into agricultural fields)	Increasing: Some native plants invaded the land washed away by the 2010 flood along the river banks.
Riparian shrubs (SWE)	*Xanthium, Saccharam, Calatropis, Recinus,* etc.	Abundant (less human intervention)	Decreased (habitat loss-converted into agricultural fields)	
Riparian trees (SWE)	*Salix sps., Morus, Alnus, Ficus,* etc.	Abundant (less human intervention)	Decreased (habitat loss-converted into agricultural fields, substituted with *Popular*)	

Source: Historical ecology survey (2012), field study (July-Dec., 2012), Khan, et al., (2003).

1. **Native plant species succeeded to recover after the 2010 flood***: Potamogeton indicus, Potamogeton pectinatus, Hydrilla verticillata, Paspalum, Marsilea minuta, Typha australis, Xanthium strumarium, Saccharam bengalense, Salix babylonica and S. alba, etc.*

Table 2.3. River Swat – Dynamics of native and non-native fish species.

Fish fauna	Temporal dynamics		
	Reference state (1926 – 1960)	**Before 2010 floods (1970 -2008)**	**After 2010 floods (2010 – 2011)**
Mahseer (SWE)	Abundant	Endangered[1]	Endangered
Shizothorax (SWE)	Dominant & abundant	Decreased[1]	Increasing[2]
Ghara gutyala (SWE)	Abundant	Decreased[1]	
Brown Trout (RWE)	Few	Medium	Removed[3] completely
Rainbow Trout (RWE)	-	High	Removed[3] completely

Source: Historical ecology survey (2012), Field visits (July-Dec., 2012)

1. *Mostly due to illegal fishing practices; habitat loss and water pollution.*
2. *Reduction in illegal fishing practices; recovered sharply after the 2010 flood b/c of having ecological advantage over others.*
3. *Non-native species – highly vulnerable to floods*

2.5. Threats to river Swat: River Swat, like other terrestrial freshwater systems, is facing severe threats from anthropogenic activities on watershed scale and from global climate change. Based on field observations and oral history ecological survey, threats to the river system can be divided into:

2.5.1. Threats from anthropogenic activities on watershed scale: In Pakistan, all freshwater resources are considered government property. The *Provential Irrigation Departments (PID)* and the *Water and Power Development Authority (WAPDA)* have rights to manage and extract water for irrigation, hydroelectric power generation, etc. In the Swat valley, due to lack of information about freshwater property rights and poor enforcement, local people have open access to utilize freshwater resources for extractive and non-extractive needs, such as irrigation, fishing, recreation, etc. The river and its tributaries are used as a sink for sewage and waste materials from residential and commercial areas. Illegal construction of hotels, houses and industries on the river banks and transformation of riparian zones into agricultural fields are also due to poor enforcement of the freshwater property rights. Thus the institutional and market failure are providing incentives for unsustainable use of freshwater resources in the Swat valley.

Based on the types of human activities and the way they affect freshwater resources, threats to river Swat can be classified as:

2.5.1.2. Water pollution: During the past thirty years increased population, unplanned settlement along the river and growth in tourism activities have resulted serious water pollution. Solid and liquid wastes from residential & commercial areas, marble industries and hotels are disposed directly into the river. According to a study report by the *Environmental Protection Society of Swat* on Mingora stream (2004), around 43 tons of human excreta are daily disposed into the water (Khan et al., 2004) from Mingora city. The stream has lost the characteristic of habitat and as a breeding place for native fishes and has been converted into a place for disease causing agents such as viruses, bacteria, mosquitoes, etc.

Figure 2.1: ***Mingora stream -*** *The release solid and liquid wastes into the freshwater system.*
Figure 2.2: ***Riparian zone near Chakdara –*** *Clearing and leveling activities for rice cultivation.*

2.5.1.2. Encroachment by agricultural fields: Riparian plants perform several ecological functions that are essential for clean freshwater, biodiversity conservation and resilience of the freshwater ecosystems against future environmental alterations such as climate change (Naiman and Henri, (1997), Baron et al., (2003)). Clearing of the riparian plants on river sides reduces the stability of banks (Beeson and Doyle (1995)), affects the water purification process of trapping sediments and removal of organic and inorganic pollutants (Peterjohn and Correll (1984)), reduces the supply of energy inputs in the form of leaf litters and wood pieces into the water and loss of aquatic and terrestrial wildlife animals ((Lake et al., (2007)), Gregory et al., (2003)).

In the central and lower parts of the valley, riparian zones and wetlands along the river and its tributaries have been converted into rice fields. Furthermore, due to limited agricultural land, the intensive application of agricultural inputs is common to raise per acre production. The oral history ecological survey reveals that transformation of riparian zones into agricultural fields and heavy use of agricultural inputs were the main reasons for water quality degradation and loss in habitat for wildlife animals, particularly the native fishes (Table 2.1 and Table 2.3).

2.5.1.3. Deforestation: In the Swat valley the average forest cover is around 17 %, 25% in the Swat Kohistan and the Upper Swat areas and 10 % in the Central and Lower valleys (Nafees et al., (2008)). Results from oral history ecology survey of the river Swat show that forest cover in the Central and Lower valleys has been reduced by 55 – 60% since 1960, while in the Upper Swat and Swat Kohistan, the total loss is around 20%. Some recent studies based on satellite images also report a huge loss in the forest resource. According to a study by the WWF (2010), around 7,300 ha of forest has been cleared in Swat Kohistan and Upper Swat valley since 2001, which is about 13% of the forest cover in 2001.

High deforestation can indirectly increase sediment load in freshwater resources (Nafees et al., (2008), Benavides et al., (2005), Lu et al., (2003)). However, the amount of sediments depends on alternate use of deforested land, land slope, rainfall intensity, type of soil, etc. In the Swat valley, the sandy-loam and loam-sandy types of soil, huge altitudinal variation and steep land on both sides of the river makes the land more susceptible to water erosion (Nafeese et al., 2007). High deforestation rates and intensive agricultural practices along the river have made the surface soil more exposed to natural forces causing erosion. Further, in the present scenario of more intense winter and summers rains due to climate change (see section 2.5.2.), it is likely that the sediment load in the river Swat and its tributaries will increase over time. High sediment loads increase water turbidity and kills fish eggs and developing larvae (Larkin et al., (1998)).

Figure 2.3 & 2.4. Damage caused by the 2010 flood – *Both pictures clearly show the vulnerability of the natural resources and riparian zones ecosystem. The 2010 floods completely washed away top soil of more than 31000 acres of agricultural land.*

2.5.1.4. Illegal fishing practices: The field observation shows that most of the native fishes supported by the river Swat and its tributaries are under tremendous pressure from local fishermen. They are unprofessional and mostly catch fish for their own family consumption. Others involved in commercial fishing, use illegal methods of fishing such as dynamiting, electric current and poisoning. These illegal and unethical practices have put some of the native fishes at the verge of extinction (WWF, 2004), such as the Mahseer (*Tor putitora)* and the *Shizothorax labiatus*. The use of illegal fishing practices has been decreased since 2009 due to the presence of Pakistani Army in the area.

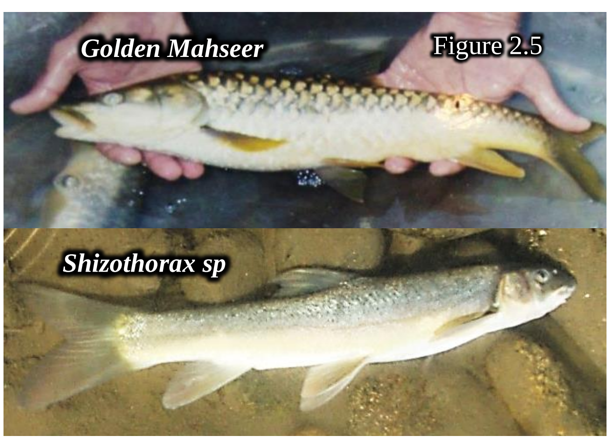

Figure 2.5 & 2.6. Fish fauna and fishing pressure - *Habitat loss, habitat degradation and illegal fishing practices have threatened the population of most native fishes, Mahseer is on the endangered species list.*

2.5.2. Climate Change: Increase in global atmospheric temperature and shifts in the timing and intensity of seasonal precipitation are expected to alter significantly the hydrological, physiochemical and biological characteristics of most terrestrial freshwater ecosystems in near future (Bates et al., 2008). Generally, in many parts of Asia, the frequency of occurrence of more intense monsoon rain events has increased, causing severe floods, landslides, and soil erosion, while the total annual amount of precipitation has decreased (Shrestha et al., 2000; Mirza, 2002; Lal, 2003). Increased global temperature is expected to speed the rate of snow and glaciers melting in the Himalayas (IPCC, 2007). According to the International Commission on Snow and Ice (ICSI) predictions, 'the glaciers in the central and eastern Himalayas could disappear by the year 2035 (Chaudhry et al., 2009). However, according to some recent studies, the response of Himalayan glaciers to climate change is non-uniform. Glaciers in the northwestern Himalayas (Karakoram and Hindukush), influenced by winter westerly's wind, are advancing in size (Scherler, 2011; Hewitt, K. 1998).

This study also evaluated the impact of global climate change on river Swat hydrology. For this purpose, time series data on water discharge of the river at two different locations, Kalam (Swat Kohistan) and Chakdara (Lower Swat) gauge stations, were obtained from the *KPK Irrigation Department (Malakand)* and *WAPDA (Peshawar).* The data was analysed by using graphical approach and deriving linear trend lines. Figure 2.7.1 (a) displays the mean monthly discharge (MMD) in cubic meter per sec for the last 40 years at the Chakdara and Kalam gauge stations. Both graphs have identical shapes showing the same flow patterns at both locations. Most of the river flow occurs in summer season (June–September), while in winter (mid Oct. – mid March) it reduces significantly. At Kalam the river is mostly fed by the snow and glaciers melting. Downstream Kalam, a number of tributaries, fed by monsoon rains, also join the river before reaching Chakdara in the South. Figure 2.7.1 (b) shows trend in mean annual discharge (MAD) at both locations. Both linear trend lines are sloping upward, indicating increased MAD during the past 40 years.

Increases in the mean annual discharge of the river Swat could be either due to: (1) increased atmospheric temperature; (2) increased seasonal precipitations; or (3) increases in both atmospheric temperature and precipitation. To identify the source of increased water discharge, this study further investigated temporal changes in atmospheric temperature and precipitation. For this purpose data for the last 40 years, on both climate factors, were obtained from the *KPK Irrigation Department (Malakand)* and *WAPDA-Peshawar*. Figures 2.7.2(a) and 2.7.3(a) summarize the mean monthly temperature (MMT) and mean monthly precipitation (MMP) respectively. The shape of MMT curve for each location (Figure 2.7.2 (a)) is closely similar to the MMF curve for the same location (Fig 2.7.1 (a)), showing positive correlation (on avg. 0.86) between MMF and MMT. To analyze changes in temperature over time, data on mean annual temperature (MAT) for the last 40 years was expressed in graphical form and linear trend lines were obtained. Fig 2.7.2 (b) shows that linear trend lines for MAT at both locations are upward sloping with annual increase of 0.11˚C and 0.012˚C at Chakdara and Kalam respectively. A rise in atmospheric temperature increases the river flow indirectly by increasing the snow and glaciers melting. Thus, increased temperature could be a factor causing increased MMF and MAF of the river Swat.

Precipitation in Swat valley occurs in two seasons, i.e. the winter season precipitation (WSP) and the summer season precipitation (SSP). WSP starts in early December and continues to the end of March. Heavy snowfall occurs during this period which becomes a source of river flow in the spring and summer when temperature starts raising. SSP occur mostly during July and August and causes floods in the Upper, Central and Lower parts of the valley. The Swat Kohistan receives very little SSP (Figure 2.7.3 (a)). To check for variation in precipitation over time, data sets on mean annual rainfall (MAR) for the last forty years at both locations were expressed in graphical forms and linear trend lines were estimated. Fig. 2.7.3(b) shows upward trend in MAR for both locations with an annual increase of 1.87 cm at Kalam and 0.00 at Chakdara.

The statistical analysis clarifies that increased temperature and precipitation were the major reasons for the increased river flow over time. Increased temperature and precipitation have also increased the frequency of occurrence of more intense summer floods in the valley (Fig 2.7.4). These results are consistent with the IPCC (2007) projections for South Asia and show that climate change extremes have already been experienced in the Swat valley and by the river Swat system during the past few decades. This study further recommends the investigation of the temporal dynamics of the glaciers in the Alpine and Cold deserts of Swat Kohistan and adjacent areas.

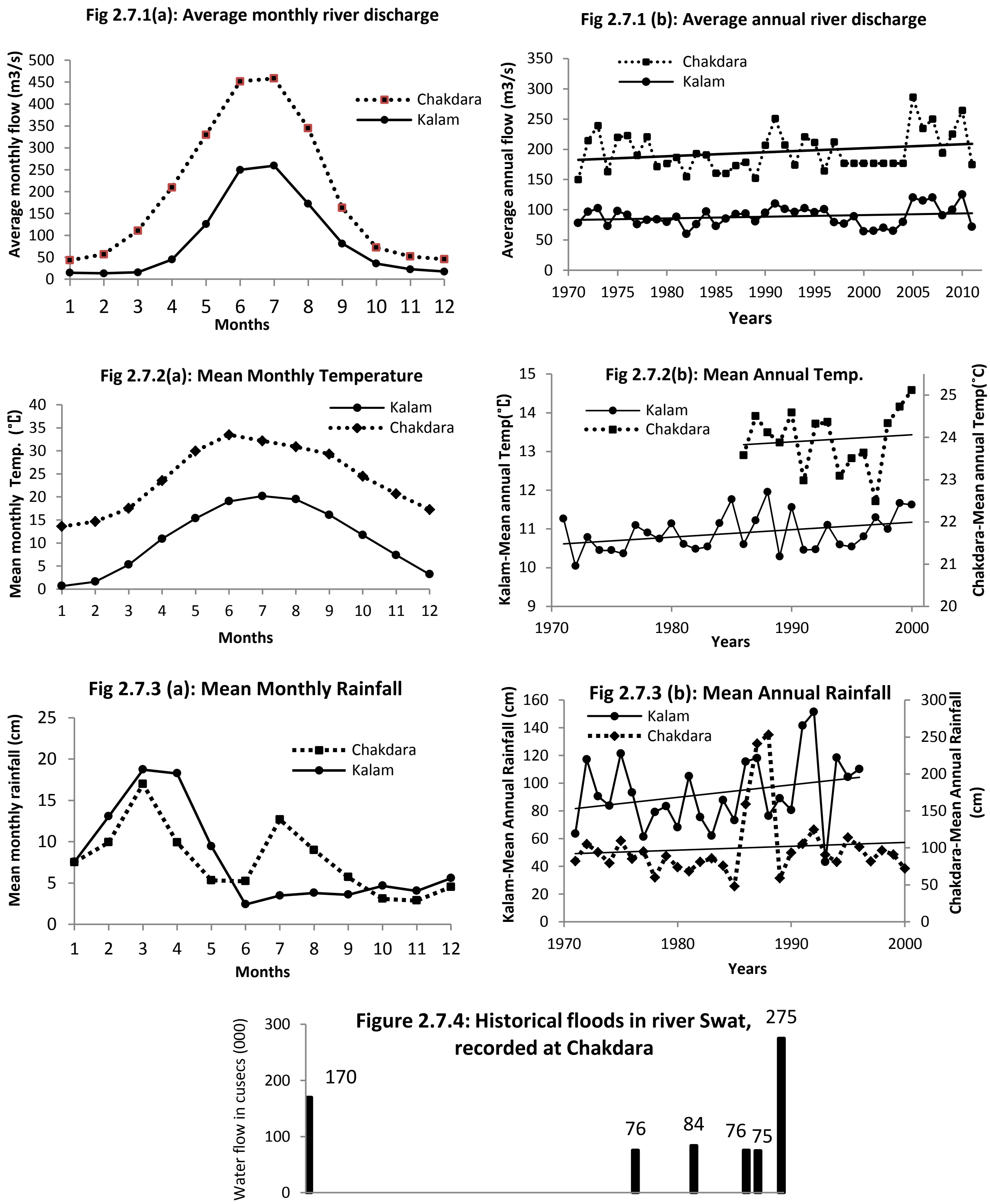

Figure 2.7. Swat valley - river discharge, atmospheric temperature and rainfall

***(Data source:** The KPK Irrigation Department (Malakand) and The Water and Power Development Authority (WAPDA) – Peshawar)*

2.6. Sustainable management of the river Swat: The intensive agricultural practices and deforestation in the valley and the release of sewage and waste materials to the main river and its tributaries have badly affected freshwater quality and have made the system more vulnerable to monsoon floods. A sound management plan is required to improve the water quality and resilience of the system against flood. The interdisciplinary team recommended an integrated water resource management (IWRM) approach that can unite all stakeholders by involving them in the planning and decision making processes with the government, donor agencies and NGOs for managing freshwater resources. The Global Water Partnership (2002) defined IWRM as the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximize the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems.

The existence of conflicting interests for different stakeholders, lack of coordination among institutions for water resource management, limited understanding about the tradeoffs between water using activities and freshwater ecosystem functioning and lack of government interest could be serious challenges for implementing IWRM approach in Swat valley. Therefore, a successful IWRM will require the central and provincial governments and institutions to enable the environment for integrated management of water resources.

Water resource managers, such as the Irrigation Department and WAPDA, will need different tools in order to work efficiently and follow an IWRM for the river Swat to achieve the objectives of water quality improvement and protection against the flood. The management tools will include:

1. Long-term programs for the entire river basin to continuously observe and analyze the freshwater system and to explain the impacts of different socio-economic and climate factors on the system;
2. Bring all stakeholders on a single platform to discuss and develop consensus on long-term sustainable freshwater management that balance the economic, social and environmental needs; resolve any conflict of interests and develop strong coordination among them.
3. Encourage stakeholders to actively participation in well-informed and transparent planning and decision-making process.
4. The use of regulatory instruments to promote environmental protection, social equity and economic efficiently in using freshwater resources. Regulatory instruments could be: direct instruments (regulations, rights, standards) and; economics instruments (prices, subsidies, incentives and taxes).
5. Sufficient funding by government, international donor agencies or NGOs in long-term water research programs and capacity building by organizing informational training programs for stakeholders and community people;

Management plan: Based on the existing and historical ecology of the river system, threats from human activities and geophysical characteristics of the valley, the interdisciplinary team discussed different management plans that could possibly improve the water quality and resilience of the system against flood. First, the economic efficiency and ecological viability of each plan was considered. Plans that fit the environment, that were effective and that could be readily adopted where considered ecologically viable. From an economic standpoint, the total economic benefit from each management plan was compared with its total cost. Next, the team discussed the designed management plans with different users and stakeholders (farmers, hotel owners, irrigation department, fisheries department and forestry department) in the valley to test the social acceptability for each option.

Any management plan which is ecologically viable, socially acceptable and economically efficient would achieve the goals of freshwater quality improvement and protection against monsoon floods without compromising the economic development process and the ability of present and future generations to meet their needs. Based on this criterion the interdisciplinary team recommended the following management plan for river Swat:

2.6.1. Restoration of riparian zones: Riparian zones are interfaces between terrestrial and freshwater ecosystems. Riparian zones consist of biotic communities that perform different ecological functions essential for a healthy freshwater ecosystem. Some of these functions are: (1) purification of river's water by trapping and removing pollutants, sediments and nutrients from terrestrial ecosystems (Gilliam (1994), Groffman et al., (1992), Peter john and Correll (1984)). Experimental studies shows that riparian grasses and trees remove 80–90% of the sediments leaving agricultural fields (Cooper et al., (1987), Daniels et al., (1992)); (2) protection of river associated biodiversity by providing them habitat, spawning places and refugia against predators and flood (Lake et al., (2007), Gregory et al., (2003), Gregory et al., (1991)); and (3) stabilize channel morphology by covering and holding soil particles that reduces bank erosion during flood (Naiman and Henri, (1997), Beeson and Doyle (1995)). Ecologists and environmentalists are using riparian zones as a tool in restoration of freshwater ecosystems, conservation of biodiversity and protection against floods due to climate change.

In the Central Swat valley, downstream from Mingora city, modification of the river channel and restoration of riparian zone (figure 2.8) along the main river will improve water quality by removing pollutants and sediments from urban areas, agricultural fields and uplands. In addition to water purification, it will provide habitat for terrestrial and aquatic wildlife animals especially the endangered Mahseer and Shizothorax fishes. Plantation of flood resistant native herbs, shrubs and trees will reduce erosion of the river banks and will improve the resilience of both terrestrial and freshwater ecosystems against extreme floods due to climate change. The restoration of a riparian zone will also improve the esthetic quality of the valley and a few spots in the zone can also be opened for limited tourism and recreation activities, such as hiking, fishing, boating and picnicking. The generated income from the recreation activities can be utilized for motivating farmers to grow native plants on both sides of the riparian zone.

Current river channel and land utilization:

1. Main River: more than one channel, wide open and high deposition of sediments.
2. River bank having no riparian plants.
3. Agricultural fields, no riparian zones

Designed management plan:
(A) Modified main river channel (200m - 250m width);
(B) Aquatic and terrestrial herbaceous plants layer (10m);
(C) Shrubs and trees layer (50m);
(D) Dense riparian tree layer (200m);
(E) Agri. farms - ½ acre crop filed surrounded by native riparian plants;
(F) Wall-water speed breaker & site for recreation;
(G) Refugia for aquatic animals against flood, fishing spot

Fig. 2.8. River Swat - riparion land utilization, downstream Mingora city

In the Swat valley, agricultural land is limited and the majority of farm households are poor. The restoration of a large riparian zone in the central-lower valley would involve high opportunity cost to farm households. Therefore, payment to farmers can encourage them to plant flood resistant native plants on their farms. However, the compensated amount should be enough to cover their opportunity cost.

2.6.2. Reforestation and farm forestry: On a watershed scale, deforestation and sediment load have a positive relationship (Benavides et al., (2005)). However, the extent of this relation depends on alternative land using practices, land slope, rainfall intensity, type of soil, etc. The Swat Kohistan, the Upper Swat and some sub-valleys in the Central and Lower part are more susceptible to erosion (Nafeese et al., (2008)). Therefore, to control the loss of soil from erosion and reduce sediment load (turbidity) in the river system, reforestation and farm forestry can play an important role and will improve the functioning of the riparian zones. Reduction in turbidity will result increase in the reproductive ability of native fishes. Reforestation, afforestation and farm forestry are also important for carbon sequestration, reduction in average annual temperature of the valley and intensity of floods.

2.6.3. Construction of protection walls: In the Upper Swat valley, where land slope increases sharply on the eastern bank of the river, heavy land sliding and erosion was observed during the field study. Construction of protection walls of proper length, width and height can reduce this problem. Protection walls should also be constructed at other locations along the river where the 2010 flood caused huge destruction.

2.6.4. Installation of sewage treatment plants and wetlands: The flow of waste materials and sewage from residential and commercial areas can be significantly reduced by the installation of sewage treatment plant and wetland downstream large towns (Mingora). In the Swat Kohistan area, where most houses and hotels are constructed near the river banks, the use of septic tanks in houses and hotels can control the direct flow of organic and inorganic pollutants into the river system.

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2.8. Appendices:

2.8.1. Ecology glossary:

Ecological services: The conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life.

Historical ecology: Historical ecology is the use of historical knowledge in the management of ecosystems. Historical perspectives increase our understanding of the dynamic nature of landscapes and provide a frame of reference for assessing modern patterns and processes (Swetnam et al, 1999).

Healthy ecosystem: A healthy ecosystem is one that is sustainable – that is, it has the ability to maintain its structure and function over time in the face of external stress (Costanza et al, 1999)

Resilience: The capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks (Walker et al. 2004). I other words it is the magnitude of disturbance that a system can experience before it shifts into a different state with different controls on structure and function (Holling, 1973)

Reference state: Reference state means 'natural' or 'pre-disturbance' ecosystem conditions. In other words reference state is the ecosystem conditions before human disturbances.

2.8.2 Interdisciplinary team:

Field visits – river ecology and threats

1. **Prof. Taj ul Malook** (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)
2. **Mr. Umar Hussain** (Assistant Secretory, BISE Swat)
3. **Kursheed Ahmad** (Assistant prof. in Botany, Govt. Degree College Thana)
4. **Syed Shah** (PhD candidate, ecological economist, Colorado State University Fort Collins)
5. **Asghar Khan** (Lecture in Botany, Govt. Degree College Totakan, Malakand Agency)

Management plan designing:

1. **Prof. Taj ul Malook** (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)
2. **Dr. Gulam Mohammad** (Chairman Dept. of Botany, Jehanzaib College Saidu Sharif, Swat).
3. **Mohammad Siraj** (Assistant Prof., Jehanzaib College Saidu Sharif, Swat).
4. **Dr. Usman Ali** (Secretary BISE Swat, Saidu Sharif, Swat)
5. **Syed Shah** (PhD candidate, ecological economist, Colorado State University Fort Collins)
6. **Iftikhar Ahmad** (Associate Prof. in Economics, Govt. Degree College Thana)

2.8.3. Sites visited by interdisciplinary team:

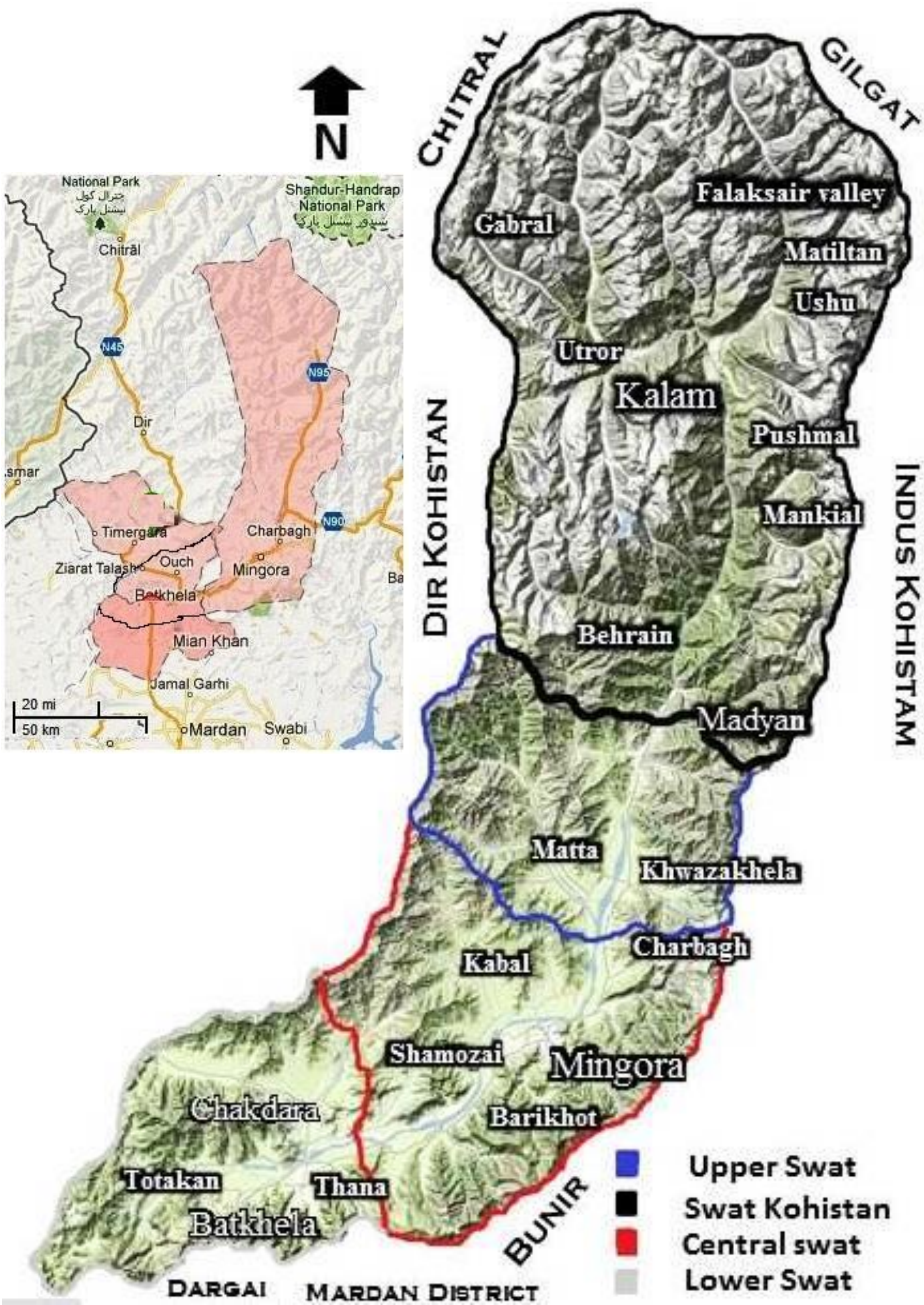
Sites	Location	Zone
Site 1	Chakdara	Lower Swat
Site 2	Mazari-Batkhela	
Site 3	Matkhary-Malakand	
Site 4	Qalangi	
Site 5	Mingora	Central Swat
Site 6	Barikoat	
Site 7	Khwazakhela	Upper Swat
Site 8	Madyan	Swat Kohistan
Site 9	Bahrain	
Site 10	Kalam	

2.8.4. Swat valley–climate zones

Zones	Zones	Altitude (m)	Temp. <10˚C (months/year)	Precipitation (mm)	Vegetation	Agriculture
Sub-tropical	Lower and Central Swat	567 - 1000	04	625 - 1250	Olea ferruginea, Acassia modesta, Reptonia, Dodonaea	Double cropping, tropical fruits and vegetables
Humid-temperate	Upper Swat and Swat Kohistan	1000-1900	06	1000 -1250	Pinus wallichiana, Quercus sps. Pyurs pashia,	Double cropping, temperate fruits and vegetables.
Sub humid temperate	Upper Swat and Swat Kohistan	1900-2300	06	500 - 1000	Cedrus deodara, Pinus wallichiana, Quercus sps. Salix sps., etc.	Mono cropping (Potato, Maize, Cabbages, Peas, Turnips).
Sub-alpine	Swat Kohistan	2300-3600	06	500 - 1000	Abies pindrow, Pinus wallichiana, Betula utilis, Vibernum foetens	No agriculture - Livestock grazing and forest products
Alpine	Swat Kohistan	3600-4600	07	500 - 1000	Juniperus squamata, J. communi, Polygonum sps. etc.	Livestock grazing and medicinal plants collection
Cold desert	Swat Kohistan	4600-6000	09		Primula macrophylla etc.	_

Source: Modified from EPS report on river Swat Ecology (2002)

2.8.5. Map- river Swat watershed



2.8.6. Riparian plants – Types, their botanical and family names

Types of vegetation	**RWE riparian plants** ***Botanical name (family name)***	**SWE riparian plants** ***Botanical name (family name)***
Aquatic plants	*Nasturciam officinal (Brassicaceae)* *Polygonum amphibium (Polygonaceae)* *Polygonum hydropiper (Polygonaceae)* *Ranunculus muricatus (Ranunculaceae)* *Veronica anagallis- aquatica (Scrophulariaceae)*	*Alisma plantago-aquatica (Alismataceae)* *Chara (Characeae)* *Cyprus sps. (Cyperaceae)* *Hydrilla verticillata (Hydrocharitaceae)* *Lema minor (Araceae)* *Marsilea minuta (Marsileaceae)* *Paspalum dilatatum (Poaceae)* *Polygonum sps. (Polygonaceae)* *Potamogeton indicus (Potamogetonaceae)* *Potamogeton pectinatus(Potamogetonaceae)* *Potamogeton perfoliatus(Potamogetonaceae)* *Segittaria trifolia (Alismataceae)* *Sparganium ramosum (Sparganiaceae)* *Typha australis (Typhaceae)*
Herbs and shrubs	*Amaranthus spinosus(Amaranthaceae),* *Amaranthus virdis(Amaranthaceae),* *Cannabis sativas (Cannabinaceae),* *Carthamus lantus (Asteraceae),* *Chenopodium album (Chenoppdiaceae),* *Cynodon dectylone (Poaceae),* *Eruca Sativa (Brassicaceae),* *Mentha longifolia (Lamiaceae)* *Nasturtium officinale (Brassicaceae),* *Plantago major (Plantaginaceae),* *P. lanceolata (Plantaginaceae),* *Polygonum amphibium (Polygonaceae),* *Polygonum hydropiper (Polygonaceae),* *Ranunculus muricatus (Ranunculaceae),* *R. aquatilis (Ranunculaceae),* *R. scleratus (Ranunculaceae),* *Rumex dentatus (Polygonaceae),* *Sonchus asper(Asteraceae),* *Sonchus oleraceous (Asteraceae),* *Solanum nigrum (Solanaceae),* *Steria virdis (Poaceae),* *Tagetes minuta (Asteraceae),* *Urtica dioca (Urticaceae),* *Verbascum Thapsus (Scrophulariaceae),* *Veronica anagallis-aquatica (Scrophulariaceae),*	*Amaranthus spinosus(Amaranthaceae),* *Amaranthus viridis(Amaranthaceae),* *Artemisia scoparia (Asteraceae),* *Calatropis procera (Asclepiadaceae),* *Canabus Sativas (Cannabinaceae),* *Chenopodium album (Chenoppdiaceae),* *Conyza conda (Asteraceae),* *Cynodon dectylone(Poaceae),* *Medicago sativa (Fabaceae),* *Mentha longifolia (Lamiaceae),* *Mentha sylvestris (Lamiaceae),* *Nerum oleander (Apocynaceae)* *Pantago major (Plantaginaceae),* *Polygonum sps. (Polygonaceae),* *Portulaca oleracea (Portulaceae),* *Ranunculus scleratus(Ranunculaceae),* *R. aquatilis (Ranunculaceae),* *Ricinus communis (Euphorbiaceae),* *Rosa webbiana (Rosaceae),* *Rumex dentatus (Polygonaceae),* *Saccharam bengalense (Poaceae),* *Setaria viridis(Poaceae),* *Solinum nigrum (Solanaceae),* *Sonchus oleraceous(Asteraceae),* *Verbascum Thapsus (Scrophulariaceae),* *Xanthium strumarium (Asteraceae),* *Ziziphus mammularia (Rhamnaceae),*
Trees	*Acer caesium (Aceraceae),* *Aesculus indica (Sapindaceae),* *Diospyrus lotus (Ebenaceae),* *Juglans regia (Juglandaceae),* *M. nigra (Moraceae),* *Morus alba (Moraceae),* *Populus alba (Salicaceae),* *Prunus cornuta (Rosaceae),* *Pyrus pashia (Rosaceae),* *Salix alba (Salicaceae),*	*Accacia modesta (Mimosaceae),* *Alnus nitida (Betulaceae),* *Dalbergia sissoo (Fabaceae),* *Ficus religiosa (Moraceae),* *Melia azedarach (Meliaceae),* *Morus alba (Moraceae),* *Morus nigra (Moraceae),* *Olea cuspidate (Oleaceae)* *Populus ciliate (Salicaceae),* *P. euphratica (Salicaceae),*

		P. nigra (Salicaceae), *Salix babylonica (Salicaceae),* *S. alba (Salicaceae),*
Slope vegetation	*Abies pindrow (Pinaceae),* *Abies spectabilis (Pinaceae),* *Acer caesium (Aceraceae),* *Aesculus indica (Sapindaceae),* *Betula utilis(Betulaceae),* *Cedrus deodara (Pinaceae),* *Diospyrus lotus (Ebenaceae),* *Juglans regia (Juglandaceae),* *Olea ferruginea (Oleaceae),* *Pinus wallichiana (Pinaceae),* *P. gerardiana (Pinaceae),* *Populus ciliate (Salicaceae),* *Prunus cornuta (Rosaceae),* *Pyrus pashia (Rosaceae),* *Querccus sps. (Fabaceae),* *Salix sps. (Salicaceae),*	*Acacia modesta(Mimosaceae),* *Berberis lyceum(Berberidaceae),* *Dodonaea viscosa (Sapindaceae),* *Eucalyptus sp. (Myrtaceae),* *Ficus religeiosa (Moraceae),* *Olea ferruginea (Oleaceae),* *Otostegia limbata (Lamiaceae),* *Pinus roxburghii (Pinaceae),* *Reptonia buxifolia (Sapotaceae),* *Sacchrum bengalense (Poaceae)* *Ziziphus mammularia (Rhamnaceae),*

Source: Field visits, July – Nov, 2012

2.8.7. The impact of river Swat management plan on poverty alleviation: In developing countries, the success of any ecosystem restoration or biodiversity conservation program depends on its social impact; particularly on poverty reduction (Adams et al, 2004). Therefore, before finalizing any management plan, ecologists and environmentalists check for any conflict with poverty reduction. For an ecosystem restoration program (ERP) any of the following three relations might occure with a household's poverty in an area: (1) ERP and poverty are not related; (2) ERP has positive impact on poverty e.g. the impact of water quality improvement on downstream communities' heath and reduction in their expenditures on heath related problems; and (3) ERP has negative impact on poverty e.g. conversion of agricultural fields into riparian zones. The first two scenarios don't impose any constraint on ERP, and therefore ecologist can recommend their designed management plan for implementation. In the third scenario, where the cost of restoration is paid by poor people, poverty limits the success of ERP. In order to successfully implement the ERP the poor people must be compensated.

To check the impact of river Swat management plan on poverty in Swat valley, this study analyzed primary data on demographic characteristics of 243 households. The data was collected during July-December, 2012 for contingent valuation (CV) study of the river Swat water quality improvement during July-December 2012 from the Swat valley and district Mardan. Based on the analysis of the demographic information, the average per-capita income in Swat valley was found to be Rs.4600/month ($1.6/day), whereas the per-capita income for 37% households was below Rs.2900/month ($1/day). These figures indicate mass poverty in Swat valley and downstream districts.

On the basis of historical records and field observations, poverty in Swat valley can be differentiated into indigenous poverty and exogenous (induced) poverty. Indigenous poverty means poverty due to internal factors such as environmental conditions (heavy snowfall, intense monsoon rains, floods, etc) and unbalanced growth in human population. Exogenous or induced poverty means poverty due to external factors such as war, short term food supply crises and lack of government investment in health, education, roads and modernization of traditional agriculture. To test the impact of the management plan on households' poverty, two dummy variables, home in flood affected areas and direct freshwater users (farmers and fishermen), were used in a binary probit analysis explaining nature of poverty in Swat valley. A list of all variables used in regression analysis is given in Table 2.4.

Table 2.4. List of variables used in probit regression analysis

1	***Poverty***	=1 if household per capita income (PCI) is > $1/day otherwise '0'
2	***Family size***	Total number of people in a house
3	***Home in WAA***	=1 if home is located in war affected area otherwise '0'
4	***Home in FAA***	=1 if home is located in area affected by the 2010 flood otherwise '0'
5	***Education***	Education of house head in years
6	***Dependence on FWR.***	=1 if directly depend on river Swat (farmers, fishermen) otherwise '0'

Table 2.5 show results from probit regression analysis. The dummy variable 'home in flood affected areas is significantly negative which means that households living in flood affected areas are more likely to be poor. Education has a significant positive impact on poverty alleviation. Households with a more educated head are less likely to be poor. Family size, house in war affected areas and dependence on freshwater resources have insignificant impacts on household poverty. The positive sign on dummy variable 'home in war affected areas' is against my prior expectations and might be due to sharp economic development there. After the War against Taliban in 2009, the Pakistani government and international organizations helped in the rehabilitation of displaced people and the restoration of the agricultural and tourism industries. That helped people to fastly recover immediately from the war-induced poverty situation. In the flood affected areas, particularly in the lower and central lower Swat valley, Govt. and NGOs support is still required to help households.

This analysis clarifies that river Swat management plan will help in reducing poverty in Swat valley. Restoration of the river Swat ecosystem will also provide ecological goods and services that will improve household's welfare (see section 2.6). Households practicing agriculture on river sides in the central and lower valley must be compensated through 'payment for ecosystem services program' for growing native riparian plants.

Table 2.5. Probit model - Nature of poverty in Swat valley and downstream districts

Explanatory variables	Coefficients (z)	
Cons	.5417424	(1.46)
Family size	-.0455171	(-1.63)
Home in war affected areas	.0033179	(0.02)
Home in floods affected areas	-.911732	(-3.57)***
Education	.0900581	(5.13)***
Dependence on freshwater	-.0860043	(-0.41)
# of observations	243	
LLR (Chi^2)	-351 (51)	

Data source: CV survey for river Swat water quality improvement (July-Dec. 2012)
**** significant at 0.01 level*

2.8.8. Survey - Historical Ecology of River Swat:

During the past thirty years, increased human population and growth in agriculture and tourism activities has resulted degradation of river Swat and its tributaries. Deposition of wastes from residential areas, commercial areas and industries, high sediments load due to large scale deforestation and intensive agricultural practices in the riparian zones and wetlands and illegal fishing practices have destroyed the entire freshwater ecosystem. Recently, very few studies have highlighted the impacts of mentioned human activities on the physical, chemical and biological characteristics of the river. To fill out this gap, this research work is designed to identify threats to the river Swat and design a management plan to restore its healthy ecosystem.

The main reason of this questionnaire is to collect information on historical ecology of the river Swat. Your correct information are important for identification of human activities responsible for changes in the biophysical characteristics of the river and for designing a sustainable management plan.

1. Your Name: ____________________
2. Your Age: ___ years
3. Location: ____________________
4. How long have you been living here?
   Years: ________________
5. What benefits are (have) you receiving (received) from river Swat.
   - ☐ Water for irrigation
   - ☐ Recreation
   - ☐ Fishing
   - ☐ Other: ____________________
     ____

6. How would you compare the current river situation with the past one in-terms of

   A. Water color: *Clear/ Turbid*
   B. Water pollution: *Low/ Medium/ High*
   C. Silt/ clay load: *Low/ Medium/ High*
   D. Population of fishes and other animals *Low/ Medium/ High*
   E. Plants communities on river banks *Low/ Medium/ High*

7. What changes have you observed in the river flow during the past _____ years?

   - ☐ Increased
   - ☐ Decreased
   - ☐ No significant change

8. What plant species have you observed / noticed on the river sides during the last __ years.

Trees	Shrubs	Grasses/ Cover plants	Submerged plants

9. What animals have you observed/ noticed during the past ______ years.

Fishes	Birds	Other animals

10. What plants and fish species were dominant and frequent?

Plants - 1926-1960	Fishes - 1926-1960	Plants - 1970-2008	Fishes - 1970-2008

11. What you have been told by your elders about plants and animals communities in the riparian zones of the river.

12. What do you know about changes in riparian zones and wetlands over time?
Ans:

13. What do you know about changes in forest resources (cover area and type) over time?

a. Swat Kohistan and Upper Swat Valley

Period	Forest cover	Forest type
1926 - 1960		
1970 - 2008		
2011 - 2012		

b. Lower and Central Swat valleys

Period	Forest cover	Forest type
1926 - 1960		
1970 - 2008		
2011 – 2012		

14. What species have gone extent/ disappeared/ reduced in population?

Category	Specie	Reasons
Riparian plants:		
Fish and other animals		

15. What changes have you observed in the below listed fishes:

Fishes	1926-1960	1970-2008	2011-2012
Brown Trout			
Rainbow Trout			
Shizothorex species.			
Golden Mahseer:			
Gara ghtyla			

16. List at least three main reasons that affected the water quality.

Human activities: ____________________ Environmental: ____________________

____________________ ____________________

____________________ ____________________

17. Your profession: ________________

18. Education: __________(Years)

19. Family Size: ________________

20. Primary source of Income: ________________

CHAPTER 3 – PAPER TWO

ECONOMIC VALUATION OF FRESHWATER QUALITY IMPROVEMENT IN POVERTY DONIMATED AREAS: A CASE STUDY OF RIVER SWAT (PAKISTAN)

3.1. Introduction and objectives: Lakes and rivers are valuable assets. They provide different goods and services that directly and indirectly benefit human societies (Postel et al., (1997), MES (2005)). In the recent past, concern has been raised over the impacts of human activities on the quantity and quality of freshwater resources. Increased human population, along with agricultural and industrial growth, has degraded most freshwater ecosystems (Gleick 1993, Jackson et al., 2001). Overexploitations, pollution, fragmentation, degradation of habitat and invasion by non-native species are serious threats to freshwater resources. Besides direct human interventions, climate change is another factor which is expected to alter the hydrology of most freshwater ecosystems and the distribution and abundance of water associated biodiversity (Bates et al., 2008).

Like most freshwater resources, river Swat and its tributaries, which drain the entire Swat valley, have been polluted to a level which is a serious threat to people's heath and river associated biodiversity (Khan, 2003). River Swat watershed, also called Swat valley (Appendix 3.9.1), is located in the north west of Pakistan. The river Swat and its tributaries, which drains the entire Swat valley, plays important role in the economic life of the people. The valley is famous for the production of quality fruits and off season vegetables. River Swat and its tributaries are the main source of water supply for irrigation in the valley and downstream districts. Besides supplying water for irrigation, it supplies water for drinking, industrial use, fish farming and hydroelectric power generation. The valley is also famous for tourism and the esthetic beauty of the river is the main source of attraction for tourists. During the past three decades, increased human population and growth in tourism activities have severely degraded freshwater quality (Khan, 2003). The release of sewage and other wastes from residential areas, commercial areas and hotels into the river system have badly affected its water quality. The conversion of riparian zones and wetlands into agricultural fields, intensive cultivation practices and large scale deforestation have affected the clean and clear water quality regimes and the resilience of the system against intense floods which are expected to occur more frequently in the area due to climate change. The destruction caused by the 2010 flood present a clear picture of the vulnerability of the freshwater system. The flood completely washed away more than 31000 acres of fertile agricultural land along the river banks, completely removed Brown Trout and Rainbow Trout and severely affected other native fishes (WWF, 2010).

In July-December, 2012, an interdisciplinary team (Appendix 3.9.2) visited different sites along the river to study the biophysical characteristics of the main river and to identify threats to the river system. Based on the geophysical characteristics of the watershed, biophysical characteristics of the river system and threats from anthropogenic activities and climate factors, the team then recommended a management plan to improve freshwater quality and resilience of the system against flood. To test for the economic efficiency of the management plan, the team recommended measuring the monetary value for water quality improvement of the system. That's why this study was designed to measure the total economic value for water quality improvement of the river Swat. Results from this study were used for testing the economic efficiency of the recommended management plan. The paper is organized as follows: Section 2 and 3 discuss benefits that can be obtained from freshwater quality improvement and techniques for measuring its total economic value for those benefits. Section 4 & 5 discuss steps involved in designing a CVM and econometric models for estimation of mean-WTP for water quality improvement. Section 6 and 7 discuss results from the econometric analysis and conclusions respectively.

3.2. Benefits provided by freshwater quality improvement: Any improvement to the water quality of river Swat would provide many benefits to local and downstream human communities. The interdisciplinary team identified those benefits along with their spatial scale of provision. Table 3.1 shows a list of some of those benefits and categorizes them into use and non-use benefits.

Table 3.1. Benefits from water quality improvement of river Swat

Benefits provided by water quality improvement of River Swat (Pakistan)		**Spatial scale of provision**		
		Swat valley	**Downstream districts**	**Global**
Direct benefits	Clean water for drinking	✓	✓	-
	Clean water for Irrigation	✓	✓	-
	Clean water for Fisheries	✓	✓	-
	Clean water for Industrial use & power generation	✓	✓	-
	Clean water for Swimming, fishing & boating etc.	✓	✓	-
	Growth in tourism and welfare gain	✓	✓	-
Indirect benefits	Hiking, picnicking, photography	✓	-	-
	Home and hotels – beautiful views	✓	-	-
	Increase in property values	✓	-	-
	More savings - less spending on heath	✓	✓	-
Protection and increase in population of native fishes, e.g Golden Mahseer (Tor petro) and Swati (Shizothorex spps) – (**Existence value)**		✓	✓	✓
Overall improvement in freshwater ecosystem's heath – (**Existence benefit)**		✓	✓	✓
Provision of above benefits in future for own use – **(Option value)**		✓	✓	✓
Provision of above benefits for next generations – (**Bequest value)**		✓	✓	✓

Source: Field survey, 2012

The use-benefits arise from the direct and indirect use of improved quality water. Direct use-benefits are the direct utilization of improved quality water for drinking, irrigation, fisheries, industrial use, and recreational purposes (e.g. swimming, boating and fishing etc.). The indirect use-benefits are the indirect utilization of water quality, such as picnicking, camping or hiking along the river, raise in property value near the river, decrease in water born human diseases and reduction in spending on health related issues, growth in tourism, etc. Nonuse benefits, also called passive use benefits, arise without consuming water. These benefits can be categorized into option benefits, bequest benefits and existence benefits. Option benefits arise due to an individual's desire to use the river, either directly or indirectly, in the future. Bequest benefit is the satisfaction an individual gets from sustaining a river's water quality or associated biodiversity for future generations. Some people have altruistic desire and get satisfaction from preserving a river system and associated biodiversity, not for any direct or indirect use benefits, but for its own intrinsic value. This type of benefit is termed as existence benefit. Improvement in water quality of river Swat will protect native fishes such as the endangered *Golden Mahseer* and the vulnerable *Shizothorex sps*.

3.3. Measurement of benefits provided by freshwater quality improvement: Freshwater ecosystem services exhibit public goods like characteristics such as 'non-excludability' and 'non-exhaustibility' in consumption. The purification of a river's water by a riparian buffer zone benefit both local and downstream users. There is no way to restrict the flow of benefits from water quality improvement to local people and exclude downstream users. To measure the economic value for such services, economists use non-market valuation techniques which are based on utilitarian approach of measuring satisfaction people derive from the direct or indirect consumption of goods.

Suppose a household maximizes its utility (U) from the consumption of market goods (X) and public goods (Q) (including freshwater quality) subject to fixed budget (Y) and price (P).

$$U = u(X, Q) \quad s.t. \qquad P.X \leq Y \ldots\ldots\ldots. \qquad (3.1)$$

For any improvement in freshwater quality from q_w^0 to q_w^1, household's gain in welfare can be represented by the difference between their indirect utilities at q_w^0 and q_w^1 ;

$$\Delta U^h = \nu^h(P, q_w^1, Q_{-w}, y) - \nu^h(P, q_w^0, Q_{-w}, y) \ldots\ldots (3.2)$$

$$\nu(P, q_w^1, Q_{-w}, y - CS) = \nu(P, q_w^0, Q_{-w}, y) \ldots\ldots\ldots\ldots\ldots (3.3)$$

Where CS is the compensating surplus, which represents a change in household's welfare. In terms of an expenditure functional form ($e^h(P, Q, \overline{U})$), CS can be expressed as:

$$CS = e^h(P, q_w^0, Q_{-w}, u^0) - e^h(P, q_w^1, Q_{-w}, u^0) = \int_{q_w^0}^{q_w^1} \left(\frac{\partial e^h(P, q_w, Q_{-w}, u^0)}{\partial q_w}\right) \partial q_w \ \ldots\ldots (3.4)$$

Where $u^0$is the initial utility level at q_w^0.

As CS can't be observed directly, therefore economists use the following non-market approaches to measure it:

3.3.1. The revealed preference method: The Revealed preference method estimate the value for ecosystem services (water quality, etc.) indirectly by observing people's behavior in the markets for related private goods such as recreational activities (fishing, boating, hiking, camping, etc.) or buying a property along a river or lake with improved water quality. The two most well-known reveled preference methods are travel cost method (TCM) and hedonic pricing model (HPM). Both methods are based on the assumption of complementary relationship between the public good and the private good (Appendix 3.9.3 and Appendix 3.9.4) e.g. improvement in water quality of a river and trips for recreational activities. TCM assume that people make repeated trips to a recreational site until the marginal utility derived from a trip equals the marginal costs of a trip. The marginal cost is equal to travel cost (time cost and transportation cost) per trip. These travel costs can be regarded as directly revealed preference for recreation and an indirectly revealed preference for water quality. Since individuals reside at varying distances from a recreation site, the variation in distance and the number of trips taken are used to trace out an ordinary demand curve for that particular recreation site. The ordinary demand curve is then used to derive the consumer surplus associated with using the site. From the demand curve the change in consumer surplus of recreation (WTP) with improvements in water quality can be estimated (Loomis and Walsh, 1997). The HPM is based on the idea that private market goods are often traded at prices in which amenities are internalized (Appendix 3.9.4). For example, the price of a house along a river having improved water quality is likely to be higher than the price of the same kind of house near a polluted river. Housing market differences can be used to trace out the demand for water quality and used to measure economic benefits.

3.3.2. The stated preference method (SPM): SPM is a survey-based method in which respondents are asked questions in order to reveal information about their preferences (Freeman 2003). Based on the types of questions, SPM can be divided into several types; however, the contingent valuation method (CVM) is the most popular method and widely used to measure the monetary value for public goods. CVM can measure CS directly by creating a hypothetical market and use a survey method to directly ask respondents about their willingness to pay (WTP) for a hypothetical improvement in water quality.

CVM also has the ability to measure both use and non-use benefits from water quality improvement; while the reveled preference methods can only estimate the use values (benefits). In early nineties, after getting the status of an alternative approach to reveled preference methods, CVM was criticized by some researchers for the validity and reliability of results (Hausman, 1993). Later studies proved the validity of CVM results for use values by comparing them with results from TCM (Carson et al., 1997)**.** The National Oceanic and Atmospheric

Administration (NOAA) Blue Ribbon Panel reviewed CVM studies and concluded that this method can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resource damages including lost passive-use value (Arrow et al., (1993)). The panel established a set of guidelines for CVM to follow in order to get reliable results.

CVM is widely used in testing the economic efficiency of alternative management plans for environmental and natural resources (see Mitchell and Carson, 1989). Recently, in developing countries, several studies used this method for economic valuation of benefits from natural ecosystems restoration, drinking water infrastructure and public health projects (Xu, Z., et al., (2006), Witington et al., (2002), Xu, Z., et al., (2003)).

3.4. Contingent Valuation Method:

As any improvement in the water quality of the river Swat will provide both use and non-use benefits (Table 3.1). Therefore, CVM was selected to measure the total economic value for water quality improvement.

3.4.1. CVM survey design:

Survey designing is the central and most important part in CV studies. A good design requires more effort on providing sufficient and accurate information about a public good in question and on selecting the most efficient survey tools to elicit respondents' true WTP. Therefore, for this study, more time was spent on survey design to describe the current water quality situation of the river and the recommended management plan correctly. Furthermore, to make it understandable for a lay man, the survey was translated in the local language-Urdu. CVM survey tools were selected based on recommendations from another study on the sensitivity of households' stated WTP to payment vehicles and managing agencies for water quality improvement of the river Swat.

The designed survey was pretested on a group of 15 individuals and final changes were made in the light of results from pretesting. The final CV survey involved the following:

3.4.1.1 Water quality situation and management plan: CVM produces values contingent upon the description of the resource and the method of payment. Therefore the accurate measurement of any resource requires a detailed description of the resource (Loomis et al., 2000). That's why the CVM survey design for this study was started with a detailed description of the present water quality situation. The survey then discussed the management plan recommended by the interdisciplinary team to improve the water quality of the river system.

The management plan included the following actions:

- ***Restoration of riparian zones****: In the Central Swat valley modification of the river channel and restoration of the riparian zone along the main river will improve water quality by removing pollutants and sediments from urban areas, agricultural fields and uplands. In addition to water purification, it will provide habitat for terrestrial and aquatic animals. The plantation of flood resistant native herbs, shrubs and trees will reduce erosion of the river banks and will improve the resistance of both terrestrial and freshwater ecosystems against extreme floods due to climate change.*
- ***Reforestation and afforestation:*** *To control the loss of soil from erosion and reduce sediment load (turbidity) in the river system, reforestation and farm forestry can play important role. Reforestation and farm forestry will reduce sediment pollution in the river that will improve the functioning of the riparian zones, increase in the reproductive*

ability of native fishes and effectively increase resilience against floods.

- ***Construction of protection walls:*** *In the Upper Swat valley where land slope increases sharply on the eastern bank of the river, heavy land sliding and erosion can be prevented by construction of protection walls of proper length, width and height.*
- ***Installation of sewage treatment plants and wetlands****: The flow of waste materials and sewage from residential and commercial areas can be significantly reduced by the installation of sewage treatment plant and wetland downstream large towns. In the central and upper parts of the valley, where most houses and hotels are constructed near the river banks, the use of septic tanks in houses and hotels can control the direct flow of organic and inorganic pollutants into the river system.*

3.4.1.2. Preferences for benefits provided by water quality improvement: After describing the management plan, a list of expected benefits from water quality improvement of the river Swat, was presented to each household. The interdisciplinary team identified those benefits, along with their special scale of provision (see Table 3.1). Each household was then asked to rank the relative importance of each benefit on a four digit Likert scale. The main reason for asking this question was to reveal household preferences for use and non-use benefits and to compare them with their stated WTP.

3.4.1.3. Elicitation format: The second challenge in the design of CVM survey was the selection of WTP question format and the use of a credible payment vehicle. The NOAA panel recommended the use of single bounded dichotomous choice WTP question with mandatory payment vehicle (Arrow et al., 1993). However, the DC method requires large sample size and gives biased results on small samples. Furthermore, the use of open-ended WTP question was ignored. People in the study area were not familiar with CVM studies and the use of the OE question format might have generated high zero WTP responses. Thus payment card (PC) format was used to elicit household's WTP for the water quality improvement of the river Swat.

The PC elicitation format confronts each respondent with an ordered set of threshold values, and is asked to circle the highest amount he would be willing to pay. His true WTP is then assumed to lie somewhere in the interval between the circled value (lower bound) and the next higher value (upper bound) listed on PC (Loomis et al., 2006). The design and selection of values on PC were made on the basis of information from pretesting of the survey.

3.4.1.4. Payment Vehicle: Payment vehicles play a crucial role in CVM studies and significantly influence respondents' stated WTP. To elicit household's WTP for water quality improvement of the river Swat, I used donation to a local NGO in the designing of CV question scenario. Based on results in a separate paper on sensitivity of households' stated WTP to payment vehicle and managing agency, donation to a local NGO was found more credible than mandatory payment to a government agency because of low protest rate and people's trust on the local NGO for fund collection and allocation for community projects.

Currently in Swat valley and downstream districts, a number of NGOs are working for natural resources conservation. Among them, the most prominent ones are the Environmental Protection Society (EPS), LASOONA Society of Human and Natural Resource Development and the Integrated Rural Support Program (IRSP). Most of these NGOs are getting funding from local government and International donor agencies. In order to generate funds for river Swat water quality improvement through donation from local communities, these NGOs will need staff from each village in the valley and in downstream districts for funds collection. Further, they will require experts and other staff to implement the management plan in coordination with government and non-government agencies in the area, such as the Irrigation Department, Fisheries Department, Forest Department, Water and Power Development Authority, farmers, hotel owners, fishermen etc.

A complete list of all staff and experts required for an NGO to implement the recommended management plan for water quality improvement of the river Swat is given in Appendix 3.9.5.

3.4.1.5. WTP question: The wording of the scenario designed for asking respondents about their WTP for water quality improvement was:

Suppose a local NGO setup a river Swat protection fund for improvement in water quality of river Swat, and households in Swat valley and downstream areas would be asked to make donation every year to this fund. The fund would only be utilized for restoration of riparian zone, reforestation & afforestation and sewage treatment plants in Swat valley.

Would you be willing to contribute to this fund?

- **No**
- **Yes**

If Yes, then

Please circle the amount your household would be willing to donate every year for water quality improvement of river Swat by implementing the management plan. Please answer according to your monthly income and the benefits your household will receive from water quality improvement.

Rs. 50	***Rs. 100***	***Rs. 200***	***Rs. 300***
Rs. 500	***Rs. 1000***	***Rs. 3000***	***Rs. 5000***

If No*, then*

What is the main reason for not donating to this fund? Please select the most important one.

- ◻ *This program is not worth anything to me.*
- ◻ *Government or other donor agencies should provide funding.*

- ◻ *I can't afford to pay at this time.*
- ◻ *I don't think the program would work.*
- ◻ *Other reason (Please explain):* ________________________

3.4.2. Survey Administration: The CV survey was conducted in Swat valley and downstream districts where the river Swat irrigates most of the agricultural land. Improvement in water quality will provide non-use benefits that extend the spatial scale of beneficiaries beyond the watershed and downstream areas; however, the survey was limited to Swat valley and downstream districts only due to budget constraints.

A stratified random sample was used to select households for in-person interview. In the first stage, the whole area was divided into 6 districts and then 3 of them (Swat, Malakand and Mardan) were selected randomly. In the second stage, each selected district was divided into different villages and then at least three villages were selected randomly from each district. Thus in total 11 villages were selected for sampling of households. Using a random sampling approach, 243 households were selected for interview. To get more reliable and correct information, local volunteers were trained and used to interview randomly selected households.

3.5. Model for WTP estimation:

Contingent valuation for public goods, based on the PC elicitation format, are significantly influenced by statistical techniques used to estimate parameters and mean WTP (Cameron and Huppert, 1989). In this study the following two parametric methods were used to estimate parameters and mean WTP.

3.5.1. Intervals midpoint WTP Model: This approach is based on the assumption that respondent WTP is symmetrically distributed within the given interval on payment card (PC). It assigns a value to each interval equal to the interval's midpoint. These midpoint values are then used as proxies for respondent's true-WTP and are used as dependent variable in regression analysis using OLS method. This is the simplest approach used for estimation of WTP; however, it ignores the fact that respondents' true WTP values within the intervals are not necessarily equal to the selected interval's midpoint.

3.5.2. Double bounded approach: Cameron and Huppert (1989) recommended maximum likelihood method for PC data analysis. This method overcomes the weakness of interval midpoint method by using maximum likelihood estimation for regression models using intervals on PC as dependent variables. Following Cameron and Huppert (1989), the true WTP for *i*th respondent can be expressed as:

$$f(WTP_i) = X_i'\beta + \varepsilon_i \ldots\ldots\ldots\ldots (3.5)$$

Where $f(\cdot)$ is a normal or log-normal function; X_i' is a vector of individual 'i' characteristics; β is a parameter vector; and ε_i is iid with mean 0 and variance σ^2. The parameters can be estimated using maximum likelihood approach.

If individual i's true WTP is known to lie within in the interval defined by the lower and upper limits A_l *and* A_u , then the probability that his true WTP lies between these two bounds is given by:

$$\Pr(A_{li} \leq WTP < A_{ui}) = \Pr(f(A_{li}) \leq f(WTP) < f(A_{ui}))$$

$$= F[\{f(A_{ui}) - X_i'\beta\}/\sigma] - F[\{f(A_{li}) - X_i'\beta\}/\sigma]$$

$$= F(z_{ui}) - F(z_{li}) \ldots\ldots\ldots\ldots\ldots\ldots (3.6)$$

Where $F(\cdot)$, the cumulative standard normal distribution, is function of the variable WTP and z_{li} *and* z_{ui} represent the lower and upper limit on the standard normal distribution of the variable WTP. The joint probability distribution function for all n individuals can be interpreted by the log-likelihood function.

$$Ln(L) = \sum_{i=1}^{n} Ln[\, F(z_{ui}) - F(z_{li})] \ldots \ldots \ldots (3.7)$$

To represent all k intervals on PC in log likelihood function, equation (7) can be written as:

$$Ln(L) = \sum_{i=1}^{n} Ln\left(I_i^0[1 - F(z_{1i})] + I_i^h[F(z_{hi})] + \sum_{k=2}^{h} I_i^k \left[F\left(z_{(k+1)i}\right) - F\left(z_{(k)i}\right)\right] \right)$$

$Where$

$I_i^k = 1\ if\ individual$ "i" $choose\ A_k otherwise\ zero$;

$A = A_0, A_1, \ldots . A_k, \ldots . A_h\ (intervals\ on\ PC); and$

$A_0\ and\ A_h\ represents\ the\ lowest\ and\ highest\ intervals\ respectively.$

Maximization of log likelihood function gives optimal values for $\beta's$ and σ.These estimated values are then used to obtain the mean WTP ($E(WTP)$) using either linear or log-linear form of $f(WTP)$.

3.6. Results: The main objective of this study is to estimate household's monetary value for water quality improvement of the River Swat. However, I started first with the nonmonetary valuation to check households' preferences for use and non-use benefits from water quality improvement of the river. The nonmonetary valuation eliminates the income effect, which strongly alters the structure of household preferences especially in poverty dominated areas.

3.6.1. Preferences for benefits provided by water quality improvement of the river Swat: The nonmonetary values for different benefits that can be derived from the water quality improvement of the river Swat are given in Table 3.2. The values for '*scenic beauty & growth in* *tourism'* and '*benefits to future generations'* is 4 for each, indicating strong preferences for them. The 's*upply of clean water for irrigation'*, '*protection of native fishes'* and '*protection of freshwater ecosystem'* are also preferred by households because each of them has mean value equal to '3'. The less important benefits are the 'p*rovision of clean water for drinking'* and the '*hydroelectric power generation'*. Most people prefer underground water for drinking, that's why the value for the *'provision of clean water for drinking'* is less than 3.

This comparison reveals that households have comparatively strong preferences for non-use benefits that justify the use of CVM for measuring the total economic value for water quality improvement of the river Swat.

Table 3.2. Importance of different benefits from water quality improvement of the river Swat

Benefits provided by river Swat water quality improvement		Mean Weight 1 = Non important, 2 = Less important, 3 = Important, 4 = Very important
Use Benefits	Provision of clean water for drinking	2
	Provision of clean water for irrigation	3
	Provision of clean water for hydropower generation	2
	Scenic beauty and growth in tourism	4
Non -use Benefits	Biodiversity protection (native fishes)	3
	Flow of benefits to future generations	4
	Protection of freshwater ecosystem	3

Data source – field survey, 2012

3.6.2. Response to WTP question: In response to the WTP question, 90 households (38%) replied with zero WTP. To determine valid zero WTP response, a follow-up question (see on page 12) was asked from households who refused to pay. They were provided the following four reasons, and were asked to select one main reason for not paying: (1) this program is not worth anything to me; (2) Government or other donor agencies should provide funding; (3) I can't afford to pay at this time; and (4) I don't think the program could succeed. Those who selected the first and third statements were classified as valid refusal and were considered non-protest zeros, while those who selected the second and fourth statements were considered protest zeros. In total 52 percent of the zero WTP responses were protests, while 18 percent were declared unclear because of selecting more than one reason for refusal. To be more conservative, we included the protest zeros in our analysis. The inclusion of protest zeros understates the mean WTP as some households who refused to pay for water quality improvement, may have positive true WTP, but didn't agree with the CV scenario.

3.6.3. Mean WTP estimation: After evaluating households' preferences for benefits that can be obtained from water quality improvement, the next step was to estimate household mean WTP. For this purpose parametric analysis was followed, using MLE and OLS regression methods for estimation of parameters. A list of all variables used in regression analysis is given in Table 3.3.

Table 3.3. List of variables used in regression analysis:

S.No	Variables	Description
1	**LB**	Lower bound value or value selected by respondent on payment card
2	**UB**	Upper value next to LB on payment card
3	**Midpoint**	Midpoint value of selected interval = (LB+UB) / 2
4	**Yes**	= 1 if household wants to donate otherwise '0'
5	**Age**	in years
6	**Education**	Schooling years
7	**Family Size**	Number of people in a family (one house)
8	**Location**	=1 if home is located in Swat valley otherwise '0'
9	**NetINC**	Net monthly income in Pakistani rupees (Pak. Rs. 95.00 = $1)
10	**Water users**	'1' for extractive water users (farmers and fish farmers) otherwise '0'.
11	**Recreationists**	=1 for households having strong preferences for river Swat as a source of beauty, tourism and want to protect it in its natural state otherwise '0'.

3.6.3.1. Model estimation: To estimate the WTP regression model through MLE approach, data on dependent and explanatory variables were analyzed in STATA, using the 'intreg' regression command. This command uses both lower and upper bound values of the selected interval on PC as dependent variables and uses maximum likelihood estimation (MLE) method to estimate parameters for explanatory variables. Results from MLE method are given in the 2nd column of the Table 3.4. *Recreationists* and *family size* have strong positive and significant impact on household donation to a local NGO for water quality improvement. The coefficient value of 126 for *recreationists* means that, at the constant level of all other exogenous variables, a households belonging to the recreationist group would donate *Rs. 126 ($1.3)* more than a non-recreationists. A positive sign on *family size* means large-sized families have strong ties with the local environment and natural resources compare to small size families, and therefore, are more likely to donate more for water quality improvement. *Education* and *net monthly income* also have positive and significant impact on households stated WTP for water quality improvement. Households with a more educated head and households having high net monthly income are likely to donate more for water quality improvement. E*xtracting water users* and households *residing in Swat valley* are not significantly different from *non-extractive users* and *non-residence* in-terms of donation for water quality improvement. *Age* of the household head has insignificant impact on WTP.

Results for OLS regression analysis are given in the 3rd column of the Table 3.4. In OLS method the midpoint values of the selected interval on the payment card were used as dependent variable along with the values of other explanatory variables listed in Table 3.3. Results show that coefficients for *net income, education, family size* and *recreationists* are positive and significant (Table 3.4, column 3). *Age, home location* and *extractive water users* have insignificant impact on households' WTP. The OLS results are consistent with the MLE results; however, the estimated coefficients from OLS have slightly bigger values than MLE coefficients. Both OLS and MLE, under the "intreg" regression command, assume normal distribution of

WTP. To estimate parameters for skewed distribution of WTP, the values of the dependent variables are converted into log values first before running the regression model.

Table 3.4. Results from parametric regression analysis

Variables	MLE (Z)	OLS (t)	Mean values
Age	-1.065159 (-0.68)	-1.599146 (-0.80)	44.81481
Education	14.60317 (3.27***)	16.9488 (2.96***)	9.493827
Water users	20.10292 (0.36)	13.61157 (0.19)	.5226337
Recreationists	125.9851 (2.67***)	146.6076 (2.41**)	.6090535
Family size	30.12613 (4.17***)	35.11891 (3.83***)	7.444444
Home location	110.3753 (1.84)	141.2388 (1.85)	.7572016
Net income	.0095375 (7.81***)	.0117127 (8.70***)	9225.391
Constant	-343.8601 (-2.82***)	-400.259 (-2.56***)	
	LL = -874 χ^2 = 109	R^2 = 0.35 F = 18.34	

** Significant at 0.05 level
*** Significance at 0.01level

3.6.3.2. Mean WTP: The mean WTP values were derived separately for each model by putting the mean values for explanatory variables (column 5, Table 3.4) in the estimated models (Table 6.2). The estimated mean annual WTP per household are given in Table 6.3. The mean annual WTP from OLS model is *Rs. 260 ($2.7)*, whereas from MLE model it is *Rs. 230 ($2.4)*. The mean value for OLS model is greater than the mean value from MLE by *Rs. 30 (30 cents)*. Both values are less than 0.5 % of the average annual income per household. Thus it is more likely that households would donate this amount for water quality improvement. Assuming that households would donate this amount for 10 years, then at 8 % annual discount rate the present value of the mean WTP per household would be *Rs. 1543 ($16)*.

Table 3.5. Mean WTP per household for water quality improvement of river Swat

Model used	Mean WTP per year	For 10 years period (assuming 8% discount rate)
OLS	Rs. 260 ($2.7)	Rs. 1744.62 ($18.36)
MLE	Rs. 230 ($2.4)	Rs. 1543 ($16)

3.6.4. Economic value for water quality improvement: To measure the total economic value for the water quality improvement of the river Swat, the estimated results for the sample were expanded to the whole population in Swat valley. I also assumed two different scenarios to estimate the upper and lower bounds for the aggregate WTP (economic value/ economic benefit). The first scenario assumed the estimated WTP as the best estimate of what the average household would pay in Swat valley. This assumption allowed me to estimate the upper bound for the aggregate WTP by multiplying the mean annual WTP per household with the total households in the valley (Table 3.6, scenario 1). The second scenario is the most conservative, it excludes 38% of the total households as protestors and non-protestors who refused to pay (responded with zero-WTP). The conservative scenario helped in estimating the lower bound value for the aggregate WTP (Table 3.6, scenario 2).

Table 3.6. Aggregate economic value for water quality improvement of river Swat

Scenario	Mean annual WTP per family	# of families	Aggregate WTP per year	Time scale	Discount rate	Present value aggregate WTP (benefits)
Apply mean WTP to all households in Swat valley	Rs 230	416262 (1)	Rs.95,700,000 $1,008,000	10 years	8 %	Rs.649,000,000 $6,830,000
Apply mean to 62 % of the total households in Swat valley	-	224781	Rs.51,700,000 $544,000	-	-	Rs.350,000,000 $3,690,000
Apply mean to 10% of the total households in downstream districts	-	100000 (1)	Rs.23,000,000 $242,000	-	-	Rs.156,000,000 $1,640,000

1. The total number of households in Swat valley and downstream districts were derived by dividing the estimated population of each district in 2008 on respective average family size. The total population in 2008 was estimated using the total population and the population growth rate figures for Swat valley reported by the 1998 census report. According to that report, the total population of Swat valley was 2.427 million and the average growth rate was 3.38%.

This estimation is based on the mean WTP per household in Swat valley and downstream districts and no further stratification of the respondents was done due to limited funding for survey administration. In order to show a complete picture of the WTP for water quality improvement, a more detailed and stratified survey is required to cover all the groups who will get benefits from water quality improvement. Tourists and stockholders, such as farmers, fishermen, hotel and restaurant owners and industries owner, in the valley and downstream districts are expected to have high WTP than other people and thus their inclusion might raise the mean-WTP in the above analysis. This will help policy makers and freshwater resources managers in the area to design more efficient policies and management programs for water quality improvement and water allocation.

To check the economic efficiency of the recommended management plan, I compared the present value aggregate benefits from water quality improvement of river Swat with the total cost on the estimated management plan, given in Table 3.7.

Table 3.7. Estimated cost on the recommended management plan.

Management plan	Activities	Amount allocation (million) per year						
		1st	2nd	3rd	4th	5th	6th	7th – 10th
Riparian zones	Reshaping river flow and leveling - (15000m long x 800m wide) area	20	20	20	-	-	-	-
	Riparian zone protection walls – 10 walls (100m x 4m x 4m)	-	-	-	5	5	-	-
	Upper Swat – 10 protection walls on eastern river bank (100m x 6m x 4m)	-	5	5	5	-	-	-
Reforestation	Reforestation along the river- Swat Kohistan and Upper Swat-8000acres	5	5	5	-	-	-	-
	Riparian zones plantation – central and lower valley (15000m x 500m)	-	-	5	5	5	-	-
Sewage management	Septic tanks - 250	-	-	-	5	-	-	-
	Water treatment Plants -2	-	-	-	-	10	-	
Payment for ecosystem services	For 1250 acres @ Rs.20000/acre per annually along the riparian zone.	-	-	-	-	24	24	24 each year
Total amount		**25**	**30**	**35**	**20**	**44**	**24**	**24**
Present value aggregate total estimated cost		**Rs.274,000,000 ($2,880,000)**						

Data source: Cost estimation for septic tanks and water treatment plant – based on data provided by IRSP (a local NGO)
Cost on riparian zones reshaping & plantation - estimated per acre, using existing market rates.
Payment for ecosystem services per acre – Rs.20000/acre is equal to net return from rice crop per acre.
Cost estimation for construction of protection walls – estimated on cost per meter^2 basis, using existing market rates.

The cost & benefits comparison proves that the aggregate benefits even from the most conservative scenario would be sufficient to cover the total cost on the restoration of the riparian zone (width-800m, length-15000m), reforestation on 8000 acres, construction of 250 septic tanks and 2 water treatment plants, 20 flood protection walls (each 100m × 5m × 5m) and payment for ecosystem services on 1250 acres of land at the rate of Rs. 20000/acre annually for five years. Details on fund allocation cost on each management action and time schedule for each action are given in Table 3.7.

For the interest of government and policymakers the total economic value for water quality improvement of the river Swat was also estimated under mandatory payment to a government agency. In a separate study on the sensitivity of WTP to payment vehicle and managing agency, using the same data set, donation to local NGO per household was found almost double to mandatory payment to a government agency. This might be due to peoples' lack of trust on government agencies due to inefficient allocation of funds and high corruption. The other possibility could be the strategic behavioral response from households in replying to a donation to a local NGO question. A mandatory payment would be applied for all households in the valley; therefore, using scenario-1 in Table 3.6, the generated aggregate WTP per year and the present value aggregate WTP for 10 years under mandatory payment will be almost half of the respective figures for donation to a local NGO. However, the generated aggregate value is still enough to cover the total cost on the recommended management plan. In addition a mandatory program might be more successful than a voluntary program where payments are not assured.

3.7. Conclusion: In developing countries, the economic valuation of ecosystem services and the economic efficiency analysis of alternative ecosystem management programs are challenging and require careful selection, design and administration of the valuation techniques. In this case study of water quality improvement of the River Swat, I used the contingent valuation method to measure the total economic value for water quality improvement and to test the economic efficiency of management plan.

I found that the mean annual WTP for water quality improvement of the river Swat was Rs 230 ($2.4) per household. Generalizing this value to households living in Swat valley would generate a value of *Rs.95,700,000 ($1,008,000)* to *Rs.51,700,000 ($544,000)* per year depending on assumptions about the WTP for protestors and non-protestors who replied with zero WTP. The present value aggregate benefits for 10 years, even from the lower bound value would be sufficient to cover the total cost on the restoration of 15000 meters long riparian zone along the main river, reforestation on 8000 acres land, construction of 250 septic tanks, 2 water treatment plants and 20 flood protection walls and payment for ecosystem services on 1250 acres of land at the rate of *Rs. 20000*/acre annually for five years. For the interest of government and policy makers, the total economic value for water quality improvement was also estimated under mandatory payment to a government agency. The generated aggregate WTP per year and the present value aggregate WTP for 10 years under mandatory payment are almost half to the respective figures for donation to a local NGO. However, the generated aggregate value is still enough to cover the total cost on the recommended management plan. The mandatory payment might be more successful than a voluntary payment where payments are not assured.

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3.9. Appendices:

3.9.1. Swat valley: Swat valley is located in the north west of Khyber Pukhton khwa province of Pakistan. The valley is spread over 6288Km2 under the geographical limit 34°-36° North Latitude and 71°-73° East Longitude (Govt. of Pakista,2002). Administratively, the area is a divided into three districts: Swat District; Lower Dir; and Malakand. Area wise, Swat District make 81 percent of the total watershed, whereas lower Dir and Malakand are 12 percent and 6 percent respectively. The Valley is enclosed by Hindukush Mountains from all sides. Most of the catchment is rugged with huge altitudinal variation, ranging from 600 meters in the south to around 6000 meters in the north.

3.9.2. Interdisciplinary team:

Field visits – river ecology and threats

1. Prof. Taj ul Malook (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)
2. Dr. Fazli Subhani (Principal, Govt. College Dargai, Malakand Agency)
3. Kursheed Ahmad (Assistant prof. in Botany, Govt. Degree College Thana, Malakand Agency)
4. Syed Shah (PhD candidate, ecological economist, Colorado State University Fort Collins)
5. Asghar Khan (Lecture in Botany, Govt. Degree College Totakan, Malakand Agency)

Management plan design:

1. Prof. Taj ul Malook (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)
2. Dr. Gulam Mohammad (Chairman Dept. of Botany, Jehanzaib College Saidu Sharif, Swat).
3. Mohammad Siraj (Assistant Prof., Jehanzaib College Saidu Sharif, Swat).
4. Dr. Usman Ali (Secretary BISE Swat, Saidu Sharif, Swat)
5. Syed Shah (PhD candidate, ecological economist, Colorado State University Fort Collins)
6. Iftikhar Ahmad (Associate Prof. in Economics, Govt. Degree College Thana, Malakand Agency)

3.9.3. Travel Cost Method (Freeman, (2003)): The TCM is based on the week complementary relationship between a non-market good and a market good. Suppose the non-market good (q_w - water quality) and the private market good (x_i- recreational activity) are complementary goods. Then any improvement in q_w, from q_w^0 to q_w^1, will change the price for xi from p_i^0 to p_i^1. Under this condition the compensating surplus will be;

$$CS = e(p_i^1, P_{-i}^0, q_w^1, Q_{-w}^0, U^0) - e(p_i^0, P_{-i}^0, q_w^1, Q_{-w}^0, U^0)$$

$$-[e(p_i^1, P_{-i}^0, q_w^0, Q_{-w}^0, U^0) - e(p_i^1, P_{-i}^0, q_w^0, Q_{-w}^0, U^0)]$$

$$+ e(p_i^1, P_{-i}^0, q_w^0, Q_{-w}^0, U^0) - e(p_i^1, P_{-i}^0, q_w^1, Q_{-w}^0, U^0)$$

The first term on the RHS will cancel the sixth term on RHS and third term will cancel the fifth term on RHS. Now suppose further that x_i is weak complementary relation with q_w and that the new price for x_i is the chock price (p_i^c) for which $x_i^1 = 0$, then the last line on RHS will be zero b/c of weak complementarily assumption and the CS is simply the change in total consumer surplus for the weakly complementary good:

$$CS = e(p_i^c, P_{-i}^0, q_w^1, Q_{-w}^0, U^0) - e(p_i^0, P_{-i}^0, q_w^1, Q_{-w}^0, U^0)$$

$$-[e(p_i^c, P_{-i}^0, q_w^0, Q_{-w}^0, U^0) - e(p_i^c, P_{-i}^0, q_w^0, Q_{-w}^0, U^0)]$$

$$CS = \int_{p_i^0}^{p_i^c} x_i^h\,(p_i, P_{-i}^0, q_w^1, Q_{-w}^0, U^0)ds - \int_{p_i^0}^{p_i^c} x_i^h\,(p_i, P_{-i}^0, q_w^0, Q_{-w}^0, U^0)ds$$

Now it is possible to value the changes in non-marketed goods by changes in consumer surplus from the weakly complementary private market good.

3.9.4. Hedonic Price modeling (Freeman (2003)): HPM is based on the assumption of complementarity between the public good (freshwater quality) and the private market good (houses): that is as the quality of the public good embodied in the private market good increases, the demand for the private market good increases. Thus the market for differentiated private good market functions also as a market for the public good. The HPM measure the implicit price for the characteristic that differentiate closely related private goods in a class. Suppose that 'Y' represent a class of closely related private goods. Any model of Y can be described by a vector of its characteristics (Q). Let $= q_1, \ldots., q_j, \ldots \ldots. q_n$, say yi can be described as;

$$y_i = y_i \,(q_{i1}, \ldots.., q_{ij}, \ldots \ldots. q_{in})$$

And the HP function can be written as

$$p_{yi} = p_{yi} \,(q_{i1}, \ldots \ldots, q_{ij}, \ldots \ldots \ldots q_{in})$$

Where q_{ij} the quantity of the j^{th} characteristic provided by model "i" in class Y.

Further suppose the individual's utility depends upon the consumption of the numeraire, X, and the vector of characteristics provided by purchasing y_i by p_{yi}:

$$U = U(X, y_i) \;\; Or \;\; U = U\big(X, y_i(Q)\big) \quad s.t. \quad Y - p_{yi} = X$$

$$or$$

$$U = U(Y - p_{yi},\; q_{i1}, \ldots., q_{ij} \ldots., q_{im})$$

To maximize this utility function subject to budget constraint, the individual must choose the level of each characteristic to satisfy

$$\frac{\partial u / \partial q_j}{\partial u / \partial X} = \partial p_y \,/\, \partial q_j$$

The marginal WTP for q_j must equal to marginal cost of purchasing more of q_j, other things being equal. Now inverting the utility function and holding all the characteristics constant except the jth, would give the indifference curve that gives the maximum amount the individual would pay to obtain model y_i as a function of q_j, holding other things constant.

$$I_j = I_j(M - y_i, q_j, Q^*, u^*)$$

Where u^* is the optimal solution for the constrained utility maximization problem, Q^* represents the optimal chosen quantities of other characteristics? As different individuals' preferences and income levels are different, the indifferent curves will also be different.

3.9.5. Estimated annual budget for a local NGO – responsible for funds collection and allocation on the management plan for water quality improvement of the river Swat

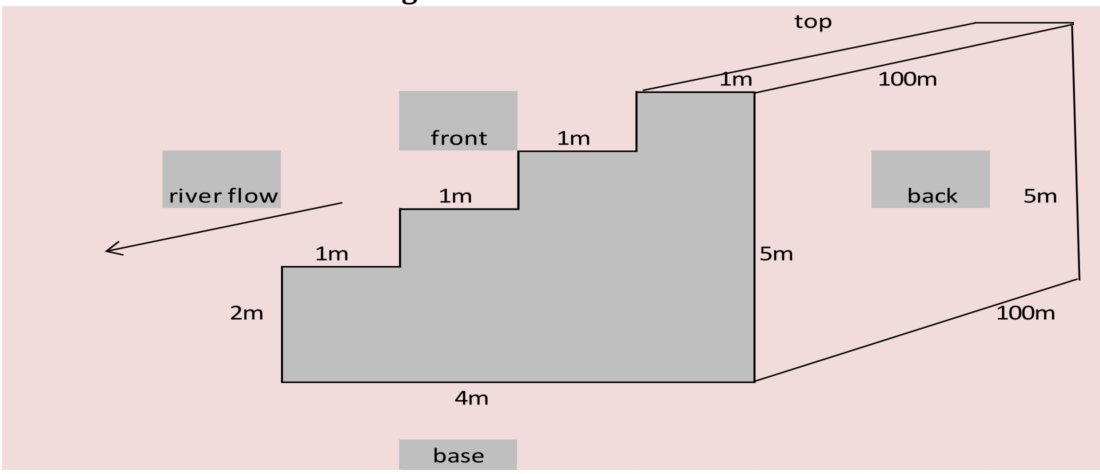
Departments	Positions	Salary (monthly)	Duration (years)	Total budget 1 year	Total budget 10 years
Management	Project director (1)	200000	10	2400000	24000000
	Assistant (1)	30000	10	360000	3600000
	Driver (1)	40000	10	480000	4800000
	Servant (1)	6000	10	72000	720000
Finance	Manager (1)	120000	10	1440000	14400000
	Assistant (2)	30000	10	720000	7200000
	Field workers (50)	8000	10	4800000	48000000
	Driver (1)	40000	10	480000	4800000
	Servant (1)	6000	10	72000	720000
Engineering	Manager (1)	120000	5	1440000	7200000
	Engineers (2)	100000	5	2400000	12000000
	Drivers (1)	40000	5	480000	2400000
Forestry & Ecology	Manager (1)	120000	5	1440000	7200000
	Social organizers (4)	33000	5	1584000	7920000
	Field workers (8)	8000	5	768000	3840000
	Drivers (2)	40000	5	960000	4800000
	Servant 1	6000	5	72000	360000
Office & Equipment	Building + Utility charges	60000	10	720000	7200000
	Computers (6)	-	-	-	180000
	Stationaries	-	-	50000	500000
Total amount				**20688000**	**Rs.162,000,000 ($1,710,000)**

Data source – Estimated based on staff required for an NGO to collect donations from households and allocated them for implementing the proposed management plan.

3.9.6. Cost estimation – Protection walls

Protection walls - Per unit estimated cost (Length=100m, Width=4m, Height=5m)			
Materials	**Items**	**Unit**	**Cost (Pak. Rupees)**
	Rocks	1 truck	3000
	Total trucks	175	525000
	Cement bags	400	180000
	Sand / gravels trucks	5	30000
	experts	-	100000
Labor	1 labor	7 hours daily	700
	Total labor hrs	1633	163300
Total cost			Rs. 998300 ($10508)

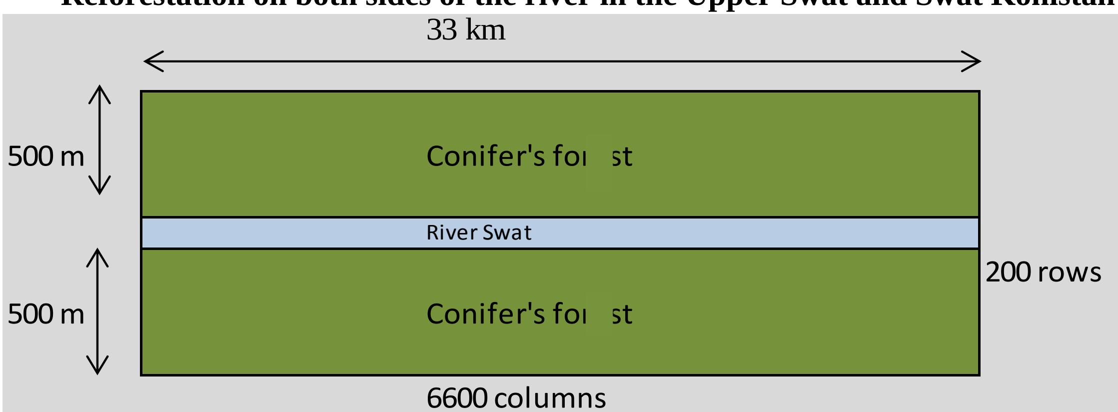
Protection wall – design



3.9.7. Cost estimation - Reforestation

Reforestation and farm-forestry	
Total area	8448 Acres
Inter trees distance	5 meters
Total rows of trees	200
Total columns of trees	6600
Total number of trees	1320000
Plants - per unit cost (Rs.)	6
Plantation cost per unit (Rs.)	6
Total cost (Rs.)	Rs. 15840000 ($166737)
Cost per acre (Rs.)	Rs. 1875 ($20)

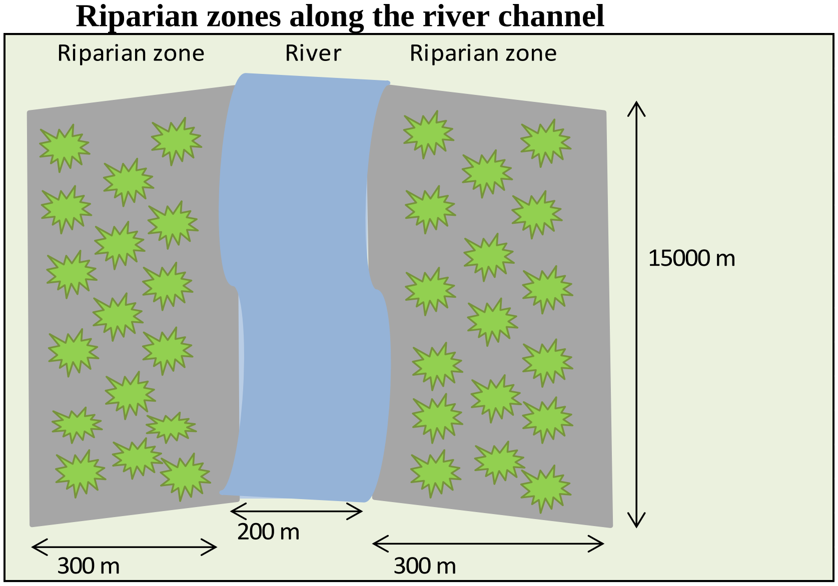
Reforestation on both sides of the river in the Upper Swat and Swat Kohistan



3.9.8. Cost estimation for riparian zone restoration & channel modification

Riparian zone - total Area		
Design	Width in meters	800
	length in meters	15000
	total area (m^2)	12000000
Total cost on leveling and channel modification		
Channel modification	**Scenarios - Cost/m^2**	**Total cost**
	Rs. 1 (Local rate)	12000000
	Rs. 2	24000000
	Rs. 3	36000000
	Rs. 4	**48000000**
	Rs. 5	60000000
Plantation cost		
Trees		
	Tree columns	125
	Tree rows	375
	Total trees	46875
	Cost per plant (Rs.)	10
	Total cost on trees	468750
	Plantation cost (Rs. 5/ uinit)	234375
	Total cost	**703125**
Herbs, shrubs and aquatic plants		
	Total plantation cost	**500000**
Consultants		
	Engineers, others	**1000000**
Total Cost		**50203125**

Riparian zones along the river channel



CHAPTER 4 – PAPER THREE:

SENSITIVITY OF HOUSEHOLDS STATED WILLINGNESS TO PAY TO PAYMENT MECHANISM AND MANAGING AGENCY IN POVERTY DOMINATED AREAS: A CASE STUDY OF RIVER SWAT (PAKISTAN)

4.1. Introduction and objectives: The contingent valuation method (CVM) is applied as an alternative approach to reveled preference methods for measuring the economic value of public goods (Carson et al., (1994), Arrow et al., (1993)). CVM has the ability to measure both use and nonuse benefits (cost) for any improvement (degradation) in environmental and natural resources, whereas the revealed preference methods, such as the Travel Cost Method and Hedonic Pricing, can only estimate the use-benefits (Loomis et al., (2000)). Thus CVM is the single method that can measure the total monetary economic value for public goods and that's why is widely used in cost-benefits analysis of natural resource management (NRM) projects. Natural resource managers and policy makers use CVM to test the economic efficiency of alternative NRM programs, deciding about funding sources (e.g. government or private sources), funds collection mechanism (e.g. income tax, sales tax, charges, donations etc.), and to determine what degree the government should be involved in spending funds on NRM.

In recent years, some quality CV studies have been done in developing countries on the economic valuation of natural ecosystems restoration, drinking water infrastructure development and public health projects (Xu, Z., et al., (2006), Xu, Z., et al., (2002), Whittington et al., (2002), Whittington et al., (1998)). However, in order to set guidelines for getting valid and reliable results, more research work is still needed on CVM survey designing and administration. According to Whittington the main reasons for the failure of most CVM studies in developing countries are: (1) poor survey implementation; (2) poor designing of the survey, particularly the WTP question scenario for the valuation of public goods; (3) and lack of research on robustness of results to variations in research design and survey method (Whittington (2002), pp.324-340). This study is designed to test the sensitivity of households' stated WTP to contingent valuation survey elements in Pakistan, using a case study of river Swat water quality improvement in the

In Swat valley, due to mass poverty (Govt. of Pakistan, 2005) and lack of familiarity with CVM studies, the use of mandatory payment vehicles, such as income tax and sales tax, might be a bad choice in the designing of WTP question scenario for water quality improvement. Further, due to corruption and inefficient allocation of funds in government projects, most households prefer local non-governmental organizations (NGOs) for small scale community based programs. They donate regularly to local NGOs for construction of religious schools, hospitals, drinking water infrastructure and irrigation canals. This shows households' familiarity with the donation mechanism and trust for local NGOs to collect and allocate funds for public goods management.

The main objective of this paper is to evaluate the sensitivity of households' stated WTP to mandatory and voluntary payments to government and non-government agencies for water quality improvement of the river Swat. The paper is organized as follows. The second section discusses previous studies on the use of mandatory and voluntary payment mechanisms in CVM surveys and their impact on respondents' stated WTP. The third section discusses the design and implementation of the CVM survey and the use of an econometrics model for data analysis. In the fourth and fifth sections, results and discussion of the analysis and conclusions are given. References and appendices are listed in section six and seven.

4.2. Payment vehicle and household's stated WTP: In CVM, the elicitation of respondent's true value for a public good is closely related to WTP question format and payment mechanism (Carson and Hanemann, 2002, Carson et al., 2007). Many studies (Xu, Z., et al., (2006), Welsh and Poe (1998), Hanemann et al., (1991) etc) have evaluated the impact of WTP question format on respondents' WTP; however, only a limited amount of studies (Champ et al., (2002), Wiser (2007), Ivehammar (2009)) have highlighted the role of payment vehicles.

Mostly, CV researchers use one of the following two types of payment vehicles in the designing of the WTP question scenario: (1) mandatory payment such as income tax, sales tax and bill charges; (2) voluntary payment e.g. donation. However, some studies reported that the use of voluntary payment vehicle in the designing of WTP question can provoke the problems of 'free riding' and 'strategic behavioral response' (Wiser (2007)). Michalle and Carson (1989) pointed out that in CVM studies, respondents would under bid if they believe that they will actually pay the exact amount they reveal, and that the good will be provided even if they understate their WTP amount. In consumer theory literature this type of behavior where a person states lower amount for a public good than its true value, is called free riding. The problem of free riding behavior was first discussed by Paul Samuelson in his paper '*The pure theory of public goods expenditures*' under the title "*Impossibility of decentralized spontaneous solution*. He stated that no decentralized pricing system could identify an efficient solution for public goods because "*it is in the selfish interest of a person to give false signals, to pretend to have less interest in a given collective consumption activity then he really has*" (Paul A. Samuelson (1954), pp. 388-389).

The second problem of strategic behavioral response arises because of the hypothetical nature of the WTP question scenario. In the case of voluntary payment, respondents may overstate their WTP if the public good is desirable to them. They do this to encourage actual fund raising for the provision of the desired public good (Carson, 1997). According to another contrasting view, suggested by Garrod and Willis (1999), respondents may actually be likely to contribute less than their true WTP when faced with a voluntary mechanism. The reason is because respondents feel it inequitable when all beneficiaries are not contributing equally. In order to minimize the problems of *free riding* and *strategic behavior* in CVM studies, the National Oceanic and Atmospheric Administration (NOAA) Blue Ribbon Panel recommended the use of single bounded dichotomous choice WTP questions with mandatory payment vehicles (Arrow et al., 1993). Carson and Groves (2007) also recommended that the payment vehicle must be compulsory to be incentive compatible in order to revel respondents' true WTP.

Nevertheless, the donation mechanism has some advantages over a mandatory mechanism. A mandatory vehicle, such as income tax is often associated with high protest rates (Loomis et al., 1993) and the protest rate could be even more in poverty dominated areas. Donation mechanisms may be more credible than referenda mechanisms in making choices about small-scale public goods (Spencer et al., 1998). The problem of strategic behavior and hypothetical bias, in response to a donation based WTP question, can be minimized by asking a follow-up question in which respondents rate the level of certainty about their response to WTP question (Champ et al., (2001)). This approach allows estimating the magnitude of the hypothetical bias and identifying respondents responsible for the bias.

4.3. Methods and Data:

4.3.1. Case Study: This study used data from a CVM survey on water quality improvement of the river Swat in the Swat valley of Pakistan. an interdisciplinary team (Appendix 4.7.5) visited different sites along the river and used oral history ecological approach to study the dynamics of the biophysical characteristics of the river system and threats from human activities and climate change. As per their observations and historical ecological records, river Swat and its tributaries in the central and lower parts of the watershed have been polluted to a level which is a serious threat to peoples' health and river associated biodiversity. During the past three decades, increased human population and growth in tourism have resulted in water pollution. Solid and liquid wastes from residential and commercial areas and from hotels on the river banks are directly disposed into the river. Clearing of the riparian zones for cultivation of agricultural crops has affected the natural water purification process and the stability of the river banks. Intensive agricultural practices and large scale deforestation have made the system more vulnerable to floods. The destruction caused by a flood in August 2010 shows the vulnerability of the present system. The flood completely washed away 31,000 acres of fertile agricultural land, heavily damaged *poplar* plantations on agricultural fields, completely removed the Brown Trout and Rainbow Trout populations from the main river and its tributaries and badly affected other native species (UNDP, 2010).

Based on the geophysical characteristics of the watershed, biophysical characteristics of the river system and threats from human activities and climate change, the interdisciplinary team recommended a management plan for the improvement in water quality and resilience of the system against floods. In order to test the economic efficiency of the recommended management plan, the interdisciplinary team decided to use CVM to measure the total economic value for water quality improvement of river Swat. The remainder of this paper shows how I addressed the main challenge of designing a realistic WTP question scenario to get more valid and reliable results. A translated copy of the survey is given in Appendix 4.7.6.

4.3.2. CV Survey design: The survey is the central and most important part in CV methods. Therefore, sufficient time was taken to design an appropriate survey for water quality improvement of the river Swat. To make it simple and understandable for a lay person, the survey was translated into the local language (Urdu) (Appendix 4.7.6). After designing the survey, it was pretested on a group of 15 individuals. Final changes were made on the basis of results from pretest.

4.3.2.1. Existing water quality situations and management plan: Before asking respondents about their WTP for water quality improvement, respondents were provided details about the existing water quality situation and its impacts on the river's ecosystem and human societies, and about the recommended management plans designed by the interdisciplinary team for water quality improvement. A description of the management plan follows:

Management Plan: *Based on geophysical characteristics of the valley, dynamics of the river system and existing and potential threats, the following management plan was recommended by the interdisciplinary team:*

- ***Restoration of riparian zones****: In the Central Swat valley modification of the river channel and restoration of the riparian zone along the main river will improve water quality by removing pollutants and sediments from urban areas, agricultural fields and uplands. In addition to water purification, it will provide habitat for terrestrial and aquatic animals. The plantation of flood resistant native herbs, shrubs and trees will reduce erosion of the river banks and will improve the resistance of both terrestrial and freshwater ecosystems against extreme floods due to climate change.*

- ***Reforestation and afforestation:*** *To control the loss of soil from erosion and reduce sediment load (turbidity) in the river system, reforestation and farm forestry can play important role. Reforestation and farm forestry will reduce sediment pollution in the river that will improve the functioning of the riparian zones, increase in the reproductive ability of native fishes and effectively increase resilience against floods.*
- ***Construction of protection walls:*** *In the Upper Swat valley where land slope increases sharply on the eastern bank of the river, heavy land sliding and erosion can be prevented by construction of protection walls of proper length, width and height.*
- ***Installation of sewage treatment plants and wetlands****: The flow of waste materials and sewage from residential and commercial areas can be significantly reduced by the installation of sewage treatment plant and wetland downstream large towns. In the central and upper parts of the valley, where most houses and hotels are constructed near the river banks, the use of septic tanks in houses and hotels can control the direct flow of organic and inorganic pollutants into the river system.*

After explaining the management plan the survey then provided a list of different use and non-use benefits that can be obtained from improvement in water quality of river Swat. Each respondent was then asked to rank each benefit on the basis of its importance. This question provides reason for asking WTP question. A description follows:

THE IMPORTANCE OF RIVER SWAT WATER QUALITY IMPROVEMENT:

Improvement in water quality of river Swat will directly and indirectly benefit human societies by providing different goods and services. A list of some of those benefits is given below. Please circle the level of importance for each benefit.

Benefits from water quality improvement of river Swat:

Benefits	*Not important*	*Less important*	*Important*	*Very important*
Clean water for drinking	*1*	*2*	*3*	*4*
Clean water for irrigation	*1*	*2*	*3*	*4*
Clean water for electric power generation	*1*	*2*	*3*	*4*
Scenic beauty and promotion of tourism	*1*	*2*	*3*	*4*
Biodiversity protection (Native fishes)	*1*	*2*	*3*	*4*
Availability clean water for future generation	*1*	*2*	*3*	*4*
Restoration of freshwater ecosystem	*1*	*2*	*3*	*4*

4.3.2.2. Payment mechanism and agencies for funds collection and allocation: To design a more realistic WTP question scenario, households in the valley were asked about their opinions regarding the provision and management of public goods. Based on information collected, the following three scenarios were selected for the designing of WTP questions: (1) mandatory payment to government; (2) donation to government; and (3) donation to a local NGO. Four different mandatory payment vehicles, i.e. income tax, sales tax, ecological protection tax and electricity bill charge, were tested during the pretest. On the basis of high acceptance rate, electricity bill charge was selected as mandatory payment vehicle for comparison with donation. In the Swat valley and surrounding districts, due to limited government funds for community programs, most rural households regularly donate money to local NGOs for religious schools, hospitals, irrigation and drainage canals construction and management. This shows their familiarity with donation for funding public goods and their trust on local NGOs to allocate the funds. Furthermore, due to corruption and misuse of funds in government projects, mandatory payment to government agencies for community programs is not popular.

4.3.2.3. WTP question format: A payment-card (PC) format was used to elicit WTP for water quality improvement of the river Swat. The design and selection of values on PC was made on the basis of results from the pretest. The PC elicitation format confronts respondents with an ordered set of threshold values. They are then asked to circle the highest amount they would be willing to pay. Their true WTP is assumed to lie somewhere in the interval between the circled value (lower bound) and the next higher value (upper bound) on PC (Loomis et al., 2006).

People in the study area were not familiar with the CVM for public goods. The use of open-ended (OE) questions might have generated unreliable data and a low response rate. The dichotomous choice (DC) method requires a large sample size and gives biased results on small sample. Thus PC was the best elicitation format for this study.

4.3.2.4. WTP questions: Based on three different scenarios for payment vehicles and managing agencies for water quality improvement, three different WTP questions were designed. The wordings of the designed questions were:

1st (2nd) WTP questions: *Suppose a local NGO (the provincial government of KPK) set up a river Swat protection fund for improvement in water quality of river Swat, and households in Swat valley and downstream areas would be asked to make a donation every year to this fund. The fund would only be utilized for restoration of a riparian zone, reforestation & farm forestry and sewage treatment plants in the Swat valley.*

Would you be willing to contribute to this fund?

- **No**
- **Yes**

If Yes, then

Please circle the amount your household would be willing to donate every year for water quality improvement of river Swat by implementing the management plan. Please answer according to your monthly income and the benefits your household will receive from water *quality improvement.*

Rs. 50	***Rs. 100***	***Rs. 200***	***Rs. 300***
Rs. 500	***Rs. 1000***	***Rs. 3000***	***Rs. 5000***

***If No**, then*

What are the main reasons for not donating to this fund? Please select the most important one.

- □ *This program is not worth anything to me.*
- □ *Government or other donor agencies should provide funding.*
- □ *I can't afford to pay at this time.*
- □ *I don't think the program would work.*
- □ *Other reason (Please explain): ___________________________*

Similarly the third question, which was based on mandatory payment to a government agency, is:

3rd WTP question: *Suppose that the provincial government of the Khyber Pakhtunkhwa (KPK) would like to improve the river Swat water quality and for this purpose the government would charge an extra amount in electricity bills from households in the Swat valley and downstream areas to generate funds. The funds would only be utilized for wastewater treatment plants, replanting along the rivers, and reforestation in Swat valley.*

Would you be willing to support this policy/ program?

No *Yes*

***If Yes**, then*

Please circle the amount your household would be willing to pay every year for water quality improvement of river Swat by implementing the management plan. Please answer according to your monthly income and the benefits your household will receive from water quality *improvement.*

Rs. 50	***Rs. 100***	***Rs. 200***	***Rs. 300***
Rs. 500	***Rs. 1000***	***Rs. 3000***	***Rs. 5000***

***If No**, then*

What is the main reason for not wanting your electricity bills to increase for this fund? Please select the most important one.

- □ *This program is not worth anything to me.*
- □ *Government or other donor agencies should provide funding.*
- □ *I can't afford to pay at this time.*
- □ *I don't think the program would work.*
- □ *Other reason (Please explain):* ___________________________

In order to provide more data on WTP, each respondent was asked two WTP questions. Thus four different types of CV surveys were designed (Table 4.1). These surveys were parallel in all respects except the WTP questions and sequence of the WTP questions. Information on household's socio-economic and demographic characteristics was also collected for regression analysis to estimate household's WTP.

Table 4.1. Types of CVM surveys designed for water quality improvement of the river Swat.

CV survey type	**First WTP question**		**Second WTP question**		**Households**
	PV	Agency	PV	Agency	
1	*Donation*	*NGO*	*Bill charges*	*Government*	95
2	*Donation*	*NGO*	*Donation*	*Government*	53
3	*Bill Charges*	*Government*	*Donation*	*NGO*	52
4	*Donation*	*Government*	*Donation*	*NGO*	43

4.3.3. Survey administration: The survey was conducted in the Swat valley and downstream areas where river Swat irrigates most of the agricultural land. Though improvement in water quality will provide non-use benefits that extend the spatial scale of beneficiaries beyond the watershed and downstream areas; however, because of limited funds, the survey was limited to the Swat valley and downstream districts only.

A stratified random sampling approach was used to select households for in-person interviews. In the first stage, the whole area was divided into 6 districts and then 3 of them (Swat, Malakand and Mardan) were selected randomly. In the second stage, selected districts were divided into different villages and 11 of them were selected randomly, having at least three from each district. A random sampling approach was used to select a sample of 243 households for interview. To get more reliable information, local volunteers were trained and used to interview randomly selected households in their own areas.

4.3.4. Model for WTP estimation: Contingent valuations for public goods, based on the PC elicitation format, are significantly influenced by techniques used to estimate parameters and mean WTP (Cameron and Huppert (1989)). In this study, I used the maximum likelihood method (MLE) recommended by Cameron and Huppert (1989) for estimation of mean WTP from payment card data. The maximum likelihood method estimates parameters for explanatory variables using intervals on PC as dependent variables. Following Cameron and Huppert (1989), the true WTP for *i* th respondent can be expressed as:

$$f(WTP_i) = X_i'\beta + \varepsilon_i \dots\dots\dots\dots (4.1)$$

Where $f(\cdot)$a normal or log-normal function; X_i' is a vector of individual 'i' characteristics; β is a parameter vector; and ε_i is iid with mean 0 and variance σ^2. The parameters are estimated using maximum likelihood approach.

If the individual i's true WTP is known to lie within in the interval defined by lower and upper limits A_l and A_u , then the probability that his true WTP lies between these two bounds is given by:

$$\Pr(A_{li} \leq WTP < A_{ui}) = \Pr(f(A_{li}) \leq f(WTP) < f(A_{ui}))$$

$$= F[\{f(A_{ui}) - X_i'\beta\}/\sigma] - F[\{f(A_{li}) - X_i'\beta\}/\sigma]$$

$$= F(z_{ui}) - F(z_{li}) \ldots\ldots\ldots\ldots\ldots\ldots \text{(4.2)}$$

Where $F(\cdot)$, the cumulative standard normal distribution, is function of the variable WTP; and z_{li} and z_{ui} represent the lower and upper limit on the standard normal distribution of the variable WTP. The joint probability distribution function for all 'n' individuals can be interpreted by the log-likelihood function.

$$Ln(L) = \sum_{i=1}^{n} Ln[\,F(z_{ui}) - F(z_{li})] \ldots\ldots\ldots. \text{(4.3)}$$

To represent all k intervals on PC in log likelihood function, equation (3) can be written as:

$$Ln(L) = \sum_{i=1}^{n} Ln\left(I_i^0[1 - F(z_{1i})] + I_i^h[F(z_{hi})] + \sum_{k=2}^{h} I_i^k\left[F\left(z_{(k+1)i}\right) - F\left(z_{(k)i}\right)\right]\right)$$

$Where$

$I_i^k = 1$ $if\ individual$ "i" $choose\ A_k otherwise\ zero$;

$A = A_0, A_1, \ldots.A_k, \ldots.A_h$ $(intervals\ on\ PC); and$

A_0 and A_h $represents\ the\ lowest\ and\ highest\ intervals\ respectively.$

Maximization of log likelihood function gives optimal values for $\beta's$ and σ. These estimated values are then used to obtain the mean WTP ($E(WTP)$) using either linear or log-linear form of $f(WTP)$.

4.4. Results and discussion:

4.4.1. Zero WTP response rate: Before detailed parametric analysis, households' responses to different contingent valuation scenarios were compared. Table 4.2 summarizes the zero WTP response rate for each WTP-question scenario. For donation to a local NGO, out of 243 respondents 38 percent (90 households) replied with zero WTP, while, for the other two scenarios, i.e. *mandatory payment to government* and *donation to government*, the average zero WTP response was 60%. Thus the overall zero WTP rate was 51%.

Table 4.2. Zero WTP response to different WTP question scenarios

WTP question scenarios	Payment Vehicle	Managing agency (Govt./Private)	Households interviewed	Percent zero WTP
Type 1	Donation	Local NGO	243	38%
Type 2	Bill Charges	Govt. Agency	147	60%
Type 3	Donation	Govt. Agency	096	60%

Based on the analysis of households' demographic characteristics obtained from CVM survey, the average per-capita income in the Swat valley was found Rs.4600/month ($1.6/day), whereas the per-capita income for 38% households was below Rs.2850/month ($1/day) (Appendix 4.7.1). Low income reduces household's ability to pay for environmental and natural resource management and this might be a reason for high zero WTP response for water quality improvement of the river Swat. The other reason could be households' lack of trust on government agencies to efficiently manage and allocate funds on water quality improvement of the river.

4.4.2. Protest zero WTP: To determine valid zero WTP response, a follow-up question was asked from households who refused to pay. They were provided the following four reasons, and were asked to select one main reason for not paying: (1) this program is not worth anything to me; (2) Government or other donor agencies should provide funding; (3) I can’t afford to pay at this time; and (4) I don’t think the program would work. Those who selected the first and third statements were classified as valid refusal and were considered non-protest zeros, while those who selected the second and fourth statements were considered protest zeros. For donation to a local NGO, 52 percent of the zero WTP responses were declared protest, while 18 percent were unclear because of selecting more than one reason in response. Similarly the combined protest rate for scenarios 2 & 3 was 78 percent, while 9 percent were declared unclear responses. This comparison clearly shows that the protest rate was lower for donation to a local NGO. As the main objective of the study is to test the sensitivity of stated WTP to different scenarios, that’s why I did not delete protest zeros from the data sets. The inclusion of protest zeros underestimate mean WTP as some people who refuse to pay for water quality improvement, even though they may have positive WTP.

4.4.3. Parametric analysis: After discussing households’ response to WTP questions, the next step was to evaluate the sensitivity of the households’ stated WTP to payment vehicle and managing agency using a maximum likelihood method (MLE) approach. For this purpose dummy variables were used in MLE analysis to differentiate each scenario and to test their impact on households’ stated WTP. A list of dummy variables and other exogenous variables is given below.

Table 4.3. List of variables used in regression analysis:

S.No	Variables	Description
1	**LB**	Lower bound value or value selected by respondent on payment card
2	**UB**	Upper value next to LB on payment card
3	**Midpoint**	Midpoint value of the selected interval = (LB+UB) / 2
4	**Pay**	= 1 if household wants to pay for water quality improvement otherwise '0'
5	**PV**	Payment vehicle, =1 if donation otherwise 0
6	**NGO**	Managing agency, =1if NGO otherwise 0
7	**QS**	WTP question sequence, =1 if asked first otherwise '0'
8	**Age**	Age in years
9	**Education**	Education level of the head in years
10	**Family Size**	Number of people per family (house)
11	**Home location**	=1 if home is located in Swat valley otherwise '0'
12	**NetINC**	Household's net monthly income in Pakistani rupees (Pak. Rs. 95.00 = $1)
13	**Water users**	=1 for extractive water users (farmers and fish farmers) otherwise '0'.
14	**Recreationists**	=1 for household having strong preferences for river Swat as a source of beauty, recreation and tourism otherwise '0'.

4.4.3.1. Sensitivity of stated WTP to payment vehicle:

To test the impact of payment mechanism (donation vs mandatory payment) on households' stated WTP for water quality improvement, a dummy variable 'PV' (=1 if donation as payment method otherwise '0') was used with other exogenous variables, listed in Table 4.3. The impact of managing agency was normalized by using data sets on scenario-2 (mandatory payment to government) and scenario-3 (donation to government). The combined data was analyzed in STATA using the 'intreg' regression command. This regression command uses both lower and upper bound values of the selected interval on the payment card as dependent variables and use MLE method to estimate parameters for exogenous variables.

MLE results, given in Table 4.4., column 2 (MLE1), show that the dummy variable 'PV' has positive insignificant value. It means households' stated WTP for water quality improvement are same under donation to government and mandatory payment to government. The insignificance of 'PV' is against prior expectation. As, donation payment vehicle allows households to overstate their WTP for a desirable public good without any fear of paying the stated amount in real. That's why I was expecting strong positive and significant coefficient for PV. The insignificance of *donation to government* might be due to households' dislike for the government as managing agency. This statement was tested in the following section.

Under NGO as managing agency, donation was the single best vehicle compare to mandatory payment vehicles.

4.4.3.2. Sensitivity of WTP to managing agency:

For testing the sensitivity of household stated WTP to managing agency, data sets on scenario-1 (donation to a local NGO) and scenario-3 (donation to government) were combined to normalize the impact of payment vehicle. A dummy variable 'NGO' (=1 if NGO otherwise '0') was used with other explanatory variables to evaluate the impact of managing agency on households' stated WTP. Results from MLE regression analysis show that 'NGO' has strong positive and significant impact on households' stated WTP (column 3 (MLE2), Table 4.4). This means that household's stated WTP is highly sensitive to managing agency, under donation payment mechanism. The coefficient value of 105 shows that, at the constant level of all other exogenous variables, the use of the NGO as managing agency, instead of the government, would raise household's stated WTP (donation) for water quality improvement by Rs.105 (approximately $1.1). This amount is exactly equal to the difference between the mean WTP values under scenario-1 and scenario-3, given in Table 4.5.

The higher stated WTP under *donation to a local NGO* than *donation to government* suggest that NGO is more popular than government for the provision and management of small scale public goods. Discussion with households during interview revealed that inefficient allocation of funds and high corruption were the main reasons for lack of trust on government agencies. As discussed in previous section, 78% of the protesters who refused to pay mentioned that government and other donor agencies should pay for the program. Peoples' preference for managing agency of natural resources also depends on their social organization and spatial scale of the program. Management programs on large geographical scale and the presence of large ethnic groups, having different social organization, could be the main hurdles for an NGO to efficiently manage natural resources and get support from local community and planners.

Table 4.4. Testing the sensitivity of WTP - results from MLE analysis

Variables	MLE1 (Mandatory vs. Voluntary payment)	MLE2 (Government vs. NGO)	MLE3 (Payment vehicles and managing agency - combined test)
Constant	-15.91 (-0.22)	-414.37 (-4.26***)	-229.09 (-3.17***)
NGO	-	**105.19 (2.71***)**	**104.5 (2.97***)**
PV	**0.144 (0.01)**	**-**	**-12.50 (-0.33)**
QS	-14.8 (-0.53)	75.47 (2.15**)	40.72 (1.52)
Age	-1.26 (-1.31)	-1.187 (-0.94)	-1.27 (-1.33)
Education	4.56 (1.82**)	12.72 (3.88***)	9.39 (3.81***)
Extractive water users	-34.64 (-1.02)	12.86 (0.29)	-10.54 (-0.32)
Recreationists	-6.01 (-0.21)	112.80 (3.01***)	59.75 (2.12**)
Family size	1.22 (0.28)	23.25 (3.99***)	15.19 (3.55***)
Home location	127.4 (3.58***)	129.80 (2.77***)	118.88 (3.37***)
Net monthly income	.008 (12.50***)	.0095 (11.60***)	.0087 (13.17***)
Observations	243	339	486
Log Likelihood	-633.6 (χ^2=142.48)	-947.7 (χ^2=191.6)	-1348 (χ^2=230.00)

*** Significant at 0.05 level*
**** Significance at 0.01level*
( ) Z value for coefficient

4.4.3.3. Donation to a local NGO vs mandatory and voluntary payment to government:

In order to select the best scenario for designing WTP question in the Swat valley, datasets on all three scenarios (*donation to a local NGO*, *mandatory payment to government* and *donation to government*) were combined and the dummy variables 'NGO' and 'PV' were used in MLE analysis. Results show that NGO has a positive and significant impact on households' stated

WTP for water quality improvement, while the PV has insignificant impact (column 4, Table 4.4). These results are consistent with results in the previous sections. The coefficient value of 104.5 for the dummy variable 'NGO' shows that 'at the constant level of all other exogenous variables, the use of donation to a local NGO (scenarion1), instead of mandatory payment to government and voluntary payment to government, in the WTP question scenario would raise household's stated WTP for water quality improvement by *Rs.104.5 ($1.1).* This proves that *donation to a local NGO* is more popular in the Swat valley and downstream districts for natural resource management and should be used in the designing of WTP question scenario for water quality improvement.

These results have important implications for contingent valuation researchers, policy makers and natural resource managers in poverty dominated areas. In order to elicit poor households' WTP for any change in the quality or quantity of a natural resource, and to test economic efficiency of any natural resource management program, *donation to a local NGO* can be used as payment vehicle in designing WTP question scenarios. In the north western rural areas of Pakistan, the provision and management of public goods, on limited geographical scale, through a local NGO will be more trusted and supported by the local community, and thus can give better results than a government agency. In poverty dominated areas where governments have limited funds for natural resource management, donation to a local NGO could be the best mechanism to generate funds from local communities, instead of using mandatory payment to government agencies, such as the income tax, sales tax, electricity bill charges, etc..

4.4.3.4. Marginal effects of exogenous variables: The parametric analysis also found consistent results for some of the exogenous variables. The *home location* has positive and significant impact on household stated WTP. The coefficient value of 119 for *home location*, given in column-4 Table 4., means that at the constant level of all other exogenous variables, households residing in the Swat valley would pay *Rs.119 (approximately $1.3)* more than nonresident household. *Education* and *net monthly income* also have a consistently positive and significant impact on household's stated WTP for water quality improvement. Households with a more educated head and households having high net monthly income are likely to pay more for water quality improvement. *Family size* is another factor that has positive and significant impact on households' stated WTP. A positive sign on family size means large-sized families have strong ties with the local environment and natural resources and therefore are more likely to pay a high value for water quality improvement. *Recreationists* and *extractive water users* were found inconsistent and have insignificant impact on WTP for water quality improvement. *Age* of the head and WTP *question sequence* also have insignificant impact on household's stated WTP.

The insignificant effects of the *recreationists* and *extractive water users* are against prior expectations and might be due to their low ability to pay high amounts. To verify this statement, the combined dataset from all three scenarios were used in a binary-probit analysis to explain household binary response (yes, no) to WTP question for water quality improvement. The estimated probit model (Appendix 4.7.4) shows that both *extractive water users* and *recreationist* have a strong positive and significant impact on household's probability to pay for water quality improvement of the river Swat. This proves that *extractive water users* and *recreationist*s have strong preferences for improved water quality; however, their ability to pay high amount is low because of their low income level (Appendix 4.7.1).

4.4.3.5. Households' mean-WTP: The mean-WTP for all three scenarios were derived by estimating MLE models separately for each data set (Appendix 4.7.2) and then putting the mean values for exogenous variables in the estimated models (Appendix 4.7.2 and Appendix 4.7.3).

Table 4.5 shows that the mean-WTP from *donation to a local NGO* is *Rs.230 ($2.4)*, whereas for the other two scenarios, i.e. *donation to government* and *mandatory payment to government*, the values are *Rs.125 ($1.3)* and *Rs.110 ($1.2)* respectively. The estimated mean-WTP from *donation to a local NGO* is substantially higher than mean-WTP from other two scenarios involving payment to government. This is consistent with my prior expectations that rural people prefer *donation to a local NGO* over *donation to government* and *mandatory payment to government*. Another possibility for this difference could be the strategic behavioral response of households. In responding to a *voluntary payment to NGO*, respondents know that they will not be required to donate to NGO; therefore, they can state a fairly high value without there being much chance they will actually have to pay this amount.

Table 4.5. Household's mean WTP under three different scenarios.

CV question scenarios	meanWTP Value
Donation to NGO	Rs. 230 ($2.4)
Donation to government	Rs. 125 ($1.3)
Mandatory payment to government	Rs. 110 ($1.2)

- *Source: CV survey, 2012*
- *The 'intreg' MLE analysis assume normal distribution of WTP. To estimate parameters for skewed distribution of WTP, log values for 'lower bound' and 'upper bound' on payment card can be used in 'intreg' MLE analysis.*

The mean-WTP amount under donation to a local NGO (Rs.230 ($2.4)) is less than 0.5% of the household's average annual income, and thus it is more likely that they would be able to afford it for water quality improvement of the river Swat.

4.5. Conclusions:

In developing countries, more research is required to test the sensitivity of CVM results to different survey tools. To meet this challenge, this study tested the sensitivity of households' stated WTP to payment mechanism and managing agency. Using a case study of the river Swat water quality improvement in the Swat valley of Pakistan, I found that *donation payment* has insignificant impact on households' stated WTP to a government agency for water quality improvement. It means that households' preferences for improved water quality remain the same under donation to government and mandatory payment to government. However, under the NGO as managing agency, donation is the single best mechanism to elicit households' WTP for water quality improvement. In testing the sensitivity of households' stated WTP to managing agencies under donation as payment vehicle, the impact of NGO was found strongly positive and highly significant compare to government. Furthermore, the estimated mean-WTP from *donation to a local NGO* was found substantially higher than the mean WTP from *mandatory payment* and *voluntary payment to government*. This sensitivity analysis reveals that donation to a local NGO is the most popular scenario for the designing of WTP question for water quality improvement of the river Swat. People lack of trust on government as managing agency was the main reason for low response rate and low mean-WTP values under other two scenarios. Another possibility could be the 'strategic behavior' of households. In replying to donation to a local NGO for water quality improvement, respondents know that they will not be required to donate to NGO; therefore, they can state a fairly high value.

These results have important implications for contingent valuation researchers, natural resource managers and policy makers. In poverty dominated areas of Pakistan, to elicit households' WTP for a public good and to test the social acceptability and economic efficiency for public goods management program, *donation to a local NGO* can be used as a tool in the designing of WTP question scenarios. Results suggest that the provision and management of public goods, on limited geographical scale, through a local NGO would be more trusted and could get more community support than a government agency. However, for NRM programs on large geographical scale and the presence of large ethnic groups, having different social organization, the use of NGO as managing agency might not be the best choice. Results also suggest that in the absence of government and international donors' fund for natural resource management, donation to a local NGO could be the best option to generate funds rather than using mandatory payment, such as the income tax, sales tax, bill charges, etc., to government.

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4.7. Appendices

4.7.1. Households' demographic characteristics

Characteristics	Households		
	Extractive water users	Non-extractive water users	All
Sex of house head (#s)	Male (127)	Male (116)	Male (243)
Age of house head (years)	49.4	39.4	44.5
Education of house head (years)	6.7	12.8	9.5
Family size	7	8	7.5
Monthly Income	Rs. 30570	Rs.39211	Rs. 34700
Monthly cons. expenditures	Rs. 21114	Rs.30241	Rs. 25472
Monthly per capita income (PCI)	Rs. 4400	Rs. 5000	Rs. 4600
# of households having PCI <$1/day	50 (39.4%)	41 (35%)	91(37.4%)
# of households having PCI <$1.5/day	76 (60%)	69 (59%)	145(59.5%)

Source: CV survey, 2012
Extractive water users: include farmers and fish farmers.

4.7.2. WTP estimation - MLE and OLS regression models

Variables	Mandatory payment to Govt.	Donation to Govt.	Donation to NGO
Constant	94.5063 (1.27)	-202.53 (-1.3)	-405.3588 (-3.28***)
QuestionSeq.	-6.8695 (-0.23)	-5.4566 (-0.1)	109.213 (2.38**)
Age	-1.9064 (-1.95**)	-0.9252 (-0.54)	-1.227065 (-0.79)
Education	3.96664 (1.42)	9.29685 (1.81)	13.67972 (3.09***)
Family size	-0.9212 (-0.21)	2.98651 (0.27)	29.87369 (4.18***)
Home location	30.4731 (0.81)	179.602 (2.78***)	117.557 (1.97**)
Net Income[1]	0.00221 (3.05***)	0.00922 (10.85***)	0.009538 (7.76***)
Water users	**-21.531** (-0.61)	17.8307 (0.31)	13.81571 (0.25)
Recreationists	**-9.0859** (-0.32)	50.545 (0.89)	143.6404 (3.04***)
LL	-351.68	-260.93	-876.008
Chi2	24.29	17	105.35

1. *For mandatory payment scenario, monthly income was used as explanatory variable instead of Net income.*

*** Significant at 0.05 level*

**** Significance at 0.01level*

4.7.3. Mean values for dummy variables

Home location	Water users	Recreationists	Question sequence		
			Scenario1	Scenario2	Scenaro3
0.76	0.522634	0.61	0.61	0.45	0.35

Source: CV Survey (2012)

4.7.4. Probit model – Probability of household to for water quality improvement

Variables	Probit coefficients (Z value)
NGO	.7060312 (4.38)
PV	.0159335 (0.09)
Qs	.0417348 (0.34)
Age	-.0050181 (-1.14)
Education	.0511095 (4.42)
Extractive water users	.4012849 (2.56)
Recreationists	.4234763 (3.28)
Family size	-.0122545 (-0.63)
Home location	.1415289 (0.80)
Net-income	9.59e-06 (1.89)
Cons.	-1.181617 (-3.46)
# of observations	*486*
LL (chi^2)	*294 (85.2)*

Source: CV Survey (2012)

4.7.5. Interdisciplinary team:

<u>Field visits – river ecology and threats</u>

1.Prof. Taj ul Malook (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)

2.Dr. Fazli Subhani (Principal, Govt. College Dargai, Malakand Agency)

3.Kursheed Ahmad (Assistant prof. in Botany, Govt. Degree College Thana)

4.Syed Shah (PhD candidate, ecological economist, Colorado State University Fort Collins)

5.Asghar Khan (Lecture in Botany, Govt. Degree College Totakan, Malakand Agency)

Management plan design:

1.Prof. Taj ul Malook (Ecologist; Principal Govt. Degree College Thana, Malakand Agency)

2.Dr. Gulam Mohammad (Chairman Dept. of Botany, Jehanzaib College Saidu Sharif, Swat).

3.Mohammad Siraj (Assistant Prof., Jehanzaib College Saidu Sharif, Swat).

4.Dr. Usman Ali (Secretary BISE Swat, Saidu Sharif, Swat)

5.Syed Shah (PhD candidate, ecological economist, Colorado State University Fort Collins)

6.Iftikhar Ahmad (Associate Prof. in Economics, Govt. Degree College Thana, Malakand Agency)

4.7.6. Translated version of the CV survey:

دریائے سوات کے پانی کے معیار میں بہتری اور حیوانات کا تحفظ

اس سوالنامے کا بنیادی مقصد دریائے سوات کے پانی کے معیار میں بہتری اور آبی حیوانات خصوصاً مچھلیوں کے تحفظ کے بارے میں مقامی لوگوں کی رائے / خیالات جاننا ہے۔ اس مقصد کے لئے ہم آپ سے کچھ سوالات پوچھیں گے تاکہ آپکے خیالات کو جان سکے۔ آپ جن سوالات کے جوابات دینا پسند نہیں کرتے اُسکو آپ چھوڑ سکتے ہو۔ ہم اس اہم وسیلے کے بچاؤ کے لئے آپکی رائے اور خیالات کو انتہائی اہم سمجھتے ہیں اور آپکے تعاون کو قابل قدر سمجھیں گے۔

دریائے سوات، پانی کے معیار کی موجودہ صورتحال

وادی سوات اور گرد و نواح کے لوگوں کو دریائے سوات سے مختلف نوعیت کے بے شمار فوائد حاصل ہوتے ہیں گزشتہ 20 سالوں کے دوران مقامی آبادی میں تیزی کیساتھ اضافے سے دریا کے پانی کا معیار بُری طرح متاثر ہوا ہے۔ EPS کے ایک رپورٹ کے مطابق مینگورہ شہر میں رہائشی اور تجارتی علاقوں سے روزانہ 43.7 ٹن انسانی فضلات براہ راست مینگورہ ندی میں خارج کی جاتی ہیں جس سے نہ صرف ندی میں مچھلیوں کی افزائش نسل کی جگہیں متاثر ہوئیں ہیں بلکہ اس سے ہیضہ، ملیریا اور ہیپاٹائٹس جیسی بیماریوں میں بھی اضافہ ہوا ہے۔

دریا کے دونوں کناروں پر، مینگورہ سے خوازہ خیلہ تک، درختوں اور دوسرے نباتات کی کٹائی اور کھیتی باڑی میں اضافے سے آبی ماحولیاتی نظام بُری طرح متاثر ہوا ہے۔ دریا کے کناروں پر نباتات نہ صرف زمین کی کٹاؤ کو روکتی ہے بلکہ مقامی مچھلیوں اور دوسرے آبی جانوروں کے لئے خوراک اور افزائش نسل کی جگہوں کی فراہمی اور پانی میں موجود زہریلے ذرات کو بھی فلٹر کرتے ہیں۔

وادی میں زرعی فصلوں خصوصاً سیب، شفتالو، پیاز اور ٹماٹر کی فصلوں پر حد سے زیادہ کیمیائی کھادوں اور زرعی ادویات کے استعمال سے بھی دریا کے پانی کے معیار پر اثر پڑا ہے اور وادی کا ماحولیاتی نظام متاثر ہو رہا ہے۔

دریائے سوات کے پانی کے معیار میں بہتری کے لئے ضروری اقدامات

پانی کے معیار میں بہتری اور اس سے حاصل شدہ فوائد کی فراہمی کے لئے مندرجہ ذیل انتظامی منصوبوں پر عمل درآمد کی اشد ضرورت ہے۔

ا۔ بڑے شہروں سے باہر، دریا کی طرف، واٹر ٹریٹمنٹ پلانٹس یا ویٹ لینڈز قائم کرنا تاکہ رہائشی اور تجارتی علاقوں سے گندہ اور آلودہ پانی کو صاف کیا جا سکے اور اس کو دریا میں چھوڑنے کے قابل بنایا جا سکے۔

۲۔ مینگورہ سے لے کر خوازہ خیلہ تک دریا کے دونوں کناروں پر نباتاتی زونز قائم کرنا تاکہ وادی میں سیلابی پانی سے زمین کی کٹاؤ کو روکا جا سکے اور آبی ماحولیاتی نظام کے تحفظ کو ممکن بنایا جا سکے۔ دریا کے کنارے نباتات پانی کی صفائی اہم کردار ادا کرتے ہیں اور وادی کی خوبصورتی میں اضافہ کرتے ہیں۔

۳۔ پہاڑوں اور بنجر زمینوں پر درخت اور دوسرے پودے لگانا تاکہ مٹی کے بہاؤ کو روکا جا سکے اور پانی میں ریت اور مٹی کے مقدار کو کم کیا جا سکے۔

سوالات

سوال نمبر 1: دریائے سوات کے پانی کے معیار میں بہتری سے مقامی لوگوں کو بے شمار فوائد حاصل ہو سکتے۔ ان میں سے چند کی فہرست نیچے دیئے گئے ٹیبل میں درج ہے۔ آپ ان فوائد کی اہمیت کے لحاظ سے درجہ بندی کریں۔

فوائد	غیر اہم	کم اہم	اہم	انتہائی اہم
صاف پانی کی فراہمی۔ پینے کے لئے	1	2	3	4
آبپاشی کے لئے	1	2	3	4
بجلی پیدا کرنے کے لئے	1	2	3	4
وادی کی خوبصورتی میں اضافہ اور سیاحت میں فروغ	1	2	3	4
مقامی مچھلیوں کی اقسام اور نباتات کا تحفظ	1	2	3	4
آنے والی نسلوں کے لئے ان فوائد کی دستیابی	1	2	3	4
وادی کے ماحولیاتی نظام میں بہتری	1	2	3	4

سوال نمبر 2: فرض کریں کہ صوبائی حکومت پانی کے معیار میں بہتری کے لئے اوپر دیئے گئے منصوبوں پر کام شروع کرنا چاہتی ہے۔ اور اس کے لئے فنڈز مقامی آبادی پر بجلی یا پانی کے بلوں میں اضافی چارجز کی صورت میں اکٹھا کرنا چاہیں۔ آپ اس پروگرام کے حق میں ہونگے۔

ہاں	**یا**	**نہیں**

اگر ہاں۔ تو نیچے دیئے گئے ٹیبل میں چارجز کا انتخاب کریں۔ جو آپ سالانہ دینا چاہیں۔ اپنی آمدنی اور حاصل شدہ فوائد کی اہمیت کو مدنظر رکھ کر جواب دیجئے۔

300 روپے سالانہ	200 روپے سالانہ	100 روپے سالانہ	50 روپے سالانہ
3000 سے زیادہ	3000 روپے سالانہ	1000 روپے سالانہ	500 روپے سالانہ

اگر نہیں۔ تو وہ کونسی وجوہات ہیں جن کی بناء پر آپ اس پروگرام کو پسند نہیں کرتے۔

(1) اس پروگرام سے مجھے کوئی فائدہ نہیں۔

(2) حکومت کو فنڈز دینے چاہئیں۔

(3) میری آمدنی بہت کم ہے۔

(4) میرے خیال میں یہ پروگرام نہیں چل سکتا۔

(5) دوسری وجوہات۔