

**POST-IMPLEMENTATION EFFECTS OF GHAZI
BAROTHA HYDRO POWER PROJECT ON THE
FLOODPLAINS ECOLOGY OF RIVER INDUS**



ZULFIQAR ALI

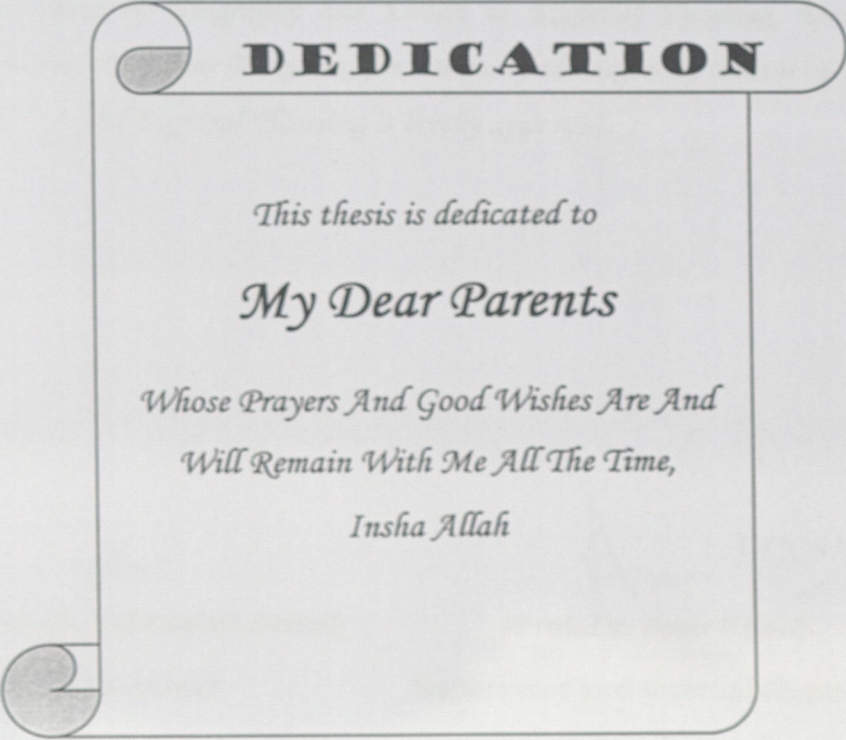
**DEPARTMENT OF GEOGRAPHY,
AND URBAN & REGIONAL PLANNING,
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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

In The Name of Allah

The Most Beneficent

The Most Merciful



DEDICATION

This thesis is dedicated to

My Dear Parents

Whose Prayers And Good Wishes Are And

Will Remain With Me All The Time,

Insha Allah

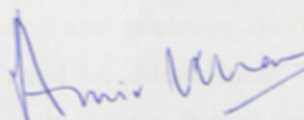
APPROVAL SHEET

This dissertation titled "Post-Implementation Effects of Ghazi Barotha Hydro Power Project on the Floodplains Ecology of River Indus", submitted by Mr. Zulfiqar Ali, under the supervision of Prof. Dr. Amir Khan, Department of Geography and Urban & Regional Planning, University of Peshawar, Peshawar (Pakistan) for award of the degree of Doctor of Philosophy in Urban and Regional Planning is hereby approved.



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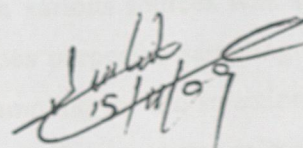
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A handwritten signature in black ink, appearing to read 'Zulfiqar Ali', with a date '15/11/09' written below it.

ZULFIQAR ALI

PhD Scholar

ABSTRACT

This study was carried out to evaluate the Ghazi Barotha Hydro Power Project (GBHPP) in Pakistan for the socioeconomic benefits vis a vis the adverse alterations that have arisen on the floodplains ecology of Indus river in the study area. The study attempted to find answer to the larger research question of "what adverse impacts have arisen on the floodplains ecology of river Indus in the study area due to diversion of waters into Power Channel of GBHPP and what mitigating measures should be adopted to ameliorate the situation? The research was operationalized through 13 variables to achieve the desired objectives of the study. The major research tools used for the study were questionnaires, interview method, Focus Group Discussions (FGDs) and personal observations for the primary data collection. Besides, the secondary data collection from various sources was also undertaken. The three stage sampling technique includes purposive sampling for the selection of study districts, followed by random sampling for the selection of villages and households. The analysis was done through the computer software; and other quantitative and qualitative techniques.

The significance of cheaper hydropower generation should not be overemphasized in the prevalent severe energy and economic crisis in Pakistan. The energy consumption, which is considered as a yardstick of economic prosperity, the Pakistan' share of 2.29 Quadrillion Btu, is less than 0.5 % of the world's total 472.274 Quadrillion Btu consumption in the year 2006. In terms of per capita energy consumption, Pakistan's level of 14.2 million Btu in 2006 was higher than Bangladesh's (5 million Btu), Sri Lanka (10.5 million Btu) and Nepal (2.4 million Btu); however, closed to India's (15.9 million Btu). In comparison with other nations of the region, it is significantly lower than them. China's per capita energy consumption in 2006 was 56.2 million Btu; and 57.9 million Btu and 104.8 million Btu in Thailand and Malaysia respectively. The running water constitutes ideal energy source that is renewable, economically cheaper and non-polluting environmentally. Pakistan due to its unique physiographic location has got enormous potentials to generate hydro energy of about 40,000 MW. However, due to lack of appropriate policies for water resource management and utilization and lack of strong political will in the past, the hydro: thermal / nuclear mix in the country is just about 29: 71.

Keeping in view, the widening gap between the demand and supply of electricity in the country and the deficit forecast for future; the Government of Pakistan launched the 1450 MW Ghazi Barotha Hydro Power Project (GBHPP) in 1995 as a solution to meet the rising demand of the country for electricity. The GBHPP is basically an intra-provincial run-of-river project on the trans-boundary river of Indus. The project is stretched over the two districts of NWFP province and one district of the Punjab province. The construction of the project started in December 1995 and became fully operational in May 2004.

The study has revealed that Ghazi-Barotha Hydro Power Project has contributed tremendous cheaper energy to the tune of 31646.19 million KWh to the national grid system and an economic return of Rs. 126.58 billion up to June 2008 since its experimental operation in 2003. The study has also shown that the project is significantly beneficial for initiating various schemes through its Integrated Regional Development Plan (IRDP), training programs and credit disbursements for socio-economic uplift of the local communities in the study area. However, the project is no exception on the environmental and socio-economic fronts, which area-wise involves a considerable spread over two provinces of the country. The project therefore, has brought some undesirable alterations, mostly reversible, in the natural and man-made environment of the floodplains ecology in the study area.

The analysis has indicated that the withdrawal of huge waters into the concrete power channel of GBHPP has deprived the river's braided channels in the vast floodplains of critical quantities of surface waters. Consequently, water diversions have caused degradation of the natural environment and its ecosystems along the down stream floodplains. Reduction in water levels in the river's braided channels during the natural low discharges seasons (October-May) has created the conditions that are increasingly unsuitable to fisheries resource, forests in the river's bar / active floodplains locally known as "*Belajats*" and wildlife.

The local population associated with earning livelihoods from the river-based resources, such as fisheries, gold panning, fuel wood supplies and livestock-keeping in *Belajats* of the braided channels have suffered economically due to drastic reductions of water quantities in the river along the downstream. Besides, the women folk who were using the "*Gudders*" (women's common gathering points on the river's bank) for a variety of daily needs have also suffered due to severe decrease of surface water quantities, especially during the low discharges

season. Water deprivations have also caused decline in ground water in the closed vicinity of the floodplains, effects on water supply, losing of the fascinating scenic beauty of the long riverside and non-compliance with the provisions of the National Water Policy for conservation of wetlands, ecology and their recreational use.

It can be concluded from the findings of the study that GBHPP has contributed significantly at the national level and has brought numerous secondary development schemes to the area. However, the hydrological regimes have changed significantly in the river's braided channels, basically due to diversion of huge waters into power channel of GBHPP. The significant reductions in the surface water quantities of the river, especially during the natural low discharges season have caused the adverse impacts of varied magnitude and significance on the physical and ecological resources. The project has, therefore, proved unprofitable for the large local populations, who historically, depend on these resources for income and other services. The compensatory water releases have proved inadequate to offset the unfavorable alterations in the vast floodplains in the study area.

The lesson learnt through this study from the experience of GBHPP, poses a greatest challenge to policy makers, planners and scientists to adopt the most suitable ways and means through efficient and dynamic Water Management Strategies for the Integrated Indus Basin Development in the area. A multidisciplinary approach based on the principles of recognition of the riparian rights can lead to cooperation amongst the states / stakeholders for development of vast river basins fed by trans-boundary rivers. The findings and conclusions of the study can be used as necessary guidelines to seek interdisciplinary approach in future for finding answer to a much broader question of how to feed and supply energy to the country's growing population, while respecting the natural environment, life supporting ecosystems and local community's livelihoods. The study has also suggested that in the existing scenario, a harmony between the environmental sustainability and socioeconomic returns of GBHPP in the study area, could be achieved through (i) Systematic Monitoring Program for the study area on regular basis throughout the project-life of GBHPP (ii) Enhancement of the Compensatory Water Releases (iii) Change in the Mechanism of Discharge of Compensatory Water Releases and (iv) Multi-Sector Multi-Year Integrated Development Program for the project's affected communities.

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GLOSSARY

Abaseen: A traditional local name for the Indus river denoting father of the rivers.

Arat: A local name for the Persian Wheel.

Bela: A local name used for as singular of *Belajats*.

Belajats: A local name meaning the small islands in the braided channels of river Indus.

Belajats-e-Darakhtan: *Belajats* having forests.

Belajats-e-Karghisht: *Belajats* having grasses only.

Chadar: A local name for a larger piece of cloth carried by men, or sometime, for a long traditional veil worn by the women to hide themselves from the unrelated men.

Chaina: A local name for the *Mystus oar* specie of fish.

Doli: A local name used for Palanquin.

Fatiha: A local name used for the condolence prayer for the deceased.

Gold Panners: The professionals who recover gold from the river's sand through repeated panning.

Gudder: A local name for women' gathering point on the river's bank for washing clothes, churning milk and other daily uses.

Hectare: Unit of area equivalent to 2.47 acre.

Hujra: A local name where the villagers assemble routinely, and, on special events.

Janj: A local name used for the wedding congregation taken to bride's house.

Jranda: A local name for the water driven flour mill.

Kakhey: Locally meaning a guard hired for the protection of forests in the *Belajats*.

Kameez: A long loose shirt.

Khairat: Local name used for the meal served to relatives and poor for the departed soul.

Kharif: Summer cropping season.

Khwar: A local name for a big stream, usually collecting storm waters.

Mahimar: Professional Fishermen.

Mahsheer: Local name for the *Barbus putitora* specie of fish.

Mallah Fish: Local name for the *Shizothorax sp.* of fish.

Masjid: A local name for the mosque.

Nullah: Local name for small hill torrent.

Paisa: Sub unit of Pak Rupee (100 paisa = 1 Pak Rupee)

Parda: A local name for the veil practiced by the women when going outside their homes.

Persian Wheels: A traditional vast dug well using animals for withdrawing of water from the well for irrigation.

Qabza Mukhalifana: Law of Adverse Possession adopted in 1939.

Quadrillion: Unit of energy (1 Quadrillion = 10^{15} Btu)

Rabi: Winter cropping season

Rehn: Mortgage

Rukhsati: A local name used for the departure of the bride to bridegroom's house.

Shalwar: A local name for a loose trouser like wearing usually made of fine cloth.

Shamilat-e-Deh: Village's common lands

Shamilat-e-Tal: Cultivated lands

Taziat: Local name meaning mourning or to offer condolences to the bereaved family.

Turban: A local name for a strip of cloth worn by the men onto the head, which is considered as a symbol of honor.

Walima: A local name for the feast served by the family of bridegroom after the wedding.

ABBREVIATIONS

Btu: British thermal unit

BCM: Billion Cubic Meters

CDP: Community Development Program

Cumecs: Cubic meters per second (1 Cumec = 35.310 Cusecs)

Cusecs: Cubic feet per second (cfs)

EIA: Environmental Impact Assessment

GAIE; Gadoon Amazai Industrial Estate

GBHPP: Ghazi Barotha Hydro Power Project

GBTI: Ghazi Barotha Taraqiati Idara

GoNWFP: Government of NWFP

GoP: Government of Pakistan

ha: hectare

IRDP: Integrated Rural Development Program

Kg: Kilogram(s)

MAF: Million Acre Feet

PC1: Project Cycle 1 / Concept Paper 1

PEPA, 1997: Pakistan Environmental Protection Act, 1997

PKR: Pakistani Rupee(s)

PNGO: Project NGO

UNEP: United Nations Environment Programme

WAPDA: Water and Power Development Authority

WCS: World Conservation Strategy

WSSD: World Summit on Sustainable Development

CHAPTER # 1

INTRODUCTION

1.1 SCOPE

Pakistan has been confronting a serious handicap in the energy sector over the years. The situation is aggravating year after year due to the swelling population and the perceived growth in industrialization and the subsequent urbanization in the country. The result is an ever-increasing gap between the energy supply and demand. The acute shortage of electricity has compelled the authorities to resort to frequent load shedding during the hot summer and dry spell. The hours-long load shedding in the scorching heat of summer is causing a huge discomfort to the large population of the country, besides proving an impediment to industrial operations, businesses and functioning of hospitals and educational institutions of the country.

Moreover, a vast fraction of the rural population (more than 40 % of the total) is yet to be provided with electricity and the associated utilities. It is also worth stating that the Government of Pakistan has set forth the target of sustained annual economic growth of around 6 percent to keep pace with the challenges of the 21st century. Such targets can be achieved only by revitalizing the agricultural sector and ensuring sustained industrial growth in the country. The adequate supply of power / electricity is the most preliminary requirement for bringing any remarkable boost in the industrial and agricultural productivity of the country. The energy consumption, which is considered as a yardstick of economic prosperity, the Pakistan's share is less than 0.5% of total world energy consumption. In terms of per capita energy consumption, Pakistan's level of about 12.9 million Btu (British thermal unit) for the 2001 is less than Iran's 80.3 million Btu, China's 30.9 million Btu, and far less than Russia's 195.3 million Btu and U.S.'s per capita consumption of 341.8 million Btu during the same year.

Although, Pakistan due to its unique physiographic location has got enormous potentials of generating hydro energy however, due to lack of appropriate policies for resource management and utilization and lack of strong political will has caused the failure to adopt a consolidated Water Policy at the

National level. The recently adopted Ten Year (2001-2011) Perspective Plan recognizes the need for development of water resources and increased hydropower generation for the country's growing economy. The Ten Year Plan encompasses the state-owned Water and Power Development Authority (WAPDA)'s comprehensive integrated water resource and hydropower development Mega-Plan, "Vision-2025" for development of additional storage capacity for irrigation and hydropower generation.

The technologically viable renewable resources to be exploited commercially in Pakistan include macro vis a vis micro-hydel, bio-energy, wind and solar energy. The hydro power being environmentally clean and economically cheaper is often perceived as critical for the supply of electricity and as a symbol of economic development and prosperity. The total power generation capacity in Pakistan is of the order of about 17,457 MW. This includes the hydropower generation capacity of 5,013 MW (excluding the recently added 1450 MW from the GBHPP), the thermal power generation capacity of 12,169 MW and the nuclear power generation capacity of 462 MW. Although, the country is blessed with enormous hydro potentials of about 40,000 MW, on the basis of the aforesaid generation capacity, the hydro: thermal / nuclear mix in the country is about 29: 71.

Keeping in view, the widening gap between the demand and supply of electricity in the country and the deficit forecast by the year 2010; the Government of Pakistan envisioned the Ghazi Barotha Hydro Power Project (GBHPP) as a solution to meet the rising demand of the country for electricity. The GBHPP is basically a run-of-river project on the Indus River, located around 100 Km from Islamabad, stretching over Swabi and Haripur districts of NWFP province and Attock of the Punjab province. It involved the construction of a partial river diversion at Ghazi, 7 Km downstream from the Tarbela dam through a barrage and water conveyance in about 52 Km long power channel for generation of power at Barotha. The Ghazi Barotha (GBHPP) project was particularly attractive as it provides for the power generation to meet peaks in demand throughout the year and allows full power generation during the months of May and June when there is a reduced generation from other hydropower projects as a result of low reservoir levels in the country.

The state-owned Water and Power Development Authority (WAPDA) is the primary sponsor of this project. Other contributing bodies include multilateral donors such as the Asian Development Bank, The World Bank, Japan's Overseas Economic Co-operation Fund and Germany's development agency, the GTZ. In total, the project is estimated to have cost US\$ 2.25 billion.

1.2 SIGNIFICANCE

Water resources projects are one of the most sensitive projects that alter both the physical and man-made environments in the area of location. Studies show that dams construction, inter basin transfers, and water withdrawals for irrigation or power generation have fragmented about 60% of the world's rivers. These projects have resulted into significant direct vs indirect and short-term vs long-term adverse environmental impacts in various parts of the world. The case studies of many such projects have shown that 60% of the impacts identified during Monitoring / Post Auditing were unanticipated prior to project construction. Most of the direct adverse impacts identified have fallen disproportionately on rural dwellers, subsistence farmers, indigenous peoples, ethnic minorities, children and women.

These projects are most often associated with bringing undesirable changes in the hydrological regimes of rivers. The changed hydrological regime in turn, adversely affect the floodplains ecology, fisheries, forests, pasture and agriculture that constituted the very organising element of community's livelihood and culture. The improper or poor accounting of the social and environmental costs and benefits of water resources projects in economic terms lead to bias in decision making process and the result is implementation of an unsustainable project causing irreversible impacts on the local community in the long run.

The GBHPP largely beneficial nationally is no exception on the environmental and socio-economic fronts locally, which area-wise involves a considerable spread over the three districts of the country. The tool of Environmental Impact Assessment (EIA), which has become mandatory under section 12 of the Pakistan Environmental Protection Act (PEPA), 1997, does ensure that proper evaluation of the economics as well as environmental gains and losses are taken into account. The EIA tool, thus foreseeing the long term

environmental gains and losses helps safeguard the natural resources base, which ultimately lead to sustainable development in the long run.

As the GBHPP was initiated prior to PEPA, 1997, the proponent of the project was not required to carry out a separate full comprehensive EIA study for GBHPP. Rather environmental assessment was conducted as a component of the Feasibility report. The mere in-brief environmental assessment as part of the Feasibility report of the project caused overlook of several environmental and socio-economic effects associated with the project. The project, therefore, has resulted into a host of adverse impacts on the natural and man-made environment of the floodplains ecology of the area. The ecological ramifications that have occurred are complex and involve considerable consequences. The withdrawal of waters into the long power channel has caused degradation of the natural environment and its ecosystems along the down stream floodplains in the study area. Reduction in water levels in the river's braided channels has created conditions that are less suitable to fisheries resource, forests in the *Belajats* (a local name meaning the small islands / river bars in the braided channels of river Indus) and wildlife. The *Belajats* created by the meandering course of the river and the river's repeated division into braided channels are shown in map # 1 and 2. The local population associated with earning livelihood from the river resources, such as fisheries, gold panning, fuel wood supplies and livestock keeping in the braided channel of *Belajats* have suffered economically due to drastic reductions of water flows downstream. In addition, the fluctuating water levels has caused a shorter recharge period and thus adversely affecting the ground water reservoirs in the surrounding areas. This has affected a large population living in the closed proximity of the river.

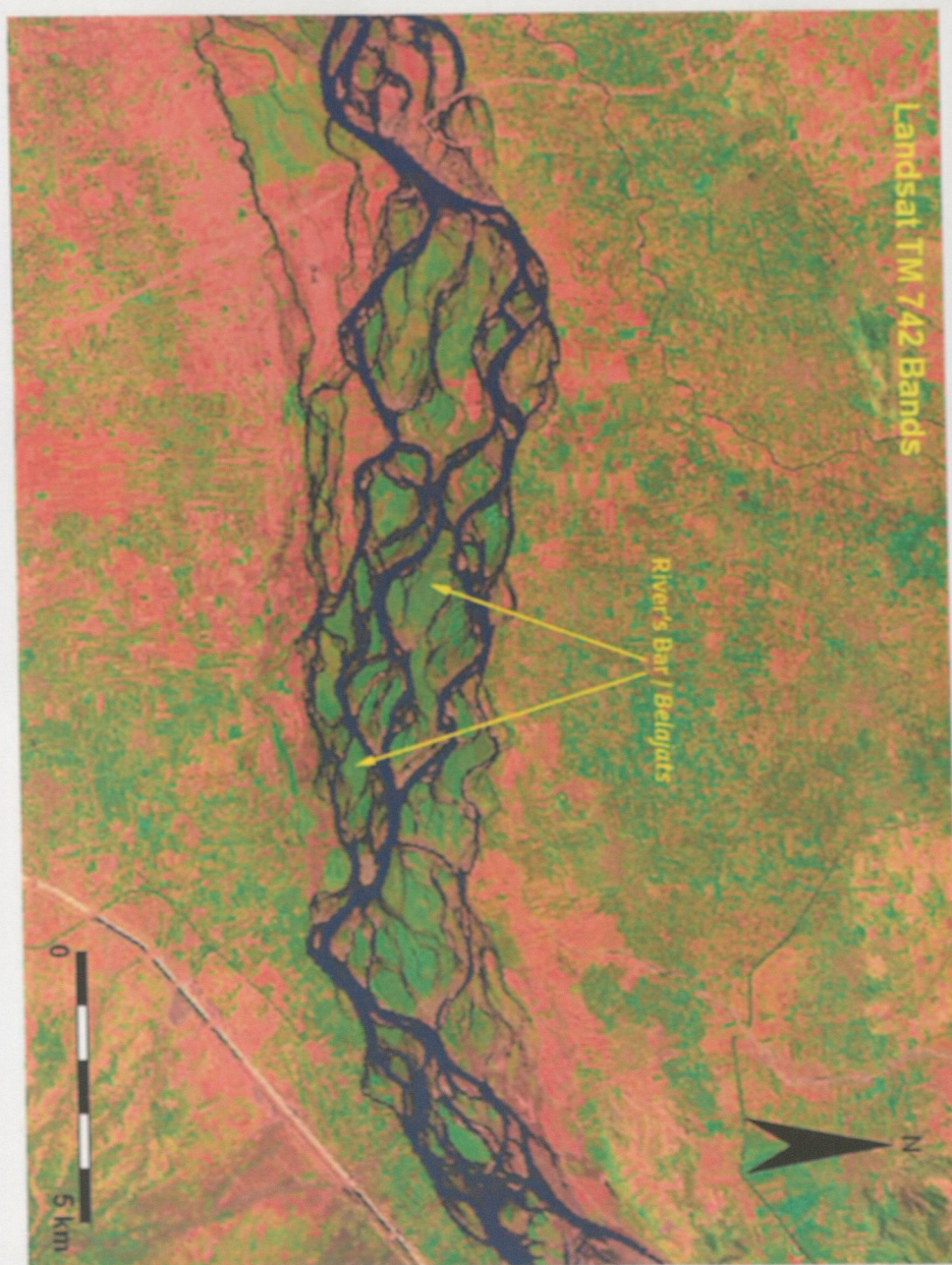
Moreover, the drastic reductions of water flows in the braided channel of the river and the consequent adverse impacts on the downstream ecosystems of the vast floodplains is also causing non-compliance with the Ramsar Convention on Wetlands and the Convention on Biological Diversity, to which Pakistan is a signatory and bear international obligations. The long braided channel of river Indus offers fascinating charm for the surrounding rural settlements. Historically, people from remote places visit the area to enjoy the cool breeze caused by the cold water of Indus during the scorching summer. The conservation of this long

coastal-strip and provision of some necessary infrastructure in the area can contribute significantly to the development of ecotourism in the area.

The project has also caused resettlement and many residents had to give up their homes and some or a portion of their agricultural land to make room for the construction of the power channel. In total, approximately 4,770 hectares of land was acquired, of which 3,457 hectares were privately owned. The previous studies suggest that relocated communities in the developing countries are often economically and culturally impoverished as a result of resettlement due to huge water resources projects.

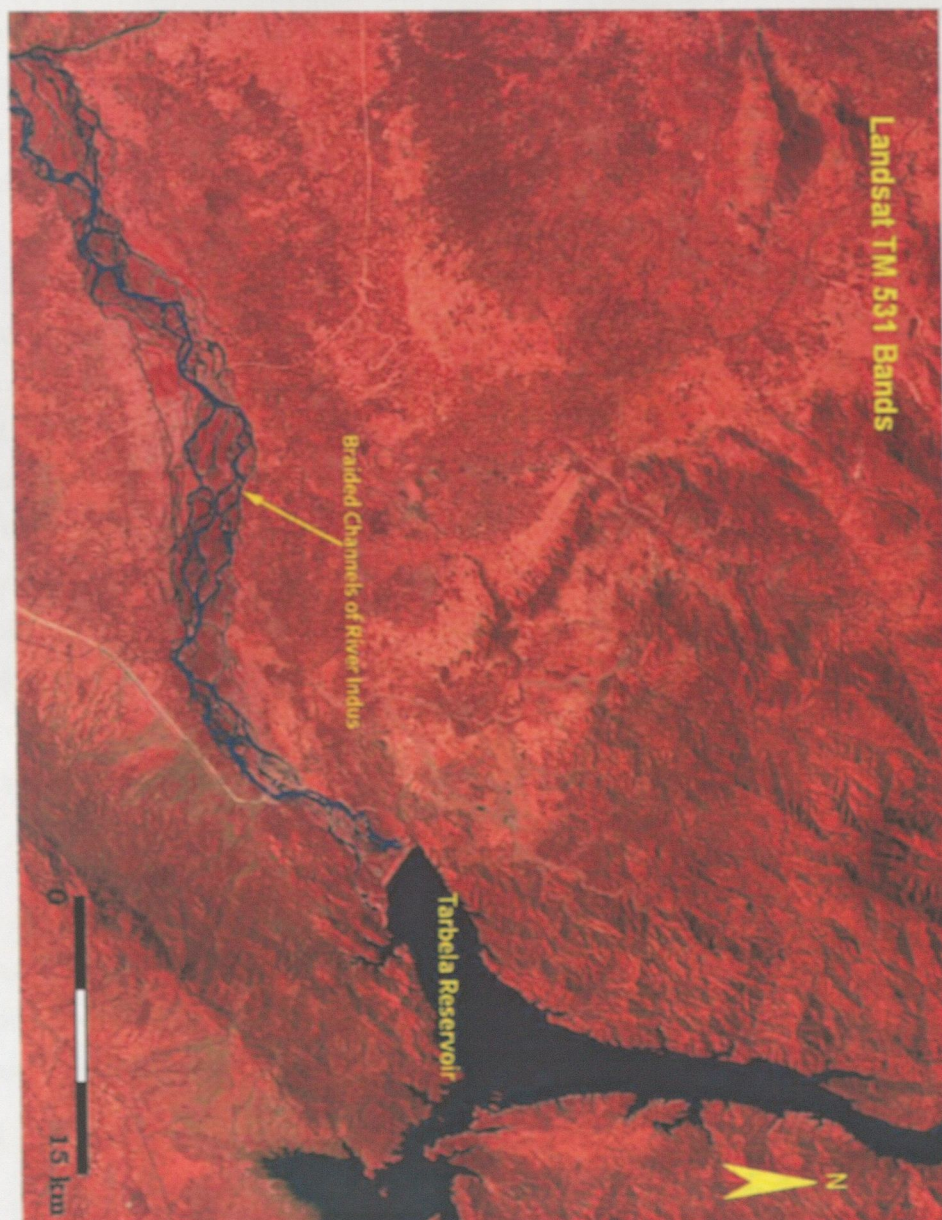
The lesson learnt through this study from the experience of GBHPP, poses a greatest challenge to policy makers and scientists to adopt the most suitable ways and means to meet the rising energy needs, water requirements and ensure food security while conserving the environmental systems, biological diversity and community's livelihoods. This research study is aimed to achieve the goal of finding answer to a much broader question of how to feed and supply energy to the country's growing population, while respecting the natural environment, life supporting ecosystems and local community's livelihoods.

Map # 1: Floodplains and *Belajats* of river Indus in the study area in color composite (Landsat TM 742 Bands)



Source: Satellite image (year 2001) from the Global Land Cover Facility (www.glcfc.com)

Map # 2: Braided channels of river Indus in color composite
(Landsat TM 531 Bands)



Source: Satellite image ((year 2001) from the Global Land Cover Facility
(www.glcfc.com)

1.3 RESEARCH PROBLEM

The construction of Barrage meant for diverting water into Power Channel has caused the withdrawal of Indus water from the river basin. The river basin covering vast area in length and breadth, constitute unique floodplains ecology between the Tarbela dam and Attock Bridge where the river Indus joins river Kabul at Kund. The withdrawal of water has caused severe environmental impacts on the groundwater reservoirs of many villages of district Swabi, Haripur and Attock, which are recharged by the river Indus. The drying of river basin has brought sever adverse impacts on the peculiar ecosystem of *Belajats* (a local name meaning the small islands in the braided channel of river Indus). These *Belajats* are natural habitats for the wildlife, besides a source of fuel wood and rangelands for the local community. Water deprivation has also caused significant losses in fish-catch of the local varieties of *Mallah* specie (local name for *Shizothorax sp.*) and *Chaina* (*Mystus oar sp.*), which were abundant in the entire river basin; impacts on agricultural land / productivity due to decline in ground water; effects on the nutritional status of the local population around the river Indus; threat to the fishermen of the local community, threat to gold panning profession of the locals and the losing of the fascinating scenic and natural beauty of the long riverside.

1.4 RESEARCH QUESTION

The central research question of this study is to answer "what adverse impacts have arisen on the floodplains ecology of river Indus in the study area due to diversion of waters into Power Channel of GBHPP and what mitigating measures should be adopted to ameliorate the situation?"

1.5 RESEARCH HYPOTHESIS

It is assumed that Ghazi Barotha Hydro Power Project (GBHPP) has contributed positively at the national level excepting the adverse impacts on the floodplains ecology of river Indus, lying in district Swabi, Haripur and Attock.

1.6 RESEARCH OBJECTIVES

The study evaluates / monitors the post-implementation effects of the project in the entire floodplains covering Swabi and Haripur districts of NWFP and Attock district of Punjab, starting from the barrage up to the Attock. This vast

floodplains area has been deprived of the previous large quantities of surface water due to its diversion into Power Channel. The Power Channel made of concrete materials connects the Barrage with the Power Complex at Barotha in Attock. Therefore, the objectives of this research are as under;

- To study and review the Environmental Assessment Study / Report of the project and other related documents / reports so as to develop an understanding about the pre-project environmental settings of the area.
- To evaluate / monitor the post-implementation changes those have arisen in the physical, ecological, human use values and quality of life values of the floodplains in the study area.
- To evaluate and determine the accuracy of predictions made during the impacts scoping and hence to help fill the gape of knowledge between the predictions and actual impacts.
- To use the research findings for giving practicable recommendations / suggestions for resolving the ill-effects of Ghazi Barotha Hydropower Project and use the same as a feedback for future Environmental Impact Assessment of Water Resources Projects. This will contribute to strengthening the role of EIA as decision making tool.

1.7 VARIABLES

The variables operationalized in the study are as given below;

Surface Water Hydrology changes based on before and after GBHPP, Ground Water Hydrology before and after the Project, Water Supplies (for drinking and irrigation), Terrestrial Flora and Fauna of *Belajats*, Fuel Wood Supply from the *Belajats*, Use of *Belajats* for Livestock by the Locals, Fish-catch before and after the Project, Fish Price in the Local and Regional Markets before and after the Project, Fish Consumption by the Local Individuals before and after the Project, Gold Panning Activities in the Study Area, Source of Irrigation, Power Generation, Socio-Economics and Aesthetics.

1.8 INTRODUCTION TO GHAZI BAROTHA HYDRO POWER PROJECT (GBHPP)

The GBHPP is located in the eastern part of NWFP and the northern part of Punjab province. It is situated in the three districts namely Swabi, Haripur (NWFP) and Attock (Punjab). The project is basically a major run-of-river power project, designed to utilize for power generation the head available between the tailrace at Tarbela and the confluence of Indus and Harro rivers at Barotha. The Government of Pakistan approved the PCI for Ghazi Barotha Hydro Power Project in June 1994 and the preparatory works were started in mid 1995, including mainly the acquisition of land for the project and the construction of the permanent colonies and the new access route to power complex site.

The construction of the barrage and the power channel was started in December 1995 and that of the power complex in February 1997. Impounding of the barrage started on 17 February 2003, with filling of the power channel beginning on 9th April, 2003 while the 500KV switchyard was energized all on the 30th April 2003. Unit # 1 testing and commissioning started with the first mechanical run on 13 May, 2003. The electrical generation started on 16th June, 2003 with the generation of 50MW. The entire project completed in May 2004.

1.9 COMPONENTS OF GBHPP

1.9.1 *The Barrage*

The barrage is located on the Indus river, about 7 Km downstream from the Tarbela Dam. The left abutment lies about 800m upstream of the village Ghazi. It provides 71M cu m storage pond allowing for the regulation of the daily discharge from Tarbela by diverting the flow into the power channel. The principal features of the Barrage are given in table # 1.

Table # 1: Principal features of the Barrage, GBHPP

Total Area of Barrage	1140 ha
Open Flume Standard Bays	20
Live volume	62 M cu m
Design flood discharge capacity	18,700 cumecs (660,000 cusecs)
Survival flood capacity	46,200 cumecs (1,631,000 cusecs)
Orifice Undersluices	08
Public Road Crossing of the Indus river	01

Source: Derived from the Project's Documents

The location and aerial view of the barrage is given in the map # 3 in the next page.

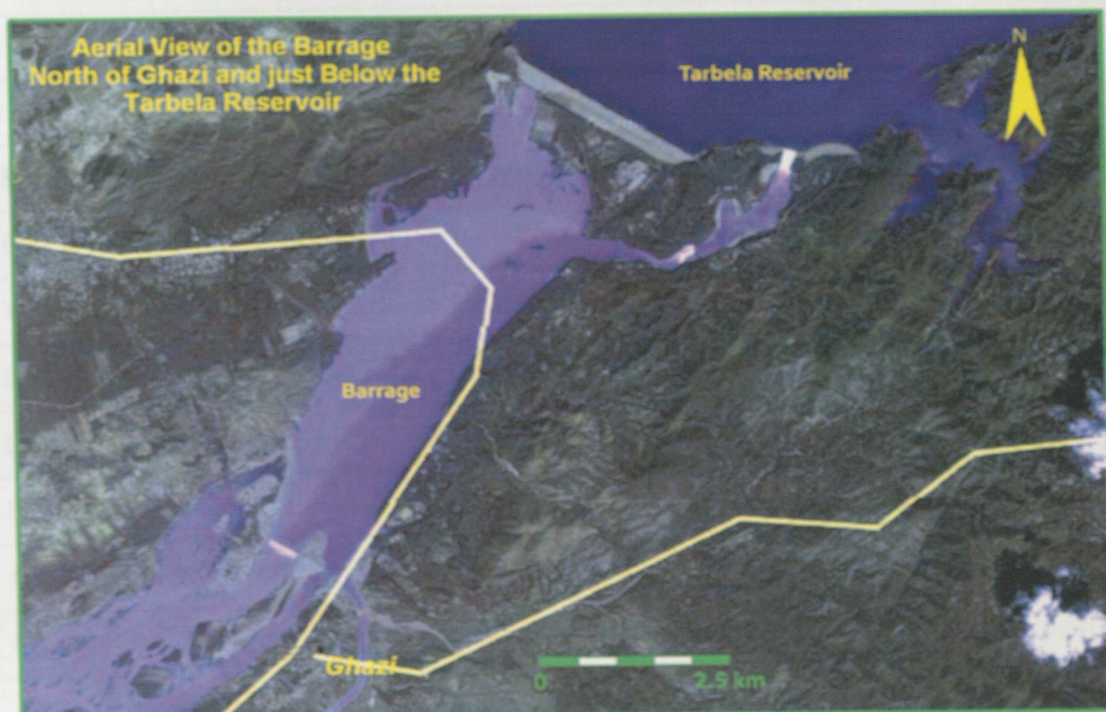
1.9.2 The Power Channel

The power channel commences at the head regulator of the barrage, extends directly south-east for 500m, then bends around the Ghazi to run generally south-west for about 20 km, where it is gradually bend westward to cross the GT road, then it passes through the kamra Aeronautical complex, bends Northward and then at last enter the fore bay of power complex.

The power channel is long concrete-lined channel. The power channel is 9.0 m (29.5 ft) deep and about 52 km long with a capacity of 1,600 cumecs (56,480 cusecs). The power channel functions to convey water from the barrage pond to the power complex with the water velocity of 2.33 m/s. The power channel has a near contour alignment with hills on the left side and the land naturally draining towards the Indus River on the right side.

The channel has service road on each side. Along its rout, it is provided with a railway bridge, 34 road bridges and 13 pedestrian bridges as well as 27 super passing and culverts for carrying flows in seasonal streams (locally called as *nullahs*).

Map # 3: Location of the Barrage, GBHPP



Source: Google image

The brief specifications of the Power Channel are given in table # 2 below;

Table # 2: Brief specifications of the Power Channel, GBHPP

Design Flow	1600 cumecs (56,480 cusecs)
Longitudinal Slope	1:9600
Length	52 km
Depth	9.0 m (29.5 ft)
Bed Width	58.4 m (191.6 ft)
Water Velocity	2.33 m / s
Road Bridges	34
Pedestrian Bridges	12
Super Passages	27
Cross Drainage Structures	43
Railway Bridge	01

Source: Derived from the Project's Documents

1.9.3 The Power complex

The Power Complex is located near the village of Barotha, on the left bank of the Indus River, just upstream of the confluence with the Haro River. The function of the power complex is to use the water delivered by the power channel to generate power and energy, before returning the water to Indus River.

The structure in the power complex comprises of the fore bay, two head ponds, a spillway, an intake structure, five penstock, a powerhouse, a tailrace channel, ancillary structures and a switchyard.

The fore bay receives water from Power Channel and delivers it to power intake structure; the fore bay has a spillway, which is meant for handling, the full 1,600 cumecs discharge of the power channel in the event of power plant shutdown.

Brief description of the Power Complex is as given in table # 3.

Table # 3: Brief descriptions of the Power Complex, GBHPP

Total Area	850 ha
Total Output	1450 MW
No. of Head Ponds	Two Head Ponds
No. of Total Generators	Five Turbo Generators Each One Having Output of 290 MW

Source: Derived from the Project's Documents

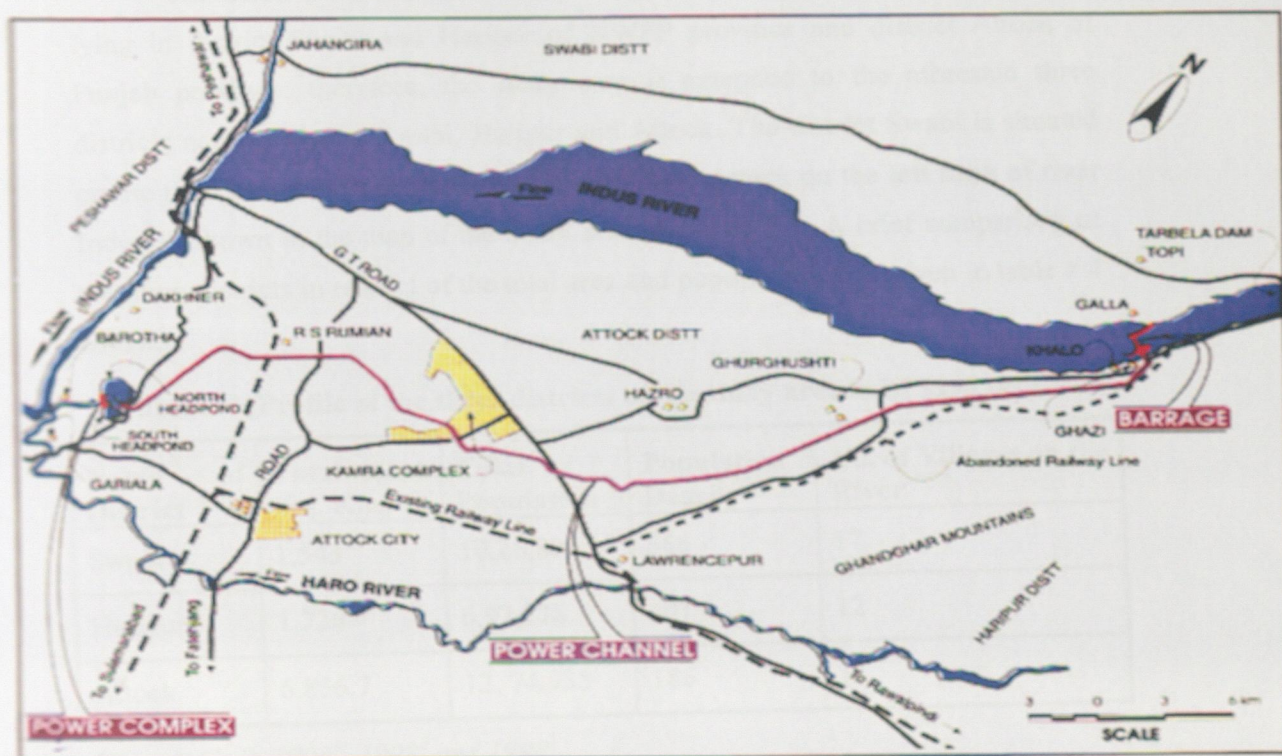
The aerial view of the Power Complex is shown in the figure # 1 in the next page.

Figure # 1: Aerial view of the Power Complex, GBHPP



Source: Google image

Figure # 2: Detailed layout of GBHPP



Source: Pakistan Hydro Consultants (1994)

1.10 INTRODUCTION TO THE STUDY AREA

1.10.1 Study Area

The GBHPP has caused diversion of water from the vast Indus river basin lying in district Swabi and Haripur of NWFP province and district Attock of Punjab province; therefore, the study area is extended to the aforesaid three districts namely district Swabi, Haripur and Attock. The district Swabi is situated on the right bank whereas the district Haripur and Attock on the left bank of river Indus as shown in the map of the study area in Figure # 2. A brief comparison of the three districts in respect of the total area and population etc is given in table # 4 below.

Table # 4: Profile of the three districts of the study area as of 1998 census

Name of District	Total Area (Sq. Km)	Total Population	Population Density	No. of Villages on the River
Swabi	1,543	10,26,804	666	17
Haripur	1,726	6,92,228	401	12
Attock	6,856.7	12, 74,935	186	11

Source: GoP, 1998¹, 1998² and 1998³

The rainfall pattern in the study area is monsoonal i.e. the rains mainly come in the summer. About 70% of the total rain falls between July and September with a peak in August. The Project area has a sub-humid tropical climate, with hot summers and cool winters. June is usually the hottest month with a mean maximum temperature (1960-2004) of 41.15 C⁰ and the maximum recorded during the period is 47.7 C⁰. January is the coldest month, with a mean minimum of 4.8C⁰ at Tarbela and a recorded low temperature of -1C⁰.

Persistence summer winds accompanied by high temperature, result in a high evaporation rate during summer months. The area is relatively dry in the most of the year, with an average annual relative humidity of 39% at Attock City and 53% at Tarbela. The relative humidity in monsoon (July to September) is the highest (68%) and the lowest (35%) in pre-monsoon (May-June) in the study area. The brief profile of the three districts constituting the study area is given in table # 5.

1.10.2 District Swabi

The Swabi district was created on 1st July 1988. It has two sub-divisions namely, Swabi and Lahore. The district lies between 33° - 55' and 34° - 23' north latitudes and 72° - 13' and 72° - 49' east longitudes. It is bounded, on the north by Buner district, on the east by Haripur district, on the south by Attock district of the Punjab province and on the west by Nowshera and Mardan districts. The total area of the district is 1543 square kilometers. Archeologists attach special significance to district Swabi for the historical fort of "Hund" that was built by the Mughal emperor, Akbar the Great in the 15th century. The town of Hund once, has been a great strategic place for the traders and military invaders in the history due to its location on the river Indus, which they used as a crossing point between the subcontinent and central Asia. The sample villages of the study area in district Swabi lie on the eastern and south eastern parts of Swabi along the right bank of Indus river. These villages are Gallah, Bata Kara and Hund. The brief profile of the sample villages is given in table # 2.

1.10.3 District Haripur

Hari Singh Nalva, a Sikh General of Ranjit Singh's Army, founded Haripur in 1822. It is situated at latitude 33° - 44' to 34° - 22' and longitude 72° - 35' to 73° - 15'. Its boundaries touch Mardan in the north-west, Abbottabad in the north-east, Mansehra district in the north, Margallah hills range in the south-east, Swat valley in the north-west, Buner and Swabi districts in the west. Besides Swabi, Mansehra and Abbottabad districts of NWFP; two districts of Punjab province i.e. Attock and Rawalpindi lie on the south-west and south-east respectively in the neighborhood of district Haripur. The sample villages in the district Haripur are Jammu, Qazi Pur, Hasan Pur and Aldo-Jabbi. The brief profile of the sample villages is given in table # 2 in the next page.

1.10.4 District Attock

Attock district owes its name from the famous Attock Fort, situated on the left bank of the Indus River. The name to fort was accorded by emperor Akbar. The Attock district was constituted in 1904 by taking Talagang Tehsil from Jhelum district and Pindigheb, Fatehjang and Attock Tehsils from Rawalpindi district. The total area of the district is 6,856.7 sq. Kms., and the total population is 1,274,935

making population density of about 186 persons per sq. km of the district as a whole. The district lies from 33° - 00' to 34° - 00' north latitudes & 71° - 43' to 72° - 56' east longitudes. The district is bounded on the north by Swabi and Haripur districts of NWFP, on the east by Rawalpindi district, on the south by Chakwal district & on the south-west by Mianwali district, in the west by Kohat district and on the north-west by Nowshera district of NWFP. The Indus River flows along the western boundary of Attock district for about 130 km. Its divides Attock district from all the three bordering districts of NWFP. The climate of the district is extreme. The annual average rainfall in the district is 783.30 m.m. The sample villages of district Attock are Jalalia, Daman, and Formali. The brief profile of the sample villages is given in table # 5.

Table # 5: Profile of the sample villages as of 1998 census

DISTRICT SWABI (Left Bank Area)					
Name of Sample Village	Area (Acres)	Population	Literacy Rate in % (above 10 years)	Total No. of House Holds	Average House Hold Size
Gallah	2,828	4,212	43.5	618	7.3
Bata Kara	3,258	5,336	29.8	576	8.6
Hund	6,946	7,114	31.4	923	7.7
DISTRICT HARIPUR (Khari Plain)					
Name of Sample Village	Area (Acres)	Population	Literacy Rate in % (above 10 years)	Total No. of House Holds	Average House Hold Size
Khalu	550	2600	67.9	400	6.5
Jammu	1,350	881	48.7	126	7.0
Qazi Pur	1,942	2,291	59.7	424	5.4
Aldo-Jabbi	1,384	1,659	38.5	280	5.9
DISTRICT ATTOCK (Chhachh Region)					
Name of Sample Village	Area (Acres)	Population	Literacy Rate in % (above 10 years)	Total No. of House Holds	Average House Hold Size
Jalalia	-	4,453	40.0	700	6.4
Daman	-	1,640	50.7	241	6.8
Formali	-	6,877	34.9	1,116	6.1

Source: GoP, 1998¹, 1998² and 1998³

1.11 SCHEME OF STUDY

The study is organized into 7 chapters to present easy comprehension of the research question and the hypothesis relating to the title of the research study and better understanding of the results obtained thereto. The present chapter # 1 titled "Introduction" provides scope and significance of the research study. This chapter also discusses the research problem, research question and the hypothesis regarding the title of the research study. The various variables, which have been operationalized in the field, have also been given in this chapter so as to provide the baseline information and the various beneficial and adverse impacts that have arisen due to GBHPP on the floodplain ecology in the study area. At the end of the chapter, a comprehensive introduction has been given to Ghazi Barotha Hydro Power Project; and to the projects area, which has experienced an alteration in the physical and man-made environment of the study area.

The chapter # 2 is titled "Research Methodology" that gives an overview of the various methods and techniques used for the collection of secondary and primary data. The chapter also discusses the various tools and techniques used for analysis of the data collected and their interpretation for easy and better comprehension of the results of the study. The sample frame and the multi-stage sampling technique used in the study is also part of the chapter # 2.

The chapter # 3 "Environment and Development in the Historical Perspective" is covered with the theoretical framework about the study, which fits the larger findings of the study in a conceptual framework that exists regionally and elsewhere in advanced and less advanced countries. The chapter is sufficiently rich with the relevant literature about the water resources projects and their impacts on the natural vis a vis man-made environment. The history of environmentalism and Environmental Impact Assessment (EIA) of development projects in the developed and less developed countries and introduction to EIA methodologies developed so far make the chapter useful for understanding the conceptual background of the study. The energy and water challenges in the near future, role of the hydropower generation and the associated environmental issues; and the stated position and initiatives of the United Nations and its sub-organizations mentioned, broaden the base of the literature review. The chapter is also comprised of an overview of the water resources projects for hydro energy in other countries, and examples of few countries have been given as case studies in-brief from Asia,

Europe, Australia, North and South America. At the end, the water resources sector in Pakistan, national water policy; energy scenario and hydro generation vs potentials of the country vis a vis environmental challenges associated with the water resources projects have been described.

The chapter # 4 "Pre-Project Environment" gives detailed descriptions about the natural vs human environment of the study area that existed prior to construction and implementation of the GBHPP. The contents include brief introduction to the study area and its population and the life style of the people that remained for generations before GBHPP. The chapter describes the pre-project physical as well as the ecological resources of the vast floodplains of river Indus, constituting the study area. Moreover, the role of the physical and ecological resources in the socio-economic status of the local and surrounding community as of before the project implementation, has been elaborated in detail.

The chapter # 5 titled "Environmental Impacts of the Ghazi Barotha Hydro Power Project (GBHPP)", which makes the central part of the study, is focused on the environmental and socio-economic effects of the water diversions from the vast braided channels of river Indus into the concrete 52 km long power channel of GBHPP. The contents of the chapter are comprised of evaluating the impacts of GBHPP on the natural as well as the human components of the environment. The impairment of the resources (physical and ecological) associated with the river and the many small islands (*Belajats* in the local language) constituted by the river, the human development component of GBHPP amongst the socio-economics; and, the impacts of GBHPP on quality of life values of the local communities have been elaborated in this chapter.

The chapter # 6 "Summary of Findings, Conclusions and Suggestions" has given summary descriptions of the beneficial and adverse impacts of GBHPP on the floodplains ecology comprising the physical, ecological and socio-economic components of the environment. The effects have been described along with their potential causative agents so as to help devise suggestions for offsetting the adverse effects and maximize the worth of the benefits associated with GBHPP. Based on the causes of the adverse effects, practicable suggestions have been provided to eliminate the adverse impacts on the vast floodplains ecology along the downstream braided channel of river Indus.

The lesson learnt from GBHPP has also helped identify the scope of an effective and comprehensive Environmental Impact Assessment (EIA) for

development projects in general, and water resources projects in particular, and thus, to avoid any critical ill effects in advance of projects' implementation. The study has contributed towards strengthening the role of EIA as decision making tool and to depoliticize the water resources projects associated with the potential trans-boundary environmental impacts within the provinces. Eventually, the country will be able to embark on the desperately needed water resources projects including multipurpose reservoirs and irrigation projects and exploit the country's huge potentials for hydro power generation and irrigating the vast rain-fed cultivable lands in the nearest future. These projects, implemented in harmony with the natural environment will prove a milestone in boosting the economic growth of the country as a whole and thus can potentially pave the way for sustainable development.

The chapter # 7 provides proposal for carrying out future research in new scientific dimensions and research approaches in the study area. The research is aimed to devise strategy to offset the ill effects of GBHPP in the long run on the local environment and vulnerable groups, which may arise over the longer course of time in future. This would help strengthen the sustainability of GBHPP, besides to bridge the gap in knowledge about the predictions and actual changes associated with water resources projects. The future research includes "Methodological / Technical Aspect", the "Optimization of the Compensatory Water Releases, Analysis of Surface and Ground Water Resources"; "Analysis of Waste Water vis a vis Population Expansion in the Study Area" and in-depth research on the "Multi-Sector Multi Year Development Plan" launched for the affected communities. The knowledge obtained from the new research will; ultimately strengthen the role of Environmental Impact Assessment (EIA) as decision making tool for decision makers and planners in future.

CHAPTER # 2

METHODOLOGY

2.1 SCOPE AND OVERVIEW

The UN Charter gives peoples the rights of development however; improvements in the living conditions have ever been the ultimate object of humankind since the journey of civilization from the Stone Age to the present technological era. To acquire better well being, man has always been interacting with natural resources one way or another, directly or indirectly. Although, there is an intricate relationship between the repository of natural resources _the environment and development, this relationship most often remained understood by the planners and decision makers unless the appearance of some tragic incidents during the first half of the 20th century. The technologically advanced countries responded quickly to the neglect of the environment in their policies and decision making however, the response in the developing countries has been unsatisfactory due to many reasons.

The developing countries have been caught in by the dilemma of acquiring development as well as to avoid the ills of development, which most often outweigh the benefits in the long term. To exploit the bounties of nature for attaining development, the developing countries need to harness the natural resources with strong focus on the conservation of natural resources and delivery of benefits of development on the principles of inter and intra-generational equity.

As water resources projects are one of most prioritized projects both in the developed and less developed countries, these projects are the most sensitive too in terms of pervasiveness of the effects on the basis of magnitude, extent, significance and special sensitivity. The Ghazi Barotha Hydro Power Project (GBHPP) has been operationalized in Pakistan in 2004, which has caused diversion of water from vast floodplains of river Indus that would constitute huge wetlands on account of flowing into long braided channels. The beneficial impact includes the generation of 1450 MWs power vis a vis acute adverse impacts on the 2 districts of NWFP and 1 district of Punjab province. The diversion of the natural flow of water into the concrete power channel has deprived a large human population of

consistent flows of water in the Indus river. The reduction of surface water quantities, in turn, is affecting the ground water reservoirs in the large areas as well as other renewable resources including fisheries, natural flora and fauna and the livelihood of large population depending on the natural resources associated with the river Indus and the constituent floodplains in the study area.

2.2 RESEARCH TOOLS AND METHODS

To assess the impacts of Ghazi Barotha Hydro Power Project (GBHPP) on the vast floodplains ecology of river Indus comprising the huge renewable and non-renewable resources and the local riparian along the braided channels, the study is designed to operationalize quite many research tools and techniques in its Methodology. The research tools and techniques used are elaborated below;

2.2.1 *Tools and Techniques for Collection of Secondary Data*

2.2.1.1 Exploratory Search

In order to achieve better understanding of the research question and hypothesis, extensive review of the literature was undertaken. Efforts were made to get access to as many as possible academic research conducted on the topic, past Environmental Assessment report of Ghazi Barotha Hydro Power Project, government's reports, relevant documents relating to the project area; other published and unpublished research materials. The new scientific research technique through the Internet was also undertaken. The literature review helped quenched the curiosity of the scholar in the research area and helped the scholar to get familiarized adequately with the research topic.

2.2.1.2 Quantitative / Qualitative Data

The relevant quantitative and qualitative data was obtained from a number of sources given below;

- Water and Power Development Authority (WAPDA) offices including Surface Water and Ground Water Sections, WAPDA House, Peshawar
- The Hydrology Section, Tarbela, WAPDA
- The Barotha Control Room, Ghazi
- Ghazi Barotha Head Office, Hattian, Attock
- Ghazi Barotha Taraqiati Idara (Project NGO)
- The Fisheries Section, Tarbela Office, WAPDA

2.2.2 Tools and Techniques for Collection of Primary Data

To evaluate the impacts of the GBHPP on the floodplains ecology of the study area, primary data was collected for the following relevant variables;

Surface Water Hydrology before and after the GBHPP, Ground Water Hydrology before and after the Project, Water Supplies (for drinking and irrigation), Terrestrial Flora and Fauna of Belajats, Fuel Wood Supply from the Belajats, Use of Belajats for Livestock by the Locals, Fish-catch before and after the Project, Fish Price in the Local and Regional Markets before and after the Project, Fish Consumption by the Local Individuals before and after the Project, Gold Panning Activities in the Study Area, Source of Irrigation, Power Generation, Socio-Economics and Aesthetics.

The variables were operationalized through Field Surveys, which incorporated the following techniques;

- 2.2.2.1 Questionnaire Survey
- 2.2.2.2 Interview Method
- 2.2.2.3 Focus Group Discussions (FGDs)
- 2.2.2.4 Personal Observations

2.2.2.1 Questionnaire Survey

The questionnaire survey was conducted for the local residents, fishermen and gold panners who are the proven affected peoples of the project area and hence to assess both the beneficial and adverse impacts of GBHP on the entire ecosystem of the floodplains. The survey used 3 different types of questionnaires (i.e. for the local residents, fishermen and gold panners), which are given in the annexures I, II and III at the end.

2.2.2.2 Interview Method

The interview method was used to collect relevant information from the project personnel, Chief Executive, Ghazi Barotha Taraqiati Idara (Project NGO), General Manager, Tarbela Dam, local councilors of the sample villages and other informed persons like school teachers and local NGOs.

2.2.2.3 Focus Group Discussions (FGDs)

The Focus Group Discussions were held with the elders of the study area in the traditional community centers called hujras of the sample villages. The FGDs were normally held after the questionnaire survey and interviews were held with the project personnel and other informed individuals of the area. The FGDs held in this way not only fulfilled the required data but proved effective tool for the research feedback. The local elders and other interested individuals were normally informed well advance of the FGDs so as to ensure appropriate participation of the people and make the activity effective for better understanding of pros and cons associated with the project.

2.2.2.4 Personal Observations

The personal observations were made to correlate the facts and findings obtained through the questionnaire surveys, interview technique and focus group discussions. Elaborate efforts were made to observe river flows in the braided channels and get understandings of the physical, ecological and socio-cultural impacts of the water diversion caused by the GBHP. The field observations proved effective to monitor the impacts of the project on groundwater quantities and the resulting impacts on the water supply, agriculture and other uses of water.

The field observations helped understand the impacts of decreased flows of water in the river channel on the natural vegetations, wildlife in general and the support of animals rearing by the *Belajats* (small islands) constituted by the braided channels. The natural settings of the physical vis a vis ecological resources and the socio-cultural impacts caused by the project were preserved in the digital photographs to support the findings of the study.

2.3 TOOLS AND TECHNIQUES FOR ANALYSIS

Data and information collected through the questionnaire surveys, interviews, focus group discussions and field observations were analyzed to draw summary conclusions of the study. The analysis was done through the computer software and other quantitative techniques such as percentages and averages etc. For certain useful yet non-quantifiable impacts qualitative analysis was carried out to arrive at the necessary findings and conclusions. The analysis of the data collected provides useful quantitative and qualitative information when

comparison of the existing situation is done with pre-project conditions when the river would flow in its natural braided channels in the study area.

2.4 TOOLS AND TECHNIQUES FOR INTERPRETATION OF FINDINGS

The findings of the study are interpreted in tables and figures to examine the impacts of the project on the floodplains ecology of the river. Further, the information have also been interpreted in simple cartographic techniques including graphs and maps etc.

2.5 SAMPLE FRAME

Before implementation of the Ghazi Barotha Hydro Power Project (GBHPP), the river would stretch into vast braided channels therefore; it was set to extend huge benefits to the local communities in the form of utilization of physical resources, ecological including terrestrial and aquatic resources; and other socio-economic advantages. As the project has caused diversion of waters from the vast Indus river basin lying in district Swabi, Haripur and Attoc; therefore, the scope of the study is limited to the three districts namely district Swabi, Haripur and Attock.

Area-wise, the district Swabi has been affected the most and to the larger extent due to the reasons that the river Indus (as per its physiographic layout passing from the point of diversion up to its confluence with river Kabul) has district Swabi all along on its right bank. The directly affected villages of district Swabi lying on the right bank of river Indus are kiara, Bara, Pehur, Gallah, Pontiya, Bata kara, Zarobi, Doke, Gar Munara, Hund, Haryan, Sallah, Beka, Nabi, Bazar, Jabar and Tannon. The western most parts of district Swabi lying on the bank of river have experienced negligible effects owing to being closed to river Kabul flowing from the north western region of the country. Although, the district Swabi has a total area of 1,543 square kilometers and a total population of 10,26,804 persons giving population density of 666 persons per square kilometer, the principal users of the resources of the river and its floodplains are located in district Swabi who through out their history would rely on Indus related resources of fishery, gold panning in the riverbeds, use of *Belajats* (small islands in the braided channels) for animals rearing and wood supplies; and the significant recharge of groundwater reservoirs by the huge surface water bodies of river Indus,

which would enable adequate supplies of water for domestic as well as agricultural uses.

The severe effects of the project in district Swabi are followed by district Haripur, which has a total area of 1,726 square kilometer having a total population of 6,92,228 persons giving population density of 401 persons per square kilometer. The directly affected villages of district Haripur are Ghazi, Khalo, Isa, Jaloo, Bhai, Jammu, Qazi Pur, Hasan Pur, Aldo-Jabbi, Mian Dheri, Naqar Chian and Sheikh Chur. District Attock though, a large district area-wise, has less area and population being affected by the project.

The district Attock has a total area of 6,856.7 square kilometers with a total population of 12, 74,935 persons giving a population density of 186 persons per square kilometer. The villages affected directly by GBHPP in district Attock are Jalalia, Yasin, Haroon, Daman, Waisa, Walia, Sarka, Shadi Khan, Formali, Khura Khel and Mallah. The study shows that comparatively small population has been affected in these villages of district Attock by the project owing to comparatively less population relying directly on the resources associated with the river Indus. The affected settlements and sample villages of the sample frame are shown in map # 5 in chapter 4.

2.6 SAMPLING

Prior to project-operation, the river would stretch into huge braided channels therefore; it would give enormous benefits to the local communities in the form of utilization of natural resources as well as extending many other socio-economic advantages. The study is designed to undertake multi-stage sampling technique for the collection of primary data for examining the impacts of GBHP on the floodplains ecology of river Indus.

2.6.1 Stage I Sampling: During the first stage, *Purposive Sampling* was carried out to select three clusters of district Swabi, Haripur in NWFP and district Attock in Punjab province, which constitute the sample frame of the study.

2.6.2 Stage II Sampling: The second stage sampling was carried out by *Random Sampling* to select sample villages from all the three clusters of Swabi, Haripur and Attock. The villages of Gallah, Bata Kara, and Hund were randomly selected out of the directly affected 17 villages in Swabi cluster, which make 17.64 %

sample size. Jammu, Qazi Pur, Hasan Pur and Aldo-Jabbi were randomly selected in Haripur cluster out of the total 12 affected villages, thus representing 33.33 % sample size. Likewise, Jalalia, Daman and Formali were selected in the Attock cluster out of the total 11 affected villages making 27.27 % sample size.

2.6.3 Stage III Sampling: The third stage of sampling was again carried out by *Random Sampling*, whereby respondents were randomly selected from the villages selected in the Stage II sampling. The total number of respondents in the Swabi cluster was 150 out of the total 2117 households, which make a sample size of 7.08 %. Similarly, the total number of respondents was 95 out of the total 1087 households in Stage II giving the sample size of 8.73 % for Haripur cluster. The Attock cluster was comprised of total number of 150 respondents out of the total 2057 households in Stage II giving the sample size of 7.3 % in the Stage III sampling.

The sample size of the fishermen was above 15 %, of whom 90 % are located in Swabi cluster and about 8 % in Haripur, while the remaining 2 % in Attock. The sample size of the gold panners was between 30-35 %, of whom 80 % reside in Haripur while 20 % in Swabi Cluster who practice gold panning in the riverbeds as their ancient profession.

The highest percentage of fishermen in Stage III sampling in Swabi cluster is due to fishery being practiced more as profession than in Haripur and almost negligibly being practiced in Attock. Similarly the gold panning is practiced more as profession in Haripur than in Sawbi and Attock cluster.

CHAPTER # 3

ENVIRONMENT AND DEVELOPMENT IN THE HISTORICAL PERSPECTIVE

3.1 SCOPE AND OVERVIEW

The technological advancement has brought many comforts for the humankind on earth and has introduced a distinctive luxurious lifestyle for many of the technologically advanced countries. The environment, which is the repository of all the natural resources, plays in fact, its ultimate crucial role in determining the present and future wellbeing of inhabitants living on it. It is the environment, which supplies all the renewable and nonrenewable resources for development of human civilization(s). However, it is again the development, which in turn influences the environment and its resources. Thus the very lack of development, which is named as "poverty" or "pollution of poverty" by some of the economists also adversely, influences the quality of environment and so of its resources. The history of development has shown that any development process pursued without due regards to environmental quality or natural resources has had proved detrimental in the long run and has had thus caused retardation of development. Such development, which stops in future, is commonly called as unsustainable development. The lack of development or pollution of poverty causes the mismanagement or inefficient use of resources that in all cases deteriorates the quality of natural resources and ultimately the wellbeing of humankind is threatened. As the poverty increases more and more, the mismanagement of resources and utilizing the natural resources beyond their carrying capacity become a persistent feature of the human environment.

The above discussion proves that there is an intricate relationship between the environment and development. Both are interdependent and potentially closely influential on each others. The environment supplies resources for development, whereas the development pursued with due care for the environment, leads to further efficient and effective utilization of environmental resources. Such development accelerates the pace of development, which eventually paves the way for sustainable development. The headings and subheadings following this brief introduction are aimed to describe the history of development and relate the same

to level of environmental deterioration through the long history of human civilization. Through the course of development, the humankind through experience has learnt how to respond to environmental challenges at the national, regional and international level. Furthermore, the focus of the humankind how to utilize the natural resources in the best interest of both the environment and humankind through effective environmental planning and management is also scope of this chapter. In the end of the chapter, the water resources projects have been evaluated in respect of attention of the developed, less developed and international lending agencies towards water resources projects and their wetting on the scale of benefits vis a vis harms associated with these projects.

The chapter is organized into two main parts with properly named headings and subheadings to explain theme of the thesis in light of the available literature. The first part is focused on the historical background of development of human civilization, the history of environmental considerations in development processes and programs; the genesis of Environmental Impact Assessment (EIA) as discipline, advancement in EIA methodologies and its application in the developed and less developed countries.

The second part explains water resources projects and their contribution to hydropower generation and the various water challenges being faced with varying gravity by different individual states and international community. The role of the key players such as United Nations, World Summit, individual states and international NGOs has been discussed for the efficient utilization of water resources for the services of humanity; and management of the environmental harms associated with these projects. In the end, the chapter discusses the water resources, the emerging energy issues and environmental safeguards / legislation in detail in the context of Pakistan. The water resources projects that are put at the heart of the "vision for economic growth" through cheaper hydro-energy generation for domestic, industrial and commercial use and irrigation water for the country's vast rain fed agriculture is also the core part of the literature in this chapter.

PART A: HISTORY OF ENVIRONMENTAL PRESERVATION

The history of environmental preservation is in fact the study of the past so-called development of human civilisation. Man has always altered the natural world in his pursuit of food and resources. Although, the surroundings of the mankind unconsciously has always been a focus of concern through the long developmental history of civilisation, culture and living style, the terms "environment" and such as "environmental impact assessment (EIA)" have been referred to most frequently recently, after the widespread adverse consequences of development during the last 20-25 years. To give a brief account of the background of environmental deterioration and the possible safeguard of environment through time "adverse impacts on environment through history" is discussed first.

3.2 ADVERSE IMPACTS ON ENVIRONMENT THROUGH HISTORY

Before the dawn of civilisation man was a hunter. During this period the population was limited, therefore demand for environmental resources was very limited. This limited need for environmental resources led to lower consumption of the environmental resources and hence the lower generation of waste. The environment was fully capable of retaining its homeostasis.

After the expansion of population, man started to domesticate plants and animals. This is the stage when man invented the plough. The invention of the plough can be considered the beginning of the agricultural revolution. The agriculture revolution resulted in enormous alteration of the physical environment. In the view of author, the agriculture revolution accompanied by monoculture farming paved the way for pest population.

The pest population started to compete with man for space and food the so called survival. At that time the control of pests was mainly by,

- i. Rotation of crops,
- ii. Sanitation,
- iii. Destruction of crop residues, and
- iv. Hoeing

After the unmanageable growth of pests, the idea to combat them with chemicals was conceived. Hence fertilizers and pesticides were the first chemicals

introduced in our environment, which accordingly resulted in contamination of soil, water and so the entire food chain.

Before the industrial revolution, the inorganic chemicals like sulphur before 1000 B.C and arsenic in 79 A.D were used against pests (Ali and Asif, 1991). After the industrial revolution in the 18th century, the use of various chemicals and the consequent waste, posed considerable threats to environmental quality. Other chemicals such as mercuric chloride in year 1705 and copper sulphate in year 1800 were discovered to be useful for widespread use in agricultural fields (Horsefall, 1956). In 1850 rotenone and pyrethrum (Ali and Asif, 1991) and Bordeaux mixture in 1882 were discovered and brought into use (Mc Callan, 1967).

After the technological revolution in the 20th century, the use of radionuclides, the discovery of various hazardous chemicals and the enormous generation of effluent and waste had enormous consequences on the environment which resulted in various calamities such as London Smog in 1952, Minimata disease in 1953 in Japan etc. The discovery of DDT by Muller in 1939 was considered a welcome addition to chemical stock till 1960s, after which it was banned almost in all developed countries due to its broad spectrum nature, persistence in the environment and bio-accumulation in living organisms. Mellanby (1970) has described the role of DDT in WWII, and suggests that it was the widespread use of DDT which helped the western powers to win the war.

However the trend to increase chemical use and pollution remained almost unchecked at policy level till the appearance of terrible tragedies like the London Smog in 1952, Minimata disease in Japan in 1953, the Bhopal tragedy in India in December, 1984 and the Chernobyl reactor accident in spring 1986 in former U.S.S.R.

3.2.1 Environmental Impact Assessment through History

The history of EIA is as old as human life. Some of the authors have traced its history to Biblical times, while some even back to life in Paradise before life on the earth. However the old adopted activity has evolved into a current unified and explicit concept of EIA, which has been adopted with local variations by different states or countries.

According to Curi (1983), EIA has become popular in the last decade (i.e. in the 1970s), but in reality it was an activity performed under different names since the human history. He quotes the example of Adam (Peace be upon him) and Eve (Peace be upon her) in Paradise, when Eve made a very rapid EIA after the devil recommended her to convince Adam to eat the "Apple of Paradise" [in author's view it was the corn of wheat] in Paradise. She immediately considered the beneficial points of the proposal, i.e., the satisfaction which they were going to achieve; and so decided to put the plan into action. Her EIA was incomplete. She considered the short term beneficial effects, not the long term, _adverse effects. She did not foresee the adverse aspect associated with the short term _"satisfaction".

The failure of Eve was the first error in predicting the long term effects. The example provides a good base for EIA study to take the long term effects while assessing the short term. It is interesting to look at the earlier reports and to see how closely they are related to the present-day practice of environmental study and analysis. The approach is different from the modern one, more because of their simple approach; but the basic idea behind the analysis is similar (Fortlage, 1990).

Fortlage has given an example from 1548, when a commission was set up to examine the effects of the Wealden iron mills and furnaces in Kent and Sussex. The commission consisted of four chief assessors and 16 other investigators. The main study was to examine the effects of the proliferating iron mills on the economy of Sussex. The factors they considered were very similar to those that would be studied in a contemporary environmental impact assessment. The body took into account the factors like the number of mills, consumption of wood per year, how much the cost of wood had increased due to shortage; which town would suffer; what trade would suffer from timber shortage; how many jobs would be lost and why the price of iron was higher than it was when there were fewer mills. Similarly their findings were also much like those of today's environmental impact assessment, i.e., the exhaustion of woodland resources and the trade depending on timber. Accordingly their recommendations included restrictions on tree felling and a reduction in the number of mills.

The post-war expansion in industry and intensive farming after WWII created a very different situation, both in USA and Europe due to considerable adverse alteration in atmosphere, rivers; oceans and soil. However wide-scale public interest

and concern was aroused by Rachel Carson's book "Silent Spring" published first in USA and then in UK in 1963. She succeeded in showing the people how their land and lives were affected by the large scale and indiscriminate spraying of pesticides. From this beginning arose public concern for the environment; and eventually pressure by the public and environmentalists forced state and federal authorities to exert some control over the release of toxic chemicals into environment (Fortlage, 1990).

As a result of increased public concern for the environment, two bills were submitted to the US congress in 1969 to establish a national policy for the environment. These bills were subsequently amalgamated into the National Environmental Policy Act (NEPA), which became law on 1st January, 1970. President Nixon issued Executive Order 11514 in March 1970 to implement the provisions of NEPA (Departments of the Environment & Transport, 1978).

Moreover, in the view of author, the principles of environmental assessment were fully accepted internationally at the United Nations conference on the Human Environment held on 5th June, 1972 at Stockholm; where the concern for the environment later on led to the generation of 1980 publication of World Conservation Strategy (WCS) by IUCN UNEP and WWF. Since then a number of industrialised countries have implemented EIA procedures. The Netherlands has been a driving force in the development of the state of the art of EIA in Europe. In mid seventies, the government announced its intention to submit legislation designed to create an EIA requirement. Consequently the Dutch government finally introduced its bills on EIA into parliament in May, 1981 (Moltke, 1984). Canada, Australia, and Japan for example, adopted legislation in 1973, 1974, and 1984 respectively; while the European Community (EC) finally adopted a directive in July 1985 to make environmental assessment as mandatory for certain categories of projects (Wathern, 1988). According to Turnbull (1984), there has been a slow growth of interest EIA in UK. In 1976 the Royal Commission on Environmental Pollution gave the direction that developers should provide an assessment report of air, water, waste and noise pollution arising from certain developments. Many less developed countries have also been quick in adopting EIA procedures. Columbia became the first Latin American country for adopting EIA in 1974. In Asia and the Pacific, Thailand and Philippines have long established procedures for EIA. Thailand adopted National Environmental

Quality Act in 1975, and made EIA mandatory by 1978 (Sudara, 1984). In Philippines, EIA was promulgated as part of a Presidential Decree on environmental policy; Korea adopted a mandate for EIA in December, 1979 and put into effect in January, 1980; while Brazil adopted the National Environmental Policy Law in 1981, which mandates the EIA (Lim, 1986). Pakistan adopted an Environment Ordinance in 1983, which requires environmental assessment for development projects. The said ordinance however, has been amended to and presently adopted as Pakistan Environmental Protection Act, 1997 in a more comprehensive form. A number of nations in Africa, including Rwanda, Botswana and the Sudan have the experience of EIA (Klennert, 1984).

The United Nations Environment Programme (UNEP) has provided guidance on the assessment of development proposals and so to level the way for adopting EIA (UNEP, 1980) and supported research on EIA in developing countries (Ahmad and Sammy, 1985). There is a reasonable range of differences in approach towards methodologies around the World. There has been considerable research for developing comprehensive, easier and cheaper methodologies. Canter (1977), Cheremisinoff and Morresi (1977) and Jain, et al., (1977) are the typical examples produced in USA; while Clark, et al., (1976, 1981) produced comparable handbooks for the UK. Ahmad and Sammy (1985) and Carpenter (1983) developed guidelines for developing countries. UNEP (1980) represents valuable guidance on environmental assessment for industrial projects.

3.2.2 Basic Concepts and Definitions of EIA

It is important to note that there is no general and universally accepted definition of EIA (Clark, 1984). A number of authors have attempted differently to define and value EIA in terms of scope and objectives as given below;

- (i) EIA is the study of the effects of a proposed action on the environment (Ahmad and Sammy, 1985).
- (ii) Environmental Assessment is the name given to the whole process of gathering information about a project, its possible and probable effects and the analysis of the data obtained from all sources (Fortlage, 1990).
- (iii) EIA or analysis is the systematic examination of the environmental consequences projects, policies and programmes (Clark, et al., 1980).

- (iv) An activity designed to identify and predict the impacts on man's health and wellbeing, of legislative proposals, policies, programmes and operational procedures and to interpret and communicate information about the impacts (Munn, 1975).
- (v) To identify, predict and to describe in appropriate terms the pros and cons (penalties and benefits) of a proposed development. To be useful, the assessment needs to be communicated in terms understandable by the community and decision makers and the pros and cons should be identified on the basis of criteria relevant to the countries affected (UNEP, 1978).
- (vi) An assessment of all relevant environmental and resulting social effects which would result from a project (Battelle, 1978).
- (vii) An assessment consists in establishing quantitative values for selected parameters which indicate quality of the environment before, during and after the action (Heer and Hagerty, 1977).

3.2.3 *Application of EIA*

The use of EIA as decision making tool has gained recognition both in the developed and less developed countries so as to ensure that the impacts of development projects including water resources projects are adequately assessed or addressed in the planning and design phase. Apart from the individual countries, obligations on EIA have been adopted at the regional level e. g. the European Union's comprehensive unified legislation under a EC Directive dating from 1985; and the UN Economic Commission for Europe Convention, signed in 1991, on Environmental Assessment in a Trans-boundary Context, also known as the Espoo Convention (Commission of the European Communities (CEC), 1991). At a global level, the Rio Summit Declaration in 1992 and Agenda 21 both encourage the use of EIA, in a fairly general way. The Convention on Biological Diversity is more specific. Article 14 of that Convention requires Contracting Parties to introduce appropriate procedures for EIA of proposals which might have effects on biological diversity (Pritchard, 1996).

The EIA tool takes into account both the short and long term impacts of large dams and water diversion projects on ecosystems, biodiversity and the livelihoods of the downstream communities. It is not only the EIA that is

applicable at the project level, there is a similar concept called Strategic Environmental Assessment (SEA). The SEA is concerned with assessment not just of individual projects, but it is more focused on the cumulative effects of several projects, and the frameworks of programs, plans and also on the policies within which they are promoted (Therivel, et al., 1992). Some authors are of the opinion that EIA has also applications to corporate management businesses, and the International Standards Organization (ISO) is committed to good practice of environmental standards (Hunt & Johnson, 1995). The assessment process in EIA assigns the social and environmental aspects the same significance as economic and financial factors. The options assessment process continues through all stages of planning, project development and operations. The application of EIA recognizes entitlements of the affectees of the projects that improve their livelihoods and quality of life.

The World Commission on Dams has adopted a comprehensive framework for decision-making, which is based on five core values - equity, sustainability, efficiency, participatory decision-making and accountability (WCD, 2000). There are a number of sources, which provide comprehensive guidelines for doing effective and comprehensive EIAs for various sectoral projects. Some of these guidelines are used by development assistance agencies such as the World Bank (IBRD / The World Bank 1991¹, 1991²) and Organization for Economic Cooperation and Development which are also relevant (OECD 1992). The International Institute for Environment and Development (IIED) is another organization that has produced a valuable directory of about 150 sets of national, international and sectoral guidelines (Roe, et al., 1995), and a good number of guidelines have also been explored by the research centers (University of Manchester EIA Centre 1995). Other sources of information on approaches to screening, and impacts scoping, public participation, EIA / IEE review, assessment of alternatives, post-project monitoring / environmental auditing are documented in Wathern (1988), Commission of the European Communities (CEC), 1991), Turberfield (1994) and Wood (1995).

3.2.4 Advancement in EIA Methodologies

The use of environmental impact assessment (EIA) is increasingly recognised in development plans, programmes, and projects throughout the world. To produce a

comprehensive and a thorough document of an environmental impact statement (EIS), there needs to be a systematic, regular and orderly planned approach towards the characteristics of environmental components. This section will focus on the development of EIA methodologies.

The period after the Stockholm Conference of 1972, has been very favourable for its development. After the US National Environmental Protection Act (NEPA) of 1970, there has been considerable advancement in EIA methodologies in the USA in particular and other industrialised countries in general. The steps or contents of EIA have been discussed in detail in the previous chapter. This section considers the methodologies, so far available for conducting an environmental analysis of development plans, programmes and projects.

3.2.5 Definition and Concept

Before going into in-depth study of the EIA methodologies, it is necessary to define an EIA methodology. A methodology is the structured mechanism(s) for the identification, collection and organisation of environmental impact data (Bisset, 1987). Methodologies are however, referred to means for classifying and presentation of the results (Departments of the Environment and Transport, 1978). Moreover according to Warner and Bromly (1974), methodologies are the mechanisms, where by information are collected, evaluated and displayed. These definitions show that EIA methodologies are the means or tools for the systematic and comprehensive analysis of the components of the environment which provide a base for a decision on the fate of a plan, programme or project.

3.2.6 Methodologies to Date

Environmental assessment methodologies in widespread use today, can be catalogued into the four major groups: _overlay mapping, matrix, index and modelling approaches (Sondheim, 1978). Lohani and Halim (1987) have listed them into seven categories as follows:

- a. Ad hoc
- b. Checklists
- c. Matrices
- d. Networks
- e. Overlays
- f. Cost-Benefit Analysis
- g. Simulation Modelling

Some of the authors like Warner and Preston (1974) have divided methodologies into five types _"ad hoc, checklists, overlays, matrices and networks" where as Bisset (1984) has divided them for direct impacts into checklists and matrices only. However Wathern (1984) has emphasised interaction matrices, flow diagrams and network analysis and overlay techniques for indirect impacts.

In order to give an overview of all the major methodologies, the list given by Lohani and Halim (1987) dividing the methodologies into seven categories is discussed in detail as follows next.

a. Ad hoc

This methodology is usually one of the oldest and crudest methods (Depts of the Environment and Transport, 1978). This methodology gives the broad qualitative information which is of value in comparing alternative development sites; in terms readily understandable by a lay decision maker or member of the public (Lohani and Halim, 1987). The ad hoc methodology is good in the situation where detailed investigations are not required. It is valuable for initial and rapid examination. The drawback of this methodology is its superficial examination of the environmental components, and lack of comprehensiveness of all relevant impacts and subjectivity.

b. Checklists

The checklists can be considered one of the earlier methods after ad hoc methodologies and are still used in many different forms. The term checklist covers a variety of methodologies having widely varying characteristics and degree of complexity. Many authors have divided the checklists into different forms of simple checklists, descriptive checklists, questionnaire checklists, scaling checklists and scaling-weighting checklists.

These are discussed separately as;

(a) Simple Checklists

This type of checklist provides a list of all environmental factors, which are going to be affected by a certain development project. This simple list ensures that no relevant impact is neglected. Some of the checklists give project activities which may give rise to impacts. Here no guideline is provided as to how these environmental parameters are to be measured and interpreted.

(b) Descriptive Checklists

This type of checklist provides the guidelines for the assessment of the environmental parameters. A particular feature of this checklist is the prominence given to relating impacts on the factors to affected people but however they do not give information on how impact importance can be determined (Bisset, 1987).

(c) Questionnaire Checklists

As the name shows, this type of checklist presents a series of questions relevant to the possible impacts of a project. The checklist is comprised of two sections in a recent questionnaire checklist developed by US Agency for International Aid (USAID) for rural development projects (Bisset, 1984). Here the option of yes, no and unknown is given. When insufficient information is available for a definite impact, then "unknown" (unk in the Table) is recorded. This sort of checklist is valuable when the situation is not very complex. It is comprehensible for a lay decision maker and the public as well.

(d) Scaling Checklists

This is similar to descriptive checklist, but with the addition of information basic to subjective scaling or parameter values (Lohani and Halim, 1987). It attempts to assign some values or importance to impacts which are very useful to decision maker(s). Here the concept of "Threshold of Concern" (TOC) is introduced. Many possible alternatives are examined in terms of the nature of impacts through time. So attention is given to time, and hence the duration of time is assigned a letter taken from the following scale of US Forest Service (Sassaman, 1981).

(e) Scaling-Weighting Checklists

This methodology developed by the Battele Columbus Labs in USA (Dee, et al., 1979), was used for water resources projects. This methodology is also called as Environmental Evaluation System (EES) (Lohani and Halim, 1987 and Bisset, 1984). It incorporates both the scaling and weighting of impacts. This is based on an arbitrary scale of 0-1, where 1 represents "high quality" and 0 "low quality". For example the value of 10mg/l of dissolved oxygen may be considered as high "quality score" of 1 where as 2mg/l as 0.1. This determination of "quality score" for a variety of environmental components is termed as "scaling".

The relative importance of the impacts of the environmental parameters is determined by using experts (Bisset, 1984) or the public (Sondheim, 1978) so as to assign numerical weights to each parameter. To obtain the numerical index for the "overall quality" the weightings are simply multiplied by the "quality score" of each parameter. Eventually the net change is determined by subtracting the value of "predicted state with project" from the "predicted state without project".

Advantages/disadvantages of checklists: The checklists provide a good guide especially for Initial Environmental Examination (IEE); and where the situation is not very complex. These provide a list of all environmental parameters and hence ensure that no important parameter is omitted. Some of the checklists like scaling checklist attempts to evaluate alternatives and scaling-weighting checklist attempts to minimise subjectivity.

The drawback is that they are superficial and do not give any information about the complex interaction of impacts. Some of the complex checklists are restricted to those who are familiar with organising principles and so the non-experts may find it difficult to understand. The simple and descriptive checklists are considerably subjective.

c. **Matrices**

This methodology was first developed by Leopold, et al., (1971) called as "Leopold matrix". This is a type of detailed checklist, which contains two lists of both development actions and environmental parameters. List of development actions is given on horizontal axis (columns) and that of environmental parameters along the vertical axis (rows).

The matrix which gives simply the two lists of development actions (horizontal) and environmental parameters (vertical) has been termed as simple interaction matrix by Lohani and Halim (1987). The Leopold matrix describes the impacts in terms of their magnitude and importance. Magnitude is considered to be a measure of the "degree, extensiveness or scale" and importance as the "significance" of an impact.

The upper left hand corner of each cell is reserved for the magnitude assessment (a score of 0-10) and the lower right hand corner of each cell for importance (a score of 0-10). The score 10 represents the greatest magnitude or

importance, as given in figure 9 next. Such a matrix has been termed as Quantified and graded matrix by Lohani and Halim (1987). The Leopold, et al., (1971) has many drawbacks like lack of identifying indirect impacts, time scale and lack of evaluating alternatives. Such drawbacks have been overcome by Environment Canada (1974), by developing the "Component Interaction Matrix".

The Component Interaction Matrix responds to the inter-relationships between the different environmental components or parameters. In this matrix the environmental parameters selected by the experts are listed along both the horizontal and vertical axis. Here the row component is always dependent on the column component. Wathern (1984) has termed this kind of matrix as for the assessment of indirect impacts as given in figure 9 next. Environment Canada (1974) has also given a minimum link matrix, which identifies indirect impacts; for example crabs are dependent on larvae as a food chain, while larvae depend on bacteria which in turn depend on upland vegetation (Wathern, 1984). The crab thus has a first order relationship to the larvae, a second order to the bacteria and a third order to the vegetation as given in figure 10.

An assessment team commissioned by Environment Canada (1974) has also developed a matrix - "Nanaimo Port Disruption matrix" to rank impacts in terms of the degree of disruption for each alternative.

Advantages/disadvantages: The matrix methodology acts as a comprehensive list of relevant environmental parameters. It provides a relationship between the project activities and environmental parameters thus helps identify activities having risk to environmental quality. The Leopold, et al., (1971) matrix does not show second-order relationship or indirect impacts, but the Component Interaction Matrix has eliminated this shortcoming as well.

However, there are some drawbacks like not incorporating uncertainty, risk, time element, i.e., 5 years, 10 or 20 years from the first fully operational year. Sondheim (1978) has criticised them due to lack of public input into its assessment process and the difficulty in considering temporal, spatial and the interactive nature of impacts.

d. Networks

The Networks are an extension of matrices incorporating the long-term impacts of the project activities (Lohani and Halim, 1987). This methodology is based on the principle to consider explicitly the secondary, tertiary and high order impacts which may arise from an initial impact due to a particular activity of a project. According to Bisset (1987), the first EIA network was developed by Sorenson (1971) to evaluate conflicting land uses in a coastal zone of California.

The network starts with the initiative action and spreads to all possible components and interactions and concludes with the assessment of probable importance of terminal effects (Singh and Scarlates, 1986). As the name of the methodology shows, here the environmental components are connected in the form of a web or network. Once the areas of interactions are pointed then it becomes easy to trace potential environmental change arising due to expanding sequence of activity-change-impact linkage.

Moreover, the networks provide an overview of both direct and indirect impacts. The direct impacts result from the initial condition changes where as the direct impacts ultimately may invoke a condition change leading to indirect effect.

Advantages/disadvantages: The networks appear to have two major uses in EIA. First it could be used in initial sieving exercise to identify those aspects of a particular development which should be subjected to detailed scrutiny in subsequent analysis. Secondly, the information are presented in a form which can be readily comprehended (Wathern, 1984). Networks can cope partially with the problems of uncertainty and time element (Depts of the Environment and Transport, 1978). They provide useful, concise visual summaries of project impacts which are understood easily by decision makers and the public (Bisset, 1987).

The main disadvantages of the networks are the _"non-provision of any criteria for deciding which impacts are more important than the other" and "lack of public input".

e. Overlay Mapping

The overlay mapping has a long history in a wide variety of planning activities. After the EIA became mandatory in USA in 1970, the potential of overlay mapping to show the spatial distribution of impacts was soon recognised. However

McHarg (1986) has described the use of such a method for selecting highway routes even before the legal introduction of EIA in USA (Bisset, 1987). Since then there has been a considerable development in this methodology and the old manual approach has been computerised.

The manual approach is based on preparing a transparent overlay sheet for each factor being considered significant by the expert(s). The area is extended to the boundaries of the project or as considered significant from the environment point of view. Although conceptually a simple method, there are practical difficulties in the manual application of the overlays, for example the interpretation of more than a dozen overlays is often difficult and the results confused (Wathern, 1984).

The degree of impact on each feature can be shown by the intensity of shading taken from a specific colour code. Similarly the extent of an impact can be shown by the area of the transparency given particular shading (Bisset, 1987). Many of the constraints have been removed by adopting a computerised approach. Both the manual and computerised approaches are the similar, but the computers allow greater data manipulation and flexibility (Depts of the Environment and Transport, 1978).

In computerised approach a computer file is produced which contains the digitised data for each parameter. An example of computerised overlay is shown in figure 14 on the next page. The computerised "factor" maps usually have the light shading denoting low impact, dark shading denoting high impact and the black indicating "no go".

Advantages/disadvantages: The overlay methodology seems very useful when employed in screening alternative project sites, especially for linear development projects such as pipelines, highways and transmission lines. In future its contribution may be as a component of a sieving process prior to detailed impact assessment.

The serious criticism against overlay methodology is due to three problems: boundary definition, tract heterogeneity and its limitation to landscape variables. Boundary definition means the distinct line between the different features, for example the soil or vegetation; which is usually distorted when making a large scale overlay transparency from a smaller scale map, such as soil map. A tract on a vegetation map, classified as a vegetation type, may consist of different types of vegetation below the level of definition of the map. The third problem is in the form

of considering only those environmental characteristics or features which have already been mapped by government surveys, so the definition of the environment becomes limited to landscape variables; and therefore considerable amounts of information may be lost in the process.

f. Cost-Benefit Analysis

The "Cost-Benefit Analysis (CBA) is a methodology used in EIA, which assigns a money value to the economic as well as environmental benefits and costs and applies these to all the available alternatives of a development project or proposal" (Author). In view of the author, the CBA provides a picture of the net project benefits by calculating project benefits (Bp), project costs (Cp, environmental benefits (Be) and environmental costs (Ce). Thus the net project benefits can be calculated as;

$$\text{Net project benefits} = Bp + Be - Cp - Ce$$

According to Lohani and Halim (1987), the CBA utilizes the natural resources data base in the conventional EIS as a starting point; but refining it for the purpose of development related decision-making. CBA is based on the principle of evaluating the economic and environmental costs and benefits over a time as considered by the experts. Harris (1984) has termed the understanding of the benefits of a project as the aim of the technique of CBA.

Lohani and Halim (1987) have classified the valuation technique broadly into (i) market-oriented and (ii) survey-oriented. They have argued that economic analysis thus holds great promise for improving the environmental quality management. However the economic valuation relies critically on understanding and measuring the physical, chemical and biological aspects of development activities.

The valuation technique have been discussed in detail in the previous chapter under the heading "impact valuation", Harris (1984) has argued three basic approaches for the determination of the impacts _ (a) Direct questioning (b) Voting (c) Surrogate market. In terms of damage from air pollution, Harris (1984) has emphasised the calculation of "Health damage (predicted changes in mortality and morbidity); Soiling and cleaning (changes in cleaning frequency); Vegetation (due to acid rain, oxidants, sulphur compounds and fluorides); Material damage and Aesthetics and visibility". Similarly he has argued the calculation of the damage from

water pollution in terms of its recreational, domestic, and commercial and fishery uses. In the author's view the irrigation use of water is significant as well in the tropical and temperate countries.

Bohm and Henry (1979) have given consideration to "option value" in the process of CBA. Moreover they have introduced the concept of the "Risk premium" _a higher cost than the expected cost in case of uncertainty. According to Ahmad and Sammy (1985), CBA can't be regarded in isolation or as a unique methodology. It is one of a whole range of analytical tools that should be used to obtain effective results. Lohani and Halim (1987) have given the example of CBA application to Phoenix Pulp Mill in Thailand.

For CBA, the natural systems of environment should be understood, as well as their interaction and interdependent nature. It is more valuable if the interdisciplinary team covers all the aspects of the environment including Anthropology and Sociology. The costs of mitigating measures should be included in the project's costs of all alternatives.

Advantages/disadvantages: The CBA methodology is more desirable when the decision makers are more familiar with the economics than the environment as is the situation in most of the developing countries. It provides comprehensive results after taking both economics and environmental costs and benefits into account. By calculating the net project benefits it leads to a sound decision making as given in figure # 3 at the end.

The major criticism against the CBA is due to lack of a technique to value accurately the impacts which have no market values, for example the loss of cultural, aesthetic values, health and psychological impacts due to migration and impacts on social structures generally.

g. **Simulation Modelling**

The Simulation Modelling is based on the work of Halling and his associates at the Institute of Animal Resource Ecology at the University of British Columbia, Canada and is often known as Adaptive Environmental Assessment and Management (AEAM) (Bisset, 1987). This methodology is based on recognising or creating the situation in a model that exists naturally in the field. Eventually all the exogenous

factors (development project or proposal) are introduced in the model and the consequent impacts are determined and evaluated.

This methodology has been developed in response to the main inherent problems of data inadequacy and impact prediction in other methodologies. According to Lohani and Halim (1987), the AEAM approach uses a small interdisciplinary team interacting through the modelling workshops over a relatively short time to predict impacts and evaluate alternatives, including management measures. The workshops are usually of three types: (i) the initial workshop, (ii) the second-phase workshop, and (iii) the transfer workshop.

The construction of the model begins after the spatial and time limits of the study are determined and the wide range of alternatives are limited. According to Bisset (1987), once the boundaries and alternatives have been determined, the system variables are determined and organised according to some common properties. For example the subsystem models may be constructed for social, economic and ecological variables.

After this the variables are linked in a flow diagram similar to a network/system diagrams. Finally the impact indicators are identified. The descriptive, qualitative and quantitative nature of these indicators provides the essential information to decision makers.

Advantages/disadvantages: A Simulation Model once constructed and computerised can be used to reduce the uncertainties about the impacts regarding when and where the impacts may arise, their extent and nature of severity and uncertainty about who will be affected. This methodology provides a good communication between the experts and decision makers. Due to its dynamic nature, it can be further refined to use for the present project as well as future projects.

Cost of Simulation Model is the main critique against its adoption, especially in the developing countries. Some time the Simulation Model may take more time and delay the process of environmental analysis. As AEAM is based on the data collected from the field, therefore its accuracy and comprehensiveness is mainly dependent on the accurate data from the field; thus it needs well skilled manpower and experts in relevant diverse fields.

3.2.7 *Environmental Concerns in Decision Making*

As the word "environment" is used in its broader context to include all the aspects and components of the natural and social environment, therefore, while conducting environmental impacts analysis, all the relevant parameters must be included in the study. It attempts to foresee the consequences of a proposed action on weather, flora, fauna, soil erosion, human health, migration, employment and thus possible impacts on social and economic components of the proposed project.

According to Blanchard (1974), an Environmental Impact Statement (EIS) supports decision making process by serving three functions. First it is descriptive; containing information on the nature of proposal, the local conditions, likely impacts and possible alternatives. Secondly it leads to conclusions in light of available evidence. Thirdly it provides a set of information upon which decisions can be made. The selection of parameters and methodologies for study will be discussed below in chapter 4. Though there is a slight divergence among the authors about the desirable contents of the EIA, the common philosophy behind it is always the same, i.e., it is a guide to decision making.

The US Council on Environmental Quality (CEQ) established under the National Environmental Policy Act (NEPA) to administer the Act, have redrafted the contents of EIS (The document which assembles the information of EIA and summarises the results and recommendations of the study to decision makers) into eight components (Departments of the Environment and Transport, 1978). These are;

- i. Description of a proposed action.
- ii. Relationship between present and projected land-use.
- iii. Description of potential impacts.
- iv. Alternatives to a proposed action.
- v. Consideration of adverse impacts.
- vi. Relationship between long term and short term uses of the environment.
- vii. Irreversible and irretrievable commitment of resources.
- viii. Likely interactions with other Federal proposals.

The outline of an environmental impact assessment recommended by Hopkins, et al., (1973) emphasises the description of present conditions, alternative actions (including engineering options, design options, location options and current

action), description of probable adverse impacts and description of mitigating actions.

The essential steps in contents of EIA can be condensed, but the basic notion remains the same as discussed earlier as given by OECD (1979). According to OECD, EIA is comprised of the following five essential elements;

- i. Description of the project being assessed, in particular its characteristics with regard to emissions to the environment, etc;
- ii. Description of the environment into which the project is to be placed, including wider locational aspects;
- iii. Description and preferably quantified estimation of each separate impact of the project on the environment;
- iv. Consideration of alternatives, if available, including comparison of "with project" and "without project" future situation;
- v. Analysis of the environmental impacts leading to an overall assessment and recommendations.

According to Garner and O'Riordan (1982), EIA plays its ultimate role for economic development by describing the repercussions of proposals on bio-physical process, social processes and cultural norms; thus aiding decision making. Moreover, Turnbull (1983), in discussion of "The Role of EIA in Decision Making" has described its function as to generate and make available information on the environmental implications of a particular plan or development project. Studying solely the essential elements or contents of EIA, one can easily reach the conclusion that EIA is the only option left to protect the environment while achieving economic development by giving the basis for making a sound decision. The elements/contents discussed above are no less convincing but sought by Ahmad and Sammy (1985), in a more explicit and unique manner. Likewise the steps or contents of EIA recommended by them can be absolutely considered as a bridge between environmental experts and decision makers as given bellow;

- i) Preliminary activities including,
 - _identify decision maker(s)
 - _select a coordinator
 - _decide on work allocation

- _write description of proposed action
- _review existing legislation
- ii) Impact identification (scoping)
- iii) Baseline study
- iv) Impact evaluation (quantification)
- v) Mitigation measures
- vi) Assessment (comparison of alternatives)
- vii) Documentation
- viii) Decision making
- ix) Post auditing

3.2.8 *EIA as Decision Making Tool*

The contents of EIA, discussed above uphold the notion of using EIA as a complementary tool for sound decision making. Most of the authors have submitted substantial findings on the specific attributes of EIA — "Alternatives" and "Impact Valuations". The concept of exploring alternatives for a proposed development project is not current, but impacts-valuation is relatively a recent advance in the field of environmental assessment, and much development is needed in it yet. This is especially so for the impacts which do not have a direct market value. The subjectivity involved in valuating such impacts is intricate, but this problem can be resolved by the continuous practice of EIA for development projects.

3.2.8.1 *Concept of Alternatives*

The concept of exploring alternatives is a very desirable aspect of EIA; leading to investigate all possible means in the form of changing project site, modification in design or structure and changes in operational processes.

Consideration of alternatives has been directed by the US Council on Environmental Quality 1973, so as to investigate fully the range of alternatives rather than a justification for a decision which has already been taken. From the environment point of view, a project may either be abandoned altogether or considered the least detrimental alternative action (OECD, 1979). The practice of examining areas for possible alternatives should be at the very beginning of the planning process. Also this was the objective discovered in a study (Hill and Ortolano, 1978), where detailed

information relating to the range of alternatives including their formulation and evaluation was investigated in the planning process of the two agencies — "Corps of Engineers" and "Soil Conservation Service". In order to proceed to compare alternatives, two pieces of information on each project alternative are required (Ahmad and Sammy, 1985). These are;

- _a summary of positive and negative environmental impacts; and
- _a summary of economic cost and benefits

EIA has been used for examining a number of alternatives available for a proposed development project. Accordingly EIA not only provides for exploring a number of alternatives, but also provide techniques for selecting the best among them. EIA was used for the selection of the best sites from among alternatives sites for a Wolf Creek nuclear power station, Kansas (Ahmad, et al., 1979). The study had accommodated public reactions for selecting the best choice. A mini-environmental impact statement can also be drafted for each alternative and then relative importance can be assigned to each factor before decision making. This was used in a study for the nuclear power plant when eight factors were considered in six "mini-environmental impact statements" (Burnham, et al., 1975). Motayed (1980) has advocated this approach for investigating a large number of alternatives and feasible sites for power plants and also a "Weighting-Scaling" technique for the evaluation of alternatives, in order to eliminate the problems and complexities; arising due to subjectivity in the assessment.

A field test of Water Resources Assessment Methodology (WRAM) was conducted in the Tensas River Basin facing the flooding problem (Peterson, et al., 1979). Five alternatives plus a "no action" option were considered. An interdisciplinary team was formed representing expertise in ecology, economics, engineering and sociology/anthropology. Finally a summary table was made, listing each variable's weight and impact for each alternative. The use of the interdisciplinary team proved quite successful in the division of labour, giving a system of checks and balances and thus minimising duplication of effort. Sondheim (1978) has considered project alternatives and public participation one of the basic components of a methodology for environmental impact assessment.

According to Tambllyn and Cederborg (1975), the power plant procedures have undergone extensive change since the passage of the National Environmental Policy Act of USA in 1969. They have described environmental assessment matrix _a methodology for EIA, as an active tool in an ongoing nuclear power plant siting study. Yapijakas and Molof (1981) have presented a comprehensive methodology in EIA as a decision making method for evaluating alternatives for "multinational river basin development". They have described the method as a tool, not a panacea. In this study each government creates a coordinating group, a weighting panel, and a rating panel, each composed of specialists and experts. The coordinating team lists project alternatives and defines the factors in terms of their government's policies and chooses the rating and weighting panels. The weighting panel established a weighting scheme for each aspect, whereas the rating panel judge the alternatives in their own field of expertise. Final selection of the preferred alternative is done by one of two methods: (i) ranking the alternatives from all countries in a single matrix on an equal weight basis, or (ii) producing a single list from the combined project ratings obtained from each individual country.

3.2.8.2 Impacts Valuation

Impacts valuation is attracting the attention of all those involved in project appraisal. It provides a base for decision makers to proceed for decision avoiding environmental losses and so the consequent economic cost. Impact valuation has the fundamental approach of calculating all economic and environmental losses and gains; and so to convert them in pure economic terms to monetary values. One attraction to this approach lies in the fact that a large number of decision makers in developing countries are quite familiar with economic terms, whereas rather unfamiliar with environmental concepts; thus the decision makers are being addressed in a language which they understand (Ahmad and Sammy, 1985). After converting the environmental gains and losses into pure monetary values, the most widely adopted technique _"Cost Benefit Analysis" can be used for decision making (Wathern, 1988). Many of the attributes arising due to a particular project can be converted into economic cost and benefits _Monetary Values, but some of the attributes are "unquantifiable". The quantifiable gains like power generation, crop production due to irrigation, avoidance of flooding losses and fishery production; loss of land due to inundation and water logging & salinity etc are easy to be calculated.

But losses of cultural/archaeological heritage and scenic view are difficult to be calculated. Recently there have been some attempts by economists to put some monetary values to "unquantifiable environmental losses and gains". Pearce and Turner (1990) have submitted considerable findings for sound decision making; following the environmental valuation methodologies. They have given the basic rules for decision making as;

(i) proceed with the development if

$$(B_D - C_D - B_P) > 0$$

and

(ii) don't develop if

$$(B_D - C_D - B_P) < 0$$

Where B_D refers to the benefits of development, C_D refers to the costs of the development and B_P to the benefits of the development i.e., preserving the environment by not proceeding with the development in the area. Total Economic Values (TEV) is in fact a measure of B_P , the total value of the asset left as a natural environment. The authors have given the following formula for calculating total economic values:

$$TEV = \text{Actual Use Value} + \text{Option Value} + \text{Existence Value\#}$$

They have also given that:

$$\text{Option Value} = \text{Value in Use (by the individuals)} + \text{Value in Use by Future Individuals (descendants and future generation)} + \text{Value in Use by Others.}$$

3.2.8.2.1 Direct and Indirect Valuation

Direct Valuation

The Direct Valuation looks for measuring directly the money value of environmental gains _an improved scenic view and better levels of air or water quality, etc. This may be done by surrogate market or experimental techniques. The surrogate market attempts to value environmental costs or benefits from the actual market by correlating prices to environmental quality; where as the experimental techniques are based on simulating a market where the respondents express their

hypothetical valuation as real as possible. Direct approach has further been explained as:

(a) Hedonic Price Approach

(b) Contingent Valuation Method and

(c) Travel Cost Approach

(a) Hedonic Price Approach: The Hedonic Price Approach is based on the basis of utility, we derive from a particular asset. In this approach all the variables are taken into account and then relation of environmental variables (quality of air, low level of NO_x, SO_x and Noise etc and access to parks and beaches etc. Table # 6 given on next page shows the results of percentage fall in property value for a percentage increase in pollution.

(b) Contingent Valuation Method: The Contingent Valuation Method (CVM) attempts to make hypothetical value as real as possible. This approach is based on asking people for compensation of cost or cost for improvement. Data or information are collected through asking questions by Direct Questionnaire Technique or through survey. Respondents are asked for their Willingness To Pay (WTP) for an env-benefit i.e., improvement or Willingness To Accept (WTA) for an env-cost i.e., damage. Here personal valuations of the respondents for increases or decreases in the quality of some good are contingent upon a hypothetical market.

(c) Travel Cost Approach: The Travel Cost Approach (TCA) attempts to find out the cost, incurred on travelling for achieving utility from an environmentally improved area i.e., park or beach etc. Here importance is given to time, which can be used for earning some money. So therefore the actual cost is the sum of the cost incurred on travelling to that area, entrance charges plus the money forgone in time spent on visit. The visitors may also be asked for further willingness to pay if the facilities are improved further on the site. Facilities improvement includes improvement from boating to swimming and from swimming to fishing facilities. Accordingly the benefits can be estimated due to improvements in environmental quality.

Table # 6: Percentage fall in property value for a percentage increase in pollution

City	Year of: (a) property data (b) pollution measure	Pollution	Percentage fall in property value for a percentage increase in pollution
St Louis	(a) 1960	Sulphation	0.06-0.10
	(b) 1963	Particulates	0.12-0.14
Chicago	(a) 1964-67	Particulates	
	(b) 1964-67	and sulphation	0.20-0.50
Washington	(a) 1970	Particulates	0.05-0.12
	(b) 1967-68	Oxidants	0.01-0.02
Toronto-Hamilton	(a) 1961	Sulphation	0.06-0.12
	(b) 1961-67		
Philadelphia	(a) 1960	Sulphation	0.10
	(b) 1969	Particulates	0.12
Pittsburg	(a) 1970	Dustfall and sulphation	0.09-0.15
	(b) 1969		
Los Angeles	(a) 1977-78	Particulates	
	(b) 1977-78	and oxidants	0.22

Source: Pearce and Turner, 1990

3.3 EIA AND GHAZI BAROTHA HYDROPOWER PROJECT

The Ghazi Barotha Hydropower Project is a mega project aiming to supplement Pakistan's growing energy demands for domestic, industrial and other commercial uses. It is a major run-of-river hydropower project with 1450 MW power generation through a 52 Km long concrete canal (power channel) from Ghazi in NWFP province to Barotha village of district Attock in Punjab province (Pakistan Hydro Consultants, 1994). The project was conceived first, when WAPDA carried out a pre-feasibility study and published a report in 1987, asserting the project viable. However, the project required a more detailed study to ensure economic, technical and environmental reliability. Such study was initiated by Pakistan Hydro Consultants, Binnie and Partners Ltd UK, EWbank Preece Ltd UK and Harza Engineering International LP USA in Dec 1989. The study was conducted in two stages and was completed by mid of 1991.

Although, the main feasibility study took into account the environmental considerations of the project, however, the study apparently focused on the onsite impacts rather to study the entire river basin and study the potential effects of water diversion on the vast floodplains lying in three districts of Swabi and Haripur in NWFP and Attock in Punjab province (Pakistan Hydro Consultants, 1991). That was the time when Pakistan had no stringent law enforced to evaluate / vet the development projects for environmental friendliness and safeguard or otherwise. Perhaps, this was the reason that no formal study called Environmental Impact Assessment (EIA) was conducted to study the effects of Ghazi Barotha Hydropower Project on all the physical, ecological and other socio-economic aspects of the environment in the vast project area that is extending from Ghazi in NWFP to Barotha in Punjab.

The lack of proper Environmental Impact Assessment (EIA) study of the project failed the decision makers to study the project on economics, technical vis a vis environmental sustainability. The feasibility study superficially discussed the onsite impacts and submitted a too brief environmental assessment report giving the go ahead signal for implementation of the project. Thus the Government of Pakistan approved the PC 1 for Ghazi Barotha Hydropower project in June 1994 without conducting Environmental Impact Assessment of the project.

The most comprehensive law dealing with environmental safeguards in the development projects, was enacted in 1997 called "Pakistan Environmental Protection Act, 1997", which is still in vogue. The said Act requires for the Environmental Impact Assessment under section 12 and provides for major penalties for any violation / noncompliance in respect of Environmental Impact Assessment or Initial Environmental Examination for development projects. Under the Pakistan Environmental Protection Act, 1997, the Government of Pakistan has recently adopted special regulations for effective implementation of the provisions under section 12 of the Act concerning Environmental Impact Assessment / Initial Environmental Examination. These regulations are called "Review of Initial Environmental Examination and Environmental Impact Assessment Regulations 2000". Under these regulations all the development projects have been categorized into Schedule I Projects requiring IEE, Schedule II Projects requiring detailed EIA and Schedule III Projects not requiring any IEE or EIA (GoP, 2000¹).

After granting approval to the PC1 of the GBHP, the necessary preparatory works were started in mid 1995. The preparatory works mainly involved the acquisition of land, construction of the permanent colonies and a new access road to power complex site. The construction of the barrage and the power channel started in December 1995 and whereas of the power complex in February 1997. Impounding of the barrage started on 17th February 2003. The filling of the power channel began on the 9th April 2003 while the 500KV switchyard was energized on 30th April 2003. Unit # 1 testing and commissioning started with the first mechanical run on 13th May 2003. The trial generation started on 16th June 2003 enabling 50MW power generation. The entire project completed in may 2004.

Since the construction started in 1995, the project impacted both the natural and human environment of the area. To minimize the ill effects of the project and in case of unavoidable adverse impacts, WAPDA adopted "Resettlement Action Plan (RAP)" (Ghazi Barotha Hydro Power Project (GBHPP), 1994), which included the following key activities:

- I Construction of three resettlement villages for relocation of people losing housing units and associated buildings, with the provision of access roads, a water supply and sewerage system, electricity, a primary school each for boys and girls, a basic health centre, and a mosque;
- II Entitlements to receive cash and land compensation for persons losing privately owned land;
- III Cash compensation based on the market value of land and;
- IV Assistance for agricultural workers and tenant farmers whose livelihood was affected by the project.

On the basis of experience gained in badly handling the Project Affected Persons (PAPs) in the mega projects of Tarbela, Mangla and others, the donors of the project suggested the establishment of an independent non-government organization to facilitate the PAPs in an effective and transparent way. Agreeing to the proposal, WAPDA contacted the National Rural Support Program (NRSP) to establish the conceptualised Project NGO (PNGO). Eventually NRSP established the PNGO with the name of Ghazi Barotha Taraqiati Idara (GBTI) in October 1995, under section 42 of the Company's Ordinance 1894. Now the GBTI is

functioning as an autonomous company directed by its Chairman and Board of Directors, presently, consisting of seventeen members, which also include six members from the affected communities and one member from WAPDA in Ex-officio capacity. GBTI has operationalized its mandate / task through establishing various sectors in its organisation including Social Organisation Sector, Rural Credit and Enterprise Development (RC & ED), Physical Infrastructure and Technology Development (PITD), Human Resource Development (HRD), Natural Resource Management (NRM), Gender & Social Sector Services GSSS) and Monitoring Assessment and Planning (MAP) sector. The Resettlement Action Plan, nevertheless has presently attained due cover under the National Resettlement Policy 2002 (GoP, 2002¹).

3.4 GLOBAL OBLIGATIONS TOWARDS ENVIRONMENTAL SAFEGUARDS

Both the individuals and member states of the European Community (EC) have committed themselves to the integration of environmental protection requirements into their wider governmental policies (Wilson, 1993). Environmental impact assessment of certain major public and private development projects has been a requirement in EC countries since the implementation of the EC environmental impact assessment Directive 85/337 in 1988 (Commission of the European Communities, 1985). The environmental assessment of policies, plans and programmes, known as Strategic Environmental Assessment (SEA) is drawing considerable attention in the European Communities and elsewhere. According to Therival, et al., (1992), SEA can be defined as; "the formalised, systematic and comprehensive process of evaluating the environmental impact of a policy, plan, or programme and its alternatives, the preparation of a written report on the findings, and the use of the findings in the publicly-accountable decision making". A draft proposal prepared by the Directorate-General XI of the European Commission in 1991, has drawn attention to it in debates over the Maastricht Treaty and so the adoption of some form of SEA into decision making (Wilson, 1993).

Moreover, Wilson on discussion of the "Need for EIA" has described it a tool in decision making and a way to inform both the decision makers and the public. The Fifth Environmental Action Programme (1992-1997) – "Towards Sustainability", focuses on integrating environment into five main target sectors, namely

manufacturing industry, agriculture, transport, energy and tourism. It further states that member states should undertake similar integration by applying EIA to their own plans and programmes (Commission of the European Communities, 1992).

The same point has been focused in the Maastricht Treaty, Article 130r (2), which states that "Environmental protection requirements must be integrated into Community policies" (Council of the European Communities, Commission of the European Communities, 1992). The EC Environment Council has also agreed in a meeting in September, 1992 to look positively at the matter of attaching environmental statements to new legislative proposals in policy areas which are significant from the environment point of view (Department of the Environment, 1992). This was also recommended by the UK House of Lords Select Committee on European Community in its report on Fifth Environmental Action Programme (House of Lords Select Committee on the European Communities, 1992).

Therival, et al., (1992) have more emphasised for exploring alternatives to a specific development proposal which should not be after the project's form, scale and location are already irreversibly detailed; and the technical and financial feasibility studies completed.

3.4.1 EIA and Decision Making in Past

In spite of being a developing field, EIA has been used as a necessary tool in decision making process for many years; and most effectively after the adoption of National Environmental Policy Act (NEPA) in USA. Moreover, it has drawn adequate attention since the United Nations Stockholm Conference on "Human Environment" on 5th Jun, 1972 in Sweden. Consequently, most of the developed/industrialised nations have responded immediately towards EIA obligations, while in developing countries the progress towards it has been slow mainly due to lack of expertise in this field; lack of finances and lack of interest among the general public.

However, in these countries there has been a new interest in this long neglected field of EIA. Legislations have been enacted, institutions established and courses on environmental studies are being incorporated in curricula in educational institutions at different levels.

Since 1970, most agencies in the USA have been able to generate information on the consequences of major development projects/proposals. This was shown by a survey conducted by US Council on Environmental Quality (CEQ) to investigate the influence of NEPA legislation and EISs on government decisions (US Council on Environmental Quality, 1976). US Agency for International Aid (USAID) has adopted a policy, which is aimed to ensure the provisions of environmental implications in decision making process of the projects going to be funded by Agency in Less Developed Countries (LDCs). The Agency helps the developing countries to develop their own expertise as well in the field of environmental analysis (Prince, 1978).

Randolph and Ortolano (1976) have described how EIA has achieved two main benefits in the Carmel River Study in USA in the past. First it has improved interagency coordination and secondly it has developed the incorporation of mitigating measures for reducing the adverse environmental impacts.

Concern for environmental impact analysis in the United Kingdom arose after two inquiries were conducted; one for the third London airport and the second for the discovery of North Sea oil and gas. Since then a number of adhoc impact studies were prepared by environmental consultants for the Scottish Development Department and planning authorities in whose area the developments were proposed (Clark, et al., 1980). In response to growing concern about UK planning system's ability to deal with the environmental and social implications, the Scottish Development Department and the Department of the Welsh Office established the Project Appraisal for Development Control (PADC) research group in the department of Geography, University of Aberdeen in 1971. Under the European Community Act 1972, the United Kingdom has the obligations to respect EC environmental impact assessment Directive 85/337. The directive became operational in UK in 1988. Since then there have been a considerable number of EISs on major development projects.

In Canada, the ultimate decision of the cabinet led to the establishment of the Environmental Assessment Review Process (EARP) — "a body, authorised to appoint a separate panel for the appraisal of major development proposals". This panel is called the "Environmental assessment Panel" and has the function of reviewing the results of an assessment and providing recommendations to the appropriate Minister. So by March 1978, 24 Environmental assessment Panels had been appointed each

one considering a single major development proposal (Clark, et al., 1980). The ongoing process has led many provinces to follow the example of the Federal government and issued either cabinet directives or their own executive orders requiring the assessment of major provincial projects. In Australia some adhoc studies of the impacts were conducted by the Department of Environment and Conservation even before the Environmental Protection Act of 1974 (Cass, 1975).

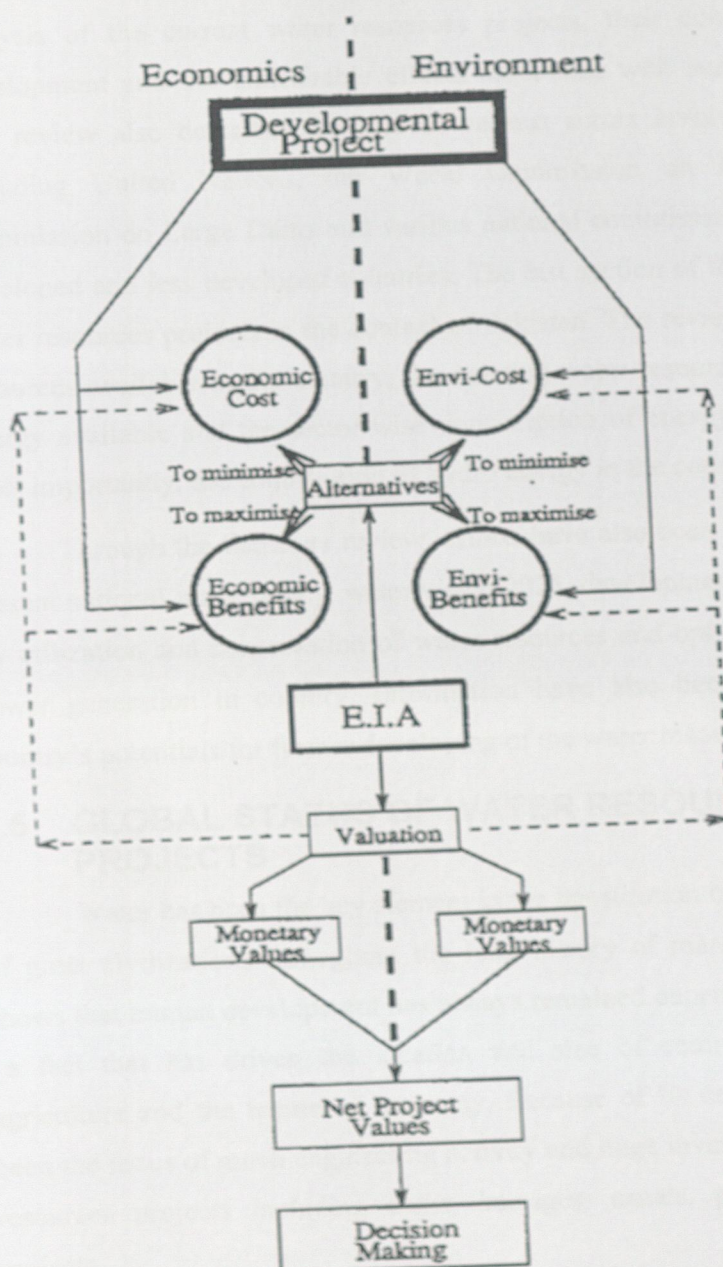
Moreover, some countries like New Zealand and Hong Kong have had EIA for major public sector projects without EIA, whereas Bangladesh, India, Pakistan, Srilanka, Indonesia and Singapore have the system of EIA on adhoc basis (Clark, et al., 1980).

In conclusion, the words are recorded that there has been a widespread interest in the world for adopting the procedures of environmental impact assessment over the last two three decades. Both the developed/industrialised and developing countries have realised the need for integrating environmental impact assessment into their planning and decision making process. The ongoing research and development in the field of EIA is contributing to its adoption and extensive application in the world. EIA is truly a valuable tool, assisting in the complex hierarchical system of decision making; particularly when there is a risk of association between a development project and environmental deterioration.

Moreover, it is safely argued that EIA attempts to evaluate both the likely adverse and beneficial impacts and to explore for possible alternatives. Thus it provides the net values of a development project and so leads to a sound decision making as shown in the figure # 3 in the next page. The figure shows that the process of EIA makes it possible to evaluate the economic and environmental cost and benefits, on the other hand explores the range of alternatives for a project/proposal. Eventually it provides the "net project values" of all the alternatives of a project/proposal to decision makers.

The current complexities in EIA would get resolved by resorting to its application in all different environmental conditions. Future research in the field of EIA is hoped to reduce its cost, minimise the time required for it and simplify the techniques and methods of EIA.

Figure # 3: The role of EIA in decision making process



Source: Developed by the Author

PART B: WATER RESOURCES PROJECTS

This part discusses the status of water resources projects at the global level vis a vis in the context of Pakistan. The literature review makes an in-depth analysis of the current water resources projects, their contribution to human development and the undesirable effects associated with such gigantic projects. The review also describes the role of various actors involved in water affairs including United Nations, the World Commission on Dams, International Commission on Large Dams and various national commissions from the selected developed and less developed countries. The last section of this part discusses the water resources projects in the context of Pakistan. The review explores the water resources available in the country, the existing water resources projects, the total energy available and the sector-wise consumption of energy in the country; and most importantly, the contribution of hydro energy in the country.

Through the literature review, efforts have also been made to elaborate the present national water policy, water vision 2025, development plans of the country for utilization and conservation of water resources and optimization of the hydro power generation in country. Information have also been provided about the country's potentials for further developing of the water resources in the near future.

3.5 GLOBAL STATUS OF WATER RESOURCES PROJECTS

Water has been the key element in the constitution or otherwise elimination of great civilizations throughout the long history of mankind on earth. History shows that human development has always remained dependent on adequate water _a fact that has driven the location and size of communities, the extent of agriculture and the nature of economy. Because of its centrality, water has also been the focus of much engineering activity and huge investments in various water resources projects including dams, barrages, canals, pipelines and irrigation projects.

To accomplish the enormous ambitions of attaining development and political influence in the world, human beings have invariably kept one significant regards in mind _safe access to safe water supplies. Today, even in the era of modern civilization, most of the disputes originate from the rights of proprietorship

over the usage of water varying from the use for the very survival to its use for multifaceted sustainable economic development. Such disputes and controversies have been arising not only at the regional and international level but also at the intra-national level in many states of the world. Pakistan is also a sorry witness to such disputes wherein the four provinces of the country have serious reservations to a number of water resources projects proposed for implementation in future.

Estimates of water scarcity calculated by the World Resources Institute in collaboration with the University of New Hampshire show that some 41 percent of the world's population, or 2.3 billion people, live in river basins under "water stress," meaning they are subject to frequent water shortages. Some 1.7 billion of these people live in "highly stressed" water basins where problems with local food production and economic development abound (Revenga, et al., 2000). At the global level, the food production must increase in the years ahead to accommodate population growth, which means the world's farmers will need more water for irrigation purposes. Global freshwater use tripled during the second half of the twentieth century as population more than doubled and as technological advances let farmers and other water users pump groundwater from greater depths and harness river water with more and larger dams. As global demand soars, pressures on the world's water resources are straining aquatic systems worldwide. Rivers are running dry, lakes are disappearing, and water tables are dropping. Nearly 70 percent of global water withdrawals from rivers, lakes, and aquifers are used for irrigation, while industry and households account for 20 and 10 percent, respectively (*earth-policy website*).

Today, many rivers in the world are running dry due to overuse of their water for different purposes including water diversion for irrigation and power generation. The details of such rivers in the world are shown in the table # 7.

Table # 7: Overview of the running dry

RIVER	SITUATION
Amu Darya	The Amu Darya is one of the two rivers that feed into the Aral Sea. Soaring demands on this river, largely to support irrigated agriculture, sometimes drain it dry before it reaches the sea. This, in combination with a reduced flow of the Syr Darya—the other river feeding into the sea—helps explain why the Aral Sea has shrunk by roughly 75 percent over the last 40 years and has split into two sections.
Colorado	All the water in the Colorado, the major river in southwestern United States, is allocated. As a result, this river, fed by the rainfall and snowmelt from the mountains of Colorado, now rarely makes it to the Gulf of California.
Fen	This river, which flows from the northern part of China's Shanxi province and empties into the Yellow river at the province's southern end, has essentially disappeared as water withdrawals upstream in the watershed have lowered the water table, drying up springs that once fed the river.
Ganges	The Gangetic basin is home to some 450 million people. Flowing through Bangladesh en route to the Bay of Bengal, the Ganges has little water left when it reaches the bay.
Indus	The Indus, originating in the Himalayas and flowing southwest to the Arabian Sea, feeds Pakistan's irrigated agriculture. It now barely reaches the ocean during much of the year. Pakistan, with a population of 161 million projected to reach 305 million by 2050, is facing trouble.
Nile	In Egypt, a country where it rarely ever rains, the Nile is vitally important. Already drastically reduced by the time it reaches the Mediterranean, it may go dry further upstream in the decades ahead if the populations of Sudan and Ethiopia double by 2050, as projected.
Yellow	The cradle of Chinese civilization, the Yellow River has frequently run dry before reaching the sea over the past three decades. In 1997, the lower reaches saw no flow for 226 days. While better management practices have enabled the river to reach its mouth year round during the past several years, flow levels are still extremely low during the dry season.

Source: Brown, L. R., (2005)

Furthermore, due to diversion of more water from the lakes and rivers, many lakes, some of which ancient by age, are shrinking and at the brink of disappearance. Some of the lakes confronting such threatening situations are given next in table # 8.

Table # 8: Overview of the disappearing lakes and shrinking seas

LAKE	SITUATION
Aral Sea (Kazakhstan and Uzbekistan)	Excessive diversion of the Amu Darya and Syr Darya, largely for irrigation, has shrunk the 5 million year old lake to about 25 percent of its 1960s size of 66,000 square kilometers. It now holds less than one fifth of its previous volume and has split into two sections. The larger South Aral Sea is unlikely to be restored, but the construction of a dam between the two sections, slated to be completed in September 2006, has already led to a rise in water level in the smaller North Aral Sea.
Lake Baikal (Russia)	Lake Baikal, the world's oldest and deepest lake, contains nearly one fifth of the worlds unfrozen freshwater. Over the past century the amount of soil flushed into the lake increased by two and half times due to regional agricultural and industrial development.
Lake Chad (Chad, Niger, Nigeria, and Cameroon)	Lake Chad has shrunk from 23,000 to 900 square kilometers over the past 40 years, a result of increased irrigation and decades of depressed rainfall. The Lake, which once covered part of Chad, Niger, Nigeria and Cameroon, is now contained entirely within Chad's borders.
Lake Chapala (Mexico)	Mexico's largest lake is the main water source for Guadalajara's 5 million people. Its long-term decline began in the late 1970s corresponding with expanded agricultural development in the Río Lerma watershed. Since then, the lake has lost more than 80 percent of its water. Between 1986 and 2001, Chapala shrank from 1,048 to 812 square kilometers and its level dropped by up to 4 meters.

Dal Lake (India)	Lake Dal has shrunk from 75 square kilometers in 1200 AD to 25 square kilometers in the 1980s, to smaller than 12 square kilometers today. Over the last decade the lake has dropped 2.4 meters in height. All the untreated sewage of Srinagar city and some 1,400 houseboats is deposited directly into the lake. Other lakes in the Kashmir Valley are facing similar problems.
Dead Sea (Jordan, Israel, and Palestine)	At 417 meters below sea level, the Dead Sea is the lowest place on earth, and is falling by up to 1 meter per year. The Sea has shrunk in length since the early 1900s, from over 75 to 55 kilometers long, and has split in two, with the southern basin turned into evaporation ponds for potash extraction. The salty lake could disappear entirely by 2050, along with the 90 species of birds, 25 species of reptiles and amphibians, 24 species of mammals, and 400 plant species that live on its shores.
Dojran Lake (Macedonia and Greece)	More than 50 islands have appeared in the middle of the lake as overuse has dropped the water level by up to 3.48 meters below the minimal water level established in a 1956 bilateral agreement between Greece and Macedonia. Now with an average depth of 1.5 meters, the lake is turning into a swamp to the detriment of local plants and animals, especially fish.
Sea of Galilee (Lake Tiberias) (Israel)	The Sea of Galilee is Israel's largest freshwater lake, with a total area of 170 square kilometers and a maximum depth of approximately 43 meters. At 209 meters below sea level, it is the lowest freshwater lake on Earth and is expected to drop even lower as the lake shrinks and becomes saltier due to excessive water withdrawals, drought, and evaporation.
Lake Manchar (Pakistan)	Diversion of the Indus River, largely for irrigation schemes, has deprived Manchar, Pakistan's largest lake, of fresh water. Salt content has increased dramatically in recent years and the polluted water fosters diseases previously absent from the region. The lake had been a source of fish for at least 1,000 years, but due to its deterioration some 60,000 fishers have left the area.

Lake Nakuru (Kenya)	The lake has shrunk in area since the 1970s from 48 to less than 37 square kilometers today. Nearby forests are being cleared for farmland to feed a fast growing population, causing soils to erode and wash into the lake. Failed urban sewage systems and unregulated industrial effluent have polluted the lake.
Owens Lake (United States, California)	This perennial lake in southeastern California held water continuously for at least 800,000 years, spanning 518 square kilometers at its peak, but since the mid-1920s, after a decade of diverting water from the Owens River to Los Angeles, the lake has been completely drained. The dry lake bed, which contains carcinogens including nickel, cadmium, and arsenic, became the single largest source of particulate matter pollution in the United States, elevating air pollution in surrounding areas to up to 25 times the acceptable level under national clean air standards. Since 1998, Los Angeles has tried to abate these toxic dust storms by shallowly flooding a portion of the lake, reclaiming saline soils, and cultivating fields of salt tolerant grass.
Tonle Sap (Cambodia)	Tonle Sap performs the important function of holding excess water during flood season, yet siltation from eroding farmland and deforested areas has reduced the lake's capacity and has destroyed aquatic habitat.

Source: Larsen, J., (2005)

(www.earth-policy.org/Indicators/Water/2006_data.htm#fig5)

Moreover, due to unsustainable exploitation of the groundwater resource, some countries are experiencing decrease in the groundwater reservoirs. The long term serious impacts on ground water resources are arising on account of excessive withdrawal / over-drafting or re-channeling rivers and natural streams to meet the growing water demands for domestic, irrigation and many other commercial uses including power generation. The situation as such in few of the countries is explained in the table # 9 given below.

Table # 9: Underground water depletion in key countries

COUNTRY	SITUATION
Mexico	In Mexico, where a third of all the water used comes from underground, aquifers are being depleted throughout the northern arid and semiarid regions. In a country where irrigated land is more than three times as productive as rain-fed land, the coming loss of irrigation water will be costly.
United States	Over-pumping is widespread, and the over-drafting of the vast Ogallala or High Plains aquifer—essentially a fossil aquifer that underlies eight states, from southern South Dakota to Texas—is a matter of national concern. Water levels have fallen, sometimes by as much as 30 meters, since irrigation began in the 1940s.
Spain	More than half of Spain's 99 aquifers are overexploited. In some of Spain's smaller aquifers water tables have fallen by 40-170 meters in the last two decades of the 20th century.
Saudi Arabia	When the Saudis turned to their large fossil aquifer for irrigation, wheat production climbed from 141,000 tons in 1980 to 4.1 million tons in 1992. But with rapid depletion of the aquifer, production dropped to 2.2 million tons in 2005. It is only a matter of time until irrigated wheat production ends.
Iran	The over-pumping of aquifers is estimated at 5 billion tons per year. When aquifers are depleted, Iran's grain harvest could drop by 5 million tons, or one third of the current harvest.
Yemen	This country of 22 million people is unique in that it has both one of the world's fastest-growing populations and the fastest-falling water tables. Under most of the country the water table is falling by 2 meters or more a year.
Israel	Both the coastal aquifer and the mountain aquifer it shares with Palestinians are being depleted. The continuous tightening of water supplies is likely to further raise tensions in the region.

India	Water tables are falling in most states in India as irrigation demands soar—there are now 12 million wells in western and southern India, compared with 100,000 in 1960. With thousands of wells going dry each year, India's farmers are finding it increasingly difficult to feed 16 million new Indians each year.
China	Water tables are falling throughout northern China, including under the North China Plain, which produces half of China's wheat and a third of its corn. China's harvest of wheat, grown mostly in the north, has fallen sharply in recent years as irrigation wells have dried up.

Source: Brown, L. R., (2005)

www.earth-policy.org/Indicators/Water/2006_data.htm#fig5

3.5.1 Events at the UN Level and Water Resources Conservation

The significance of water as the most precious resource on earth and the forthcoming complex situation arising due to injudicious and unsustainable exploitation of water resources forced the policy managers, state owned organizations, individual societies, NGOs and significantly the most reputed international organization, the United Nations (UN) to act aggressively for developing water management strategies at the regional, national and local levels, which promote both equitable access and adequate supplies use of water and thus help safeguard the water resource. Water is not only essential for life but is crucial for sustainable development, including the preservation of our natural environment, life supporting systems and the alleviation of poverty and hunger in the underdeveloped world.

3.5.2 Adoption of Agenda 21

The world leaders recognizing natural resources including water as indispensable for human health and well-being gathered at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, 3 to 14 June 1992 to devise an effective course of action for conservation of natural resources and ensure attaining a development that should be in harmony with the environment—a development referred to as sustainable development. After intensive deliberations, representatives of more than 178 governments adopted the Agenda 21, which is a comprehensive plan of action to be taken globally,

nationally and locally by organizations of the United Nations System, Governments, and Major Groups in every area in which human impacts on the environment (*un website*⁸).

3.5.3 Agenda 21 and Water Resources

The Agenda 21 is a huge document for action, which addresses the pressing problems of today confronting the natural resources and also aims at preparing the world for the challenges of the 21st century that has just begun. It is comprised of 4 main sections with many chapters in each. The section I is on "Social and Economic Dimensions" while section II is about the "Conservation and Management of Resources for Development". The Section III is on "Strengthening the Role of Major Groups" and Section IV on "Means of Implementation". The Chapter # 18 of section II is exclusively on the water resources under the heading "Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources" (*sidsnet website*).

The following 7 program areas have been proposed in the Agenda 21 for the freshwater sector:

- (A) Integrated water resources development and management;
- (B) Water resources assessment;
- (C) Protection of water resources, water quality and aquatic ecosystems;
- (D) Drinking-water supply and sanitation;
- (E) Water and sustainable urban development;
- (F) Water for sustainable food production and rural development;
- (G) Impacts of climate change on water resources.

Each program area has its own Objectives, Activities, Institutional Framework and Means of Implementation. Means of Implementation include finances proposed, technology required, human resources development and capacity building programs. The finances proposed for program area # A are \$ 115 million, \$ 355 million for program area # B, \$ 1 billion for program area # C, \$ 20 billion for

program area # D, \$ 20 billion for program area # E, \$ 13.2 billion for program area # F and \$ 100 million for program area # G given above (*un website*¹).

3.5.4 Millennium Summit

On 17 December 1998, the General Assembly adopted resolution # 53/202 by which it decided to convene the Millennium Summit of the United Nations as an integral part of the Millennium Assembly of the United Nations. The Summit held at United Nations Headquarters in New York on 6 to 8 September 2000 (*un website*²).

The Millennium Declaration was adopted in September 2000 by 189 world leaders who committed to "free all men, women and children from the abject and dehumanizing conditions of extreme poverty" by the year 2015. For that purpose, eight Millennium Development Goals (MDGs) have been drawn that cope with a variety of issues such as the promotion of education, maternity health care, gender equality, poverty reduction policies, child mortality, AIDS and other fatal diseases. These goals were set for the year 2015 with reference to the international situation prevalent in 1990 (*un website*³).

The Declaration contains numerous commitments to enhance the future of humanity in the new century. The United Nations Secretariat subsequently drafted the list of eight objectives, each with a set of targets and specific indicators. The first objective is to halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger and, by the same date, to halve the proportion of people who are unable to reach or to afford safe drinking water (*un website*⁴).

The full list of MDGs is:

- 1) Eradicate extreme poverty and hunger
- 2) Achieve universal primary education
- 3) Promote gender equality and empower women
- 4) Reduce child mortality
- 5) Improve maternal health
- 6) Combat HIV/AIDS, malaria and other diseases

- 7) Ensure environmental sustainability
- 8) Develop a global partnership for development

3.5.4.1 Millennium Development Goals and Water Resources

The Millennium Development Goal # 7 is directly related to the conservation of water resources *inter alia* commitment for enforcing Kyoto Protocol, implementation of Convention on Biological Diversity and Combat of Desertification and the conservation of all types of forests.

3.5.5 World Summit on Sustainable Development (WSSD)

The World Summit on Sustainable Development was held on 26 August - 4 September 2002 at Johannesburg, South Africa, which formulated a comprehensive plan to facilitate the implementation of Rio principles / implementation of Agenda 21 and United Nations Millennium Declaration. The plan in the UN circles is often called as Johannesburg Plan of Implementation (*un website*⁵).

The Johannesburg Plan of Implementation is aimed to further build on the achievements made since UNCED and expedite the realization of the remaining goals. To this end, the world leaders committed themselves to undertaking concrete actions and measures at all levels and to enhancing international cooperation. These efforts will also promote the integration of the three components of sustainable development — economic development, social development and environmental protection — as interdependent and mutually reinforcing pillars. Poverty eradication, changing unsustainable patterns of production and consumption, and protecting and managing the natural resource base of economic and social development are overarching objectives of, and essential requirements for, sustainable development.

3.5.5.1 The World Summit and Water Resources

At the World Summit in Johannesburg in 2002, two other goals were adopted: to aim (i) to develop integrated water resource management and water efficiency plans by 2005 and (ii) to halve, by 2015, the proportion of people who do not have access to basic sanitation. The Section IV of the plan "Protecting and Managing the Natural Resource Base of Economic and Social Development" is

particularly relating to the conservation plans for water resources, which include integrated water resources management and water efficiency plans, water pollution prevention, development and implementation of the national / regional strategies, plans and programmes with regard to integrated river basin and to improve water resource management and scientific understanding of the water cycle through cooperation in joint observation and research, and for this purpose to encourage and promote knowledge-sharing and provide capacity-building and the transfer of technology, as mutually agreed, including remote-sensing and satellite technologies, particularly to developing countries and countries with economies in transition (*un website*⁶).

3.5.6 UN International Decade for Action, "Water for Life"

The United Nations General Assembly in its 58th session in December, 2003 adopted a draft resolution, without a vote (A/RES/58/217), proclaiming 2005 to 2015 as the International Decade for Action – Water for Life (United Nations, 2003). United Nations (UN), 2003, Second Committee recommends proclamation of International Decade on "Water for Life, 2005-2015", Press release GA / EF / 3068 dated 9 December 2003, New York.). This resolution was adopted to achieve internationally agreed upon water-related goals contained in Agenda 21 of 1992, the United Nations Millennium Development Goals of 2000 and the Johannesburg Plan of Implementation of the World Summit on Sustainable Development, 2002 and hence to reduce by half the proportion of people without access to safe drinking water by 2015 and to stop unsustainable exploitation of water resources (*unesco website*).

The UN member states observed the World Water Day on 22 March, 2005 to mark the commencement of period from 2005 to 2015 as the International Decade for Action, "Water for Life" (*worldwaterday website*¹).

Among the themes that are central for the 'Water for Life' Decade are: scarcity, access to sanitation and health, water and gender, capacity-building, financing, valuation, Integrated Water Resources Management, trans-boundary water issues, environment and biodiversity, disaster prevention, food and agriculture, pollution and energy. UN-Water is coordinating the 'Water for Life' Decade, 2005-2015. UN-Water is the United Nations inter-agency mechanism of

all relevant agencies, departments and programs involved with water-related issues.

The "Water for Life" Decade was launched on 22nd March 2005 by the United Nations Secretary-General Kofi Annan with the following video message:

"Water is essential for life. Yet many millions of people around the world face water shortages. Many millions of children die every year from water-borne diseases. And drought regularly afflicts some of the world's poorest countries. The world needs to respond much better. We need to increase water efficiency, especially in agriculture. We need to free women and girls from the daily chore of hauling water, often over great distances. We must involve them in decision-making on water management. We need to make sanitation a priority. This is where progress is lagging most. And we must show that water resources need not be a source of conflict. Instead, they can be a catalyst for cooperation. Significant gains have been made. But a major effort is still required. That is why this year marks the beginning of the "Water for Life" Decade. Our goal is to meet the internationally agreed targets for water and sanitation by 2015, and to build the foundation for further progress in the years beyond.

This is an urgent matter of human development, and human dignity. Together, we can provide safe, clean water to all the world's people. The world's water resources are our lifeline for survival, and for sustainable development in the 21st century. Together, we must manage them better" (un website⁷).

This is the second time that water issues have been highlighted as part of UN Decade. The UN declared 1981-1990 as the "International Drinking Water Supply and Sanitation Decade" with the aim of providing safe drinking water and adequate sanitation systems for all people by 1991. The official start of the 'Water for Life' Decade will be on World Water Day, 22 March 2005, and will coincide with the International Decade of Education for Sustainable Development, which is also set for 2005-2015 (Global Development Research Center (gdrc website).

3.5.7 Water Resources and Energy Generation

Hydropower uses the power of flowing water, without wasting or depleting it in the production of energy; therefore, all hydropower projects – small or large,

run-of-river or storage – meet the definition of renewable. Hydropower supports the development of other renewable sources (*canhydropower website*¹).

The Hydropower extracted from moving water, is essentially another way of trapping the sun's energy since it is the sun which drives the flow of water on the planet – the so called hydrologic cycle.

The main water reservoirs are of course the oceans and it is the sun's energy that warms the ocean water. The degree of warming varies from location to location on the earth's surface. The warmer the water, the greater the degree of evaporation and the higher the concentration of water vapor in the atmosphere. This process has an enormous effect on the earth's climate and for example it is the main driving force behind hurricanes. As the water vapor laden air rises, it cools, the water condenses and clouds form. The clouds are blown onshore and over land. If conditions are right, perhaps as the air mass rises over a mountain range, the clouds cool sufficiently for the condensed water to reach the point where rain or even snow is formed. This precipitation eventually makes its way back downhill to the ocean. On its way, some of it replenishes natural underground reservoirs, irrigates agricultural lands, and some of it while flowing on the earth' sloppy terrain is used to produce power. More than 2000 years ago, the Greeks used falling water to power grinding wheels and in the 1700's it was used extensively in the industrial revolution to power mills and pumps. Nowadays, power is normally produced by using falling water to power electrical turbines. Since the availability of water is ultimately dependent on precipitation, water is normally stored behind dams to better control the availability of electricity (*greenjobs website, greenandwhite website*).

Among the renewable sources, water is the second greatest source of electricity production and hydroelectric plants operate where suitable waterways are available. In the developed world at least, many of the best of these sites have already been developed. Generating electricity using water has several advantages. The major advantage is that water is a source of cheap power and requires no imported fuel. In addition, because there is no fuel combustion, there is little air pollution in comparison with fossil fuel plants and limited thermal pollution compared with nuclear plants. However the building of dams, floods land, reduces the river's flow downstream, which affects the habitats of the local plant, fish, and

animal life, and is one reason this form of renewable power has so many opponents. Thus, like other energy sources, the use of water for generation has limitations, including environmental impacts.

3.5.8 Historical Growth of Hydropower

The generation of hydroelectric power increased by 366 billion kilowatt hours between 1992 and 2001, or at an average annual rate of 1.7 percent (*ieahydro website*). Canada, Brazil, China, the United States, and Russia, were the five largest producers of hydroelectric power in 2001. Their combined hydroelectric power generation accounted for 48 percent of the world total. Canada led the world with 328 billion kilowatthours or 3.4 quadrillion Btu, Brazil ranked second with 266 billion kilowatthours or 2.8 quadrillion Btu and China was third with 263 billion kilowatthours or 2.7 quadrillion Btu. The United States was fourth with 209 billion kilowatthours or 2.1 quadrillion Btu, followed by Russia with 174 billion kilowatthours or 1.8 quadrillion Btu.

3.5.9 Status of Hydropower

Although, hydropower currently provides about one fifth of the world's electricity supply, development of the world's remaining technical potential could, by no means, cover the growth in future demand (WEC, 2005). However, carefully planned hydropower development can, and does, make a great contribution to improving electrical system reliability and stability throughout the world. Also, future development will play an important role in the improvement of living standards in the developing world, where the greatest hydropower potential still exists.

According to WEC, 2005, this development, together with the existing installed hydropower capacity (some 700 GW), will make a substantial contribution to the avoidance of greenhouse gas emissions and the related climate change issues. Hydroelectricity, at present the most important of the clean, economically feasible, renewable energy options, can be a major benefit of a water resources development project; however, it is seldom the only benefit (WEC, 1994). Hydropower stations integrated within multipurpose schemes generally subsidize other vital functions of a project, such as irrigation, water supply, improved navigation, flood mitigation, recreational facilities, and so on. It is clear,

therefore, that hydropower has an important role to play in the future, both in terms of energy supply and water resources development. As with all options, there is a need to develop the resources according to the highest social, environmental, economic and technical standards.

3.5.10 The Inevitable Increase in Energy Consumption

It is easy to predict that world energy demand, and especially that for electricity, will increase greatly during this 21st century, not only because of demographic pressures, but also through an improvement in living standards in the less developed countries, which will represent 7 billion inhabitants in 2050 (78% of the total). Consumption of primary energy will increase up to threefold by the middle of this century, and the increase will be even greater for electricity. In view of this situation, many sources of energy will be necessary, but for environmental reasons, a high priority should be the development of all technically feasible potential from clean renewable sources, especially hydropower (WEC, 1994 and 2005).

3.5.11 The Future Hydropower Generation

The general consensus appears to be that hydropower will not grow as rapidly as other renewable energy sources because of the concerns over its environmental impacts. The US DOE (2004) projects no growth in hydroelectric power generation within the USA, but rather a steady state at 309,000 GWh compared to its peak of 354 GWh in 1997 and 308 GWh in 2003.

However, more than 60 % of the increase in world primary energy demand, between 2000 and 2030, will come from developing countries especially in Asia. More than a quarter of the world's population has no access to electricity and, although the number of people without power supplies will fall in the coming decades, a projected 1.4 billion people will still be without electricity in 2030 (IEA 2000). To extend electricity supplies to the energy poor and give them better access to other forms of modern energy, stronger government policies and coordinated international action will be essential. Renewable energy will play a growing role in the world's primary energy mix. Hydropower has long been a major source of electricity production. Its share in global primary energy will hold steady, but its share of electricity generation will fall.

This has to be set in the context however of a rapidly growing energy demand, so losing ground does not necessarily means standing still. A study by the Utility Data Institute, USA, predicts that a world total of 695 GW of new electricity capacity will come on line in the next ten years from all sources, 22 per cent of which will be hydropower. The world's total technical feasible hydro potential is estimated at 14,000 TWh/year, of which about 8000 TWh/year is currently considered economically feasible for development. About 700 GW (or about 2600 TWh/year) is already in operation, with a further 108 GW under construction. Most of the remaining potential is in Africa, Asia and Latin America. A number of countries, such as China India, Iran and Turkey, are undertaking large-scale hydro development programs, and there are projects under construction in about 80 countries. According to the recent world surveys, conducted for the Hydropower & Dams World Atlas & Industry Guide, a number of countries see hydropower as the key to their future economic development: Examples are Sudan, Rwanda, Mali, Benin, Ghana, Liberia, Guinea, Myanmar, Bhutan, Cambodia, Armenia, Kyrgyzstan, Cuba, Costa Rica, and Guyana.

3.5.12 Sources Vs Consumption of Commercial Energy in Asia

The consumption of energy in Pakistan is highest than Nepal, Bangladesh and Sri Lanka. However, it is far less than some of the East Asian countries like China and South Korea. The tables given below help compare consumption of energy and the various sources of energy in South Asia, East Asia and South East Asian countries.

Table # 10: Per capita commercial energy consumption of the key Asian countries in 2006

Per Capita Energy Consumption (million Btu/person)		Percentage of the World Average
South Asia		
Bangladesh	5.0	6.96
India	15.9	21.94
Nepal	2.4	3.3
Pakistan	14.2	19.6
Sri Lanka	10.5	14.55
S. East Asia		
Thailand	57.9	79.89
Indonesia	17.9	24.70
Malaysia	104.8	144.68
Philippines	14.2	19.61
Vietnam	16.6	22.95
East Asia		
Japan	178.7	246.66
China	56.2	77.53
Korea		
North	41.1	56.66
South	193.4	266.9
World Average	72.4	---

Source: eia website¹

Table # 11: Commercial energy consumption in South Asia as in the year 2006

Total Consumption (Quadrillion Btu)		Petroleum (%)	Coal (%)	Hydro-electric (%)	Nuclear (%)	Natural Gas (%)	Others (%)
Bangladesh	0.74	29.02	2.48	1.86	0.00	67.45	0.00
India	17.67	34.28	51.89	5.00	1.41	7.05	0.31
Nepal	0.06	51.67	14.25	37.81	0.00	0.00	0.00
Pakistan	2.29	38.22	5.56	14.00	1.01	21.99	0.00
Sri Lanka	0.21	84.21	0.02	15.85	0.00	0.00	0.02
World Total	472.274	--	--	--	--	--	--

Source: eia website²

* all % contribution is of the year 2003.

1 Quadrillion = 10^{15} Btu

Table# 12: Commercial energy consumption in East Asia in 2006

Total Commercial Energy Consumption (Quadrillion Btu)		Petroleum	Coal	Hydroelectric	Nuclear	Natural Gas
		(%)	(%)	(%)	(%)	(%)
Japan	22.786	--	--	--	--	--
China	73.80	25.02	64.78	6.27	0.93	3.02
Korea	North	0.94	6.16	81.79	12.26	0.00
	South	9.44	52.00	22.00	0.57	14.34
World Total	472.274	--	--	--	--	--

Source: eia website³

Table # 13: Commercial energy consumption in South East Asia in 2006

Total Commercial Energy Consumption (Quadrillion Btu)		Petroleum	Coal	Hydroelectric	Nuclear	Natural Gas	Others
		(%)	(%)	(%)	(%)	(%)	(%)
Thailand	3.741	52.94	11.59	2.37	0.00	32.34	0.83
Indonesia	4.149	50.73	16.28	1.82	0.00	28.40	2.78
Malaysia	2.557	44.54	7.04	2.59	0.00	45.81	0.00
Philippines	1.271	55.03	16.60	6.23	0.00	6.39	15.81
Vietnam	0.98	46.04	22.34	21.63	0.00	10.15	0.00

Source: eia website⁴

It can be seen that all these countries are heavily reliant on petroleum products, coal and natural gas in their total commercial energy consumption.

The electricity generation in the South and East Asian region in 2002 was to the tune of 3,600 Bkwh, of which around 663 Bkwh was generated in South Asia. In South-east Asia, about 397 billion kwh of electricity was generated. A major proportion of the electricity generation was from conventional thermal power plants (eia website⁵).

3. 5.13 Characteristics of Hydropower

The most important characteristics of hydropower can be summarized as follows:

Its resources are widely spread around the world. Potential exists in about 150 countries, and approximately two-thirds of the economically feasible potential remains to be developed. This is mostly in developing countries, where the capacity is most urgently required;

It is a proven and well advanced technology, with more than a century of experience. Modern power plants provide extremely efficient energy conversion; It plays a major role in reducing greenhouse gas emissions in terms of avoided generation by fossil fuels. Hydro is a relatively small source of atmospheric emissions compared with fossil-fired generating options;

The production of peak load energy from hydropower allows for the best use to be made of base load power from other less flexible electricity sources. Its fast response time can add substantially to the reliability and quality of the electrical system;

It has the lowest operating costs and longest plant life, compared with other large-scale generating options. Once the initial investment has been made in the necessary civil works, the plant life can be extended economically by relatively cheap maintenance and periodic replacement of the electromechanical equipment;

As hydro plants are often integrated within multipurpose developments, the projects can help to meet other fundamental human needs (for example, irrigation for food supply, domestic and industrial water supply, flood protection). The reservoir water may also be used for other functions such as fisheries, discharge regulation downstream for navigation improvements, and recreation. Hydropower plants can help to finance these multipurpose benefits, as well as some environmental improvements in the area, such as the creation of wildlife habitats;

The 'fuel' (water) is renewable, and is not subject to fluctuations in market conditions. Hydro can also represent energy independence for many countries.

3.5.14 Hydro Potential Vs Generation _A Regional Overview

According to some careful estimates, the hydropower provides about 19% (2 650 TWh/yr) of the world's electricity supply. Information received from WEC Member Committees, supplemented by data published by *The International Journal on Hydropower & Dams*, indicates that the world's total technically feasible hydro potential is about 14 400 TWh/yr, of which just over 8 000 TWh/yr is currently considered to be economically feasible for development. Installed hydro-electric generating capacity is some 692 GW, with a further 110 GW under construction as shown in the figure 19 on next page (WEC, 2005).

The remaining economically exploitable potential is about 5 400 TWh/yr: assuming the same average annual utilization as for the totality of existing hydro power plants, the exploitation of this potential would entail the construction of some 1 400 GW of hydro capacity (twice the present installed capacity). According to ICOLD (1999), less than 20% of the world's estimated feasible hydropower potential has been developed. The greatest amount of potentials remains to be developed in Asia, South America and Africa.

3.5.15 Benefits Vs Environmental Challenges of Hydropower

The challenge to generate more power through fossil fuels combustion involves huge risks in environmental terms. The result would be more emissions and unanticipated climatic change, which is likely to bring catastrophic social and economic impacts. More research is being conducted at the international level to secure accuracy and standardization in the measuring techniques of carbon budget at the river basin level (Rosa, 2001).

The availability of energy is essential for the socio-economic development of a nation. It is advantageous to use energy that is clean, efficient, dependable and renewable. However, while assessing the adverse impacts, the beneficial impacts must also be identified and properly evaluated, particularly their significant role in the economic uplift of the Less Developed Countries (LDCs). The United Nations (1977) and UNEP (1982) have emphasized both the harmful and beneficial impacts associated with these projects. Many authors have asserted that the environmental stress in developing countries always arise due to underdevelopment and the construction of dams and reservoirs plays significant role in increasing food

production, power generation, flood control and employment opportunities. The WCD (2000) also acknowledges the benefits of large dams and asserts as *"Dams have made an important and significant contribution to human development, and the benefits derived from them have been considerable"*

Hydropower meets all of these requirements. In countries, where a vast amount of development still lies ahead, good conditions often exist for renewable energy sources. The technically most advanced and economical source of renewable energy is Hydropower (ICOLD, 1999).

The development of hydropower could contribute significantly towards reduction in the GHG emissions and it may be up to 13% (by avoided fossil fuel-based generation) if about half of the exploitable hydropower is tapped. The reduction in burning of fossil fuels will have impact on decrease in emissions of sulphur dioxide (the main cause of acid rain) and nitrous oxide. Hydropower generation also help avoids the substantial impact of particulate emissions (fly-ash, for example) and the resulting costs to human health in the form of respiratory impairment (Oud, 1999).

Avoided emissions

There is international consensus that greenhouse gas (GHG) emissions will lead to major climatic changes, and will therefore have consequences on the hydrological system (and thus on water supply and agriculture) as well as on the sea level. Measures accommodating such changes will need to be taken into account when planning the utilization of the hydropower resource.

Social Aspects

As multipurpose hydropower projects are larger in extent with greater magnitude of impacts, these usually bring unacceptable impacts on the community at and around the project. Of all the displacement of population is the serious impacts which need due consideration in the early planning phase of the project. The changes in the land use, usually, bring further secondary and other high order impacts. Studies have shown that these projects have resulted into significant direct Vs indirect and short-term Vs long-term adverse environmental and social impacts in various parts of the world. Monosowski (1990) has pointed out many adverse environmental impacts associated with the Tucurui Dam in Brazil. The most severe

of them are the displacement of 3350 families, increase of salinity in the estuarine zone and anaerobic decomposition in the deep impoundment areas causing foul smell due to H_2S . According to an estimate, more than 500,000 people have been displaced during the period 1965-1985 just by the Dams funded by the World Bank (Monosowski, 1985). According to WCD (2000), about 40-80 million people have been displaced by reservoirs.

The social impacts associated with the reservoirs / dams project vary from project to project and in many cases are site specific. However, the studies have shown that such impacts if predicted well advance and carefully quantified in the planning stage of a project, the negative impacts can be mitigated to an acceptable level or even in some cases avoided altogether.

Studies have confirmed that beneficial impacts include substantial infrastructure and community services development. It is increasingly common for an effective public participation program to be implemented from the early stages of a project. When the project is considered as an opportunity for the community, the people affected will be able to enjoy a higher standard of living through associated infrastructural developments such as the provision of water and sanitation services. Sincere and concerted efforts are being made to demonstrate this aspect. Recent examples include projects in Laos, Uganda, India, China, Japan and Brazil (*worldenergy website*). Thus, apart from the adverse alteration in the life supporting ecosystems, mainly due to submergence, the inequitable distribution of resources and incomes from dams, disparities in the rehabilitation needs to be carefully regulated.

Derban (1984) in a study of Health Impacts of Kpong Dam in Ghana has pointed the main problems of "resettlement issue" and bilharzia.

Environmental Changes

The environmental impacts associated with reservoirs / dams projects vary from project to project and depend mainly on the site of the project rather on the size of the project. The environmental impacts are dependent on resources present at the site. Based on the site, the impacts usually arise on the (1) Physical Resources, (2) Ecological Resources, (3) Human Use Values and (4) Quality of Life Values (Ali, 1993). Derban (1984) has evaluated the impacts arising due to

resettlement, alteration in the ecosystem and different water born diseases. Khan, (1967) in a study on Mangla Dam in Pakistan reveals the environmental and socio-economic facts about the dam. The dam constructed on the Jehlum river has submerged 70,000 acres land including the 400 years old district town of Mirpur. The most serious human problem arising to the dam was the displacement of 82,000 persons. The dam's positive impacts include power generation to the capacity of 1000 MW, establishment of new industries due to availability of power, facilities for sports and recreation and beautiful natural surroundings.

Tariq (1993) in a study on the environmental impacts of Tarbela Dam in Pakistan has identified the major beneficial impacts of power generation, irrigation provisions, flood control and ground water recharge along the periphery of the reservoir and downstream where previously the water table was too deep. As a result of the recharge factor, those areas once lying barren have got its ground water reservoir recharged and the lands have become lush green and productive. However, due to recharging of the ground water, the project has caused water logging and salinity in some closed areas of the project, which are devoid of adequate drainage system. The project, by dislocating about 96,000 persons has caused the resettlement issue of greater magnitude and highest significance. Whereas, the minor environmental impacts have been shown on wildlife, navigation, climate, forests and fisheries.

On account of these severe impacts associated with mega reservoirs, the World Commission on Dams was established in IUCN-World Bank sponsored workshop in Switzerland in April, 1997. The Commission started its work in May 1998 and examined around 1000 dams with varying degrees of intensity and a comprehensive global survey of 125 dams all over the world (WCD, 2000). The Commission identified many significant environmental and social impacts and advocated the "The way Forward" to ensure that Development is based on five objectives: equity in resource allocation and in the spread of benefits; sustainability in the use of the world's diminishing resource-base; openness and participation in decision-making processes; efficiency in the management of existing infrastructural developments; and accountability towards present and future generations.

Although, the hydropower reservoirs in majority of the cases, have served the community's purposes in respect of power, water supply, irrigation, fisheries, flood control and many other purposes, such huge gigantic projects have never been without environmental challenges. As, today, expertise exists to devise an effective Environmental Management Plan (EMP) to offset the unfavorable changes associated with these projects and to bring the intensity of the adverse impacts to an acceptable level. Studies have also shown that scientific methods are available to make predictions with fair precision for changes which, may arise in terms of sedimentation, fauna, flora and water quality etc. Some authors are of the opinion that huge hydropower projects planned with due considerations to environment can not only minimize the adverse impacts but have even turned them into social and / or environmental benefits / advantages (Oud, 1999).

The World Bank' Water Resources Management Policy Paper (WRMPP) seeks to ensure the broad global consensus that was forged during the Rio Earth Summit in 1992. The consensus was on three fundamental principles (a) Ecological Principle that is to consider the whole river basin as unit of analysis with greater attention to environment (b) Institutional Principle that is to involve all stakeholders including the state, private partner(s) and civil society and the (c) Instrument Principle for efficient and wise use of the scarce resource of water (World Bank, 1993).

All modern hydropower projects include undertaking a comprehensive environmental impact assessment at the early stages of investigation. Environmental management programs ensure that mitigation and enhancement measures continue throughout the operating life of the project.

Small Versus Large

Conventionally, a distinction is drawn between small and large hydro plants but it is impossible for many governments and other authorities to keep national records on very small (often privately-owned) schemes. There is a growing misconception relating to renewable technology and 'green' energy, whereby small projects are perceived as having lower impacts (*worldenergy website*¹).

Recent legislation has differentiated between projects with capacities above or below 10 MW, favoring smaller projects. There is no scientific or technical

justification for this, and it may lead to greater environmental impacts. Research has been conducted on this subject by a number of organizations, including the World Bank, and a paper was recently presented by a member of the IHA Environment Committee (Egré, et al., 1999) pointing out that valid comparisons compare impacts per unit of output. The impacts of a single large project and its distribution system should be compared with the cumulative impacts of several small projects yielding the same power output and level of service. Appleyard (2004) has advocated for the mini-hydro power generation in the Kerala state of Southern India instead of large hydro schemes, which are environmentally sensitive and politically unfeasible. However, research has shown that the most fundamental influences on the total costs and benefits of hydropower projects are the site-specific conditions, and not the scale of the project.

Economic Aspects

From the point of view of economics, it is clear that hydropower requires a substantial initial investment cost, which can be a deterrent to potential developers. However, this should always be balanced against the long life and low operating costs of hydro plants, and the fact that there is no consumption of fuel for energy production. Globally, in comparison with other plants, and considering the quality of the energy produced, the balance shows a clear advantage for hydropower. The World Bank, therefore, has formulated an ambitious policy to fund dams and reservoirs projects in order to alleviate poverty and improve the living standards of the deprived communities. According to World Bank, (2004), the Bank has adopted its mission to poverty reduction through broad-based water resources interventions such as dams and inter-basin transfers.

For some years, the idea has been developing to take into consideration the external benefits and costs. On the basis of the full costs throughout the lifetime of the various electricity generation options, hydropower (if available) appears to have the greatest advantage. Some valuable information obtained about the generating cost of hydel energy in Pakistan shows that it is the lowest among all the options available. However, it is more prone to variations due to seasonal, peak vs. average and other effects. Therefore, there is a higher tendency of cost fluctuation in hydel energy compared to thermal or nuclear energy. The average cost in the year 2000-01 of hydel energy generation in Pakistan was 19.95 paisas

per kilowatt-hour. (Hydrocarbon Development Institute of Pakistan, 2002). The detailed picture of the generating cost per unit in Pakistan can be seen in table given next.

Table # 14: Hydropower generating cost per unit in Pakistan

Energy Data of Hydel Power Stations				
Power Station	Installed Generation Capacity MW	Units Generated GWh	Overall Cost of Generation Ps /KWh	Utilization Factor %
Tarbela	3,478.0	12,826.5	21.73	41.98
Mangla	1,000.0	2,800.0	12.01	31.88
Warsak	240	917.52	24.15	43.52
Chashma	187	254.34		
Malakand	19.6	111.38	16.73	64.69
Dargai	20	133.42	6.71	75.95
Rasul	22	32.8	36.91	16.97
Shadial	13.5	42.67	22.12	35.98
Chichold Malian	13.2	22.88	40.71	19.73
Nandipur	13.8	33.66	35.95	27.77
Kumam Garhi	4	11	58	31.31
Renala	1.1	3.61	99.39	37.37
Chitral	1	4.61	101.39	52.44
Total	5,013.2	17,194.4	19.95	

Source: Pakistan Water Gateway (waterinfo website³)

The Utilization Factor indicates the amount of energy utilized against the total available energy. This can also be interpreted by the energy consumed versus installed capacity. The Utilization Factor of hydel energy is usually lower compared to thermal or nuclear energy. This is because hydel capacity/ potential is dependent on the water head in the reservoir and can not be influenced.

3.5.16 Overview of Dams / Hydro Power Generation in Few Selected Countries

Water resources projects are being developed through the world for multiple uses. The large reservoir projects serve many purposes including the cheap power generation, irrigation needs, flood control and other associated uses like fishery, navigation and scenic view for tourists' attraction. Although, there are pro and anti schools of thought and many international organizations have been advocating their view point about the big reservoirs / dams projects. However, a careful review shows that water resources projects have been developed both in the developed and less developed countries. According to the International Commission on Large Dams (ICOLD), a large dam is 15 m or more high (from the

foundation). If dams are between 5-15 metres and have a reservoir volume of more than 3 million cubic meters, they are also classified as large dams. Using this definition, there are more than 45 000 large dams around the world (*icold website*).

The tool of EIA has made it possible with fair certainty to identify the ill effects associated with such projects. The EIA not only help identify the adverse impacts but also provide a comprehensive plan for the mitigation of undesirable effects. Furthermore, the World Bank, World Commission on Dams (WCD) and many other national and international organizations have developed effective guidelines for unbiased predictions making and strategies for public participation during EIA, report writing and project appraisal.

Keeping in view the significance of the dams / reservoirs in the socio-economic uplift of the countries, thousands of large reservoirs / dams projects have been built in the developed and less developed countries. According to World Commission on Dams (WCD) (2000), at least 45 000 large dams have been built as a response to meet an energy or water need. Today nearly half of the world's rivers have at least one large dam.

As we have started the new century, one-third of the countries in the world rely on hydropower for more than half their electricity supply, and large dams generate 19% of electricity overall. Half the world's large dams were built exclusively or primarily for irrigation, and some 30-40% of the 271 million hectares irrigated worldwide rely on dams.

To give a brief account of the installed dams projects / hydro power generation, few countries from the developed and less developed countries are presented below as the case studies.

United States

The United States Society on Dams (USSD) Committee on Register of Dams is responsible for maintaining current information on United States dams, hydropower projects and reservoirs, and cooperates with the ICOLD Committee on the World Register of Dams. According to Murray (2000), out of 39000 large dams (which according to ICOLD, are about 45000), 5500 large dams are in United States alone. Summary tables showing dams / reservoirs information for the United

States have been provided by the USSD committee (USSD Register of Dams, 2004 (*ussdams website*)).

Britain

Dams in Britain have been categorized into (i) Embankment dams, (ii) Gravity dams, (iii) Buttress dams and (iv) Arch dams. The main type of dam in Britain is the embankment dam, and there are over 3000 of them. Some of them date back to the 9th Century, including Fishers Pond Dam, near Winchester, which was built by monks to provide fish. The average age of the embankment dams is over 100 years old (*britishdams website*¹).

The gravity dams are more than 250 in Britain. Masonry was used in many early dams, as far back as the 17th Century. However, concrete became more common from about 1900 (*britishdams website*²).

Since 1945, 14 buttress dams have been constructed in the UK, mainly for hydroelectric schemes in Scotland. www.britishdams.org/about_dams/buttress.htm. There are only a few arch dams in the UK, including Monar Dam in Scotland (*britishdams website*³).

Spain

According to SPANCOLD (Spanish National Committee on Large Dams), there are about 1,300 large dams in operation in Spain, (28 under construction as by 2006), with 56, 500 Hm³ reservoir capacity. They regulate a volume of 46.000 Hm³/year that is 41% of natural water resources. With this number of large dams, Spain ranks first amongst the European countries, and fourth in the world, after the U.S., India and China (SPANCOLD, 2006).

The number of dams per million inhabitants is very high in Spain, 30 dams / million, but reservoir capacity per inhabitant is relatively low, of only 1,431 m³/inhab., 32% lower than the average for high income countries, and 60% lower than the average for countries with a human development index of over 0,9. This shows that despite the large number of dams, the morphology of the rivers, their great irregularity, and relatively small flows, makes the country's reservoir capacity relatively small. Over 2.7 M ha are under irrigation with water from these reservoirs, 30 million people are supplied with drinking water, plus an additional 60 million tourists per year, and 20% of the country's electricity is obtained from

hydropower. Economic analysis show that the benefits derived from the water, regulated by dams and reservoirs, amount to 6 % of the Gross Added Value at market prizes (GAV mp). This means an average value of regulated water for various uses of about 0.55 eur/m³. Apart from the benefits derived from stored water, there are also the benefits that dams and reservoirs generate through flood mitigation, and by reducing the damage caused by floods.

Spain is a country with a great biodiversity, and it is an important bridge between Europe and Africa. The country has many different orographic, climates and levels, and thus many different bio climates, and is one of Europe greatest biological reserves. Dams must be planned, designed, constructed, and operate whilst taking into account all the possible economic, social and environmental impacts. Dams in Spain are subject to an Environmental Impact Assessment process (EIA) regulated by various laws and European directives since 1985. Spain's experience and technical expertise in dam design, construction and operation, and the country's standards, laws and regulations (SPANCOLD, 2006).

Canada

Hydropower accounts for 97% of Canada's renewable energy generation. As the largest renewable energy source, hydropower has a critical role to play in Canada's energy future (*canhydropower website*²).

Murray (2000) has given an account of about 618 large dams in Canada, which manifests the significant contribution of hydro energy towards power generation in the country.

Australia

Australia has got the distinction to have thousands of dams for various purposes, out of which there are as many as 500 large dams. The Australian National Committee on Large Dams (ANCOLD) has prepared, on behalf of the International Commission of Large Dams (ICOLD), a Register of Large Dams in Australia for inclusion in their World Register of Dams. The Dartmouth Dam, in North Eastern Victoria, is Australia's Highest dam at a height of 180m. It is currently the highest dam in the Southern hemisphere (ANCOLD, 2002). The Australian National Committee on Large Dams has shown Australia's 80 meters or higher dams in order of decreasing height (ANCOLD, 2002).

China

Dam construction in China has a long history. Tracing back to ancient Chinese history, one can find that the most ancient reservoir, Shaopi, was built in Eastern Zhou Dynasty (598-591BC) in Anhui Province. It is an earth dam, 10m high, and has been in regular operation up to now. The later Zhibo irrigation canal in Shanxi Province (453BC) and Dujiangyan irrigation project in Sichuan Province (219BC) are very famous engineering works, especially the invented masonry spillway dam, 3.8m high, on the navigation canal in Guangxi Autonomous Region, which was constructed in 219 BC and is still operating now. Dam construction has developed very fast since 1950. There are now 17,526 dams 15-30m high and 4,578 dams exceeding 30m. Dams higher than 100 m in operation by the end of 1999 number 32 (*icold-cigb website*).

There were about 320 dams under construction alone in 1999, with 23 being more than 100 m high in recent years. The highest double curvature arch dam is Ertan, 240 m high, has recently been completed. It is the fourth highest concrete dam in the world.

Regarding dam type, the embankment dam is in the majority. The number of concrete dams is gradually growing as dam heights steadily increase, but the new trend is towards the concrete faced rock fill dam and RCC dam, the number of which is gradually rising.

The Three Gorges Project, which attracted worldwide attention, has the largest hydropower station in the world. Its installed capacity of 18,200 MW and peak flood discharge of 124,300m³/s (check flood) are both world records. The *icold-cigb*, 2007, has provided detailed information about the dams, their type, height, purpose; year of completion and their installed capacity.

India

India has a large concentration of reservoirs / dams, large and small for several purposes including power generation. The Tamil Nadu State has the largest number of dams surpassing the figure of 60. Some of the state-wise details are provided by *encyclopedia wikipedia website*).

Latin America

According to a careful survey, there are almost 2000 large dams (higher than 15m as per ICOLD definition of large dams) in Latin America and the Caribbean. These dams have been built for several purposes including power generation to meet the energy needs. The most important achievements in dam construction in Latin America are related to hydropower generation in Brazil and irrigation in Mexico (*icold-cigb website*). There has been major activity of hydro plant construction in the past 40 years in most of Latin America, which together with continuity of construction of dams for other purposes, has resulted in the development of expertise on dam design and construction in several countries of the region (Viotti, 2006).

Africa:

The African countries have also been reliant on using hydropower for their growing domestic, industrial and commercial needs. Kalitsi (2006) has divided the African countries into three main regions of North Africa, West Africa and South / Central / Eastern Africa to show the hydropower available in these regions. The availability of hydropower in these regions is as given below;

North Africa -23%

West Africa -25%

South/Central/Eastern Africa -51%

The data shows that the highest generation is in the north and western African countries.

3.6 WATER RESOURCES PROJECTS IN PAKISTAN

Pakistan, administratively, is comprised of four provinces, NWFP, Punjab, Sindh and Balochistan, as well as a few areas with special status. Areas with special status include the State of Azad, Jammu and Kashmir (AJK), Federally Administered Tribal Areas (FATAs), Federally Administered Northern Area (FANA) and the Federal Capital Territory of Islamabad. Pakistan has a unique geography whose land varies from the lofty mountains in the north to the famous deserts of Thar and includes the fertile plains of the river Indus and its tributaries. It is also the birthplace of the Indus Valley Civilization. Pakistan has a

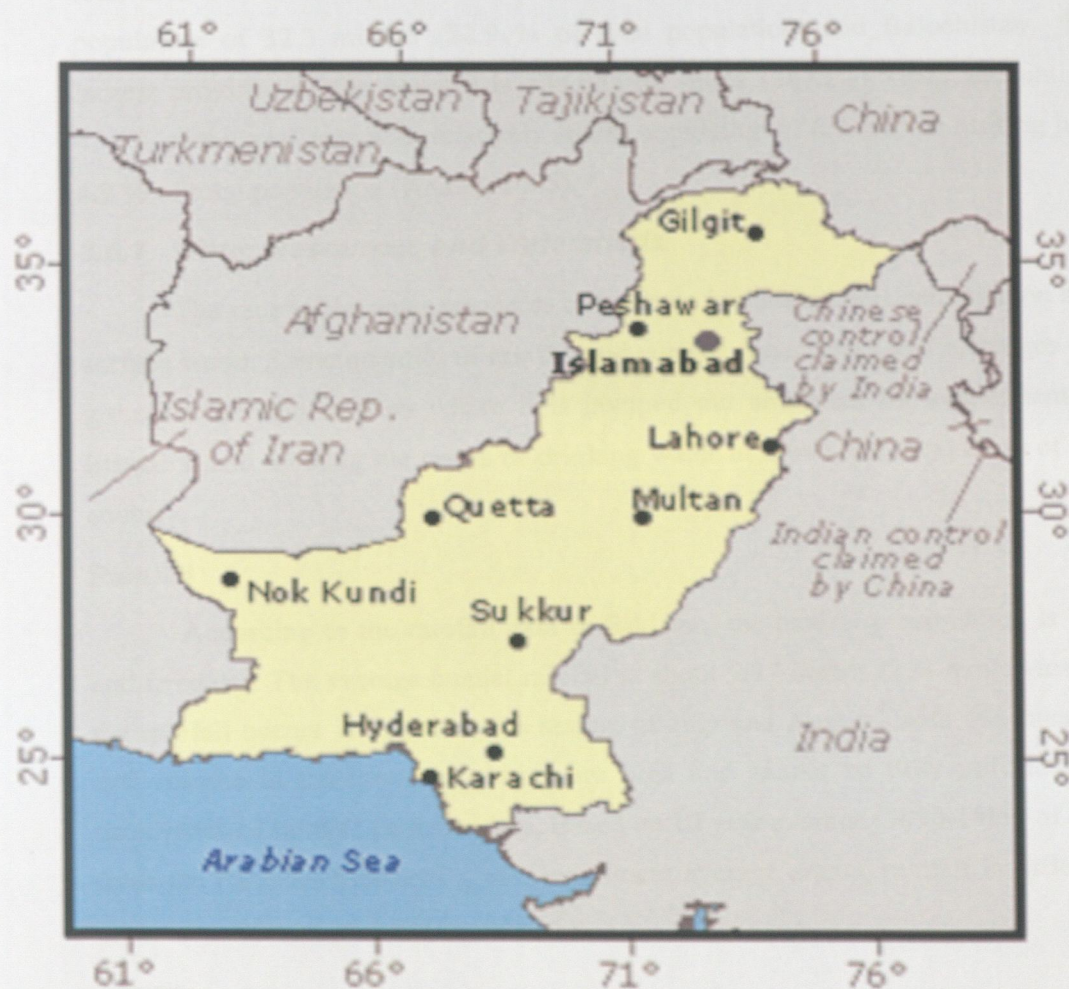
predominantly agricultural economy and is striving to develop and expand its industrial base. It is bordered by India in the east, China in the north-east, Afghanistan in the north and north-west, Iran in the south-west and the Arabian Sea to the south as in map # 4 in the next page. The country can be divided into five physiographic regions:

- The Himalayan mountain-ranges in the north-eastern part on the border with India and China. The highest peak, the Godwin-Austin (8 611 m) is part of the Trans-Himalayan Range;
- The Hindu Kush and the Western Mountains in the north on the border with Afghanistan. The Tirichmir (7 690 m) is the highest peak in the Hindu Kush range;
- The Potwar Plateau, just south of Islamabad. The elevation varies from 300 to 600 m. South of the Potwar Plateau is the Salt Range;
- The Indus Plain, stretching from the Salt Range to the Arabian Sea. This flat plain is largely made up of alluvium, over 300 m deep, deposited by the Indus river and its tributaries;
- The Balochistan Plateau in the south-west of the country, with an average altitude of about 600 m. Dry hills run across the plateau from north-east to south-west. A large part of the northwest is desert (*fao website*). Pakistan is a country of over 141 million people, which is expected to grow to about 221 million by the year 2025. According to the last 1998 Census, the population of the country was 132.4 million with an intercensal population growth rate of 2.6 percent (GoP (Government of Pakistan), 2004).

Fertility and mortality the two crucial factors underlying growth of population are estimated at a crude birth rate of 30 per thousand and a crude death rate of 9 per thousand during 2001. Other salient features of the population in Pakistan warranting immediate attention are that about 3 million people are added to the population every year with per capita income of less than US\$ 450 and with one third of its population living under the poverty line. The infant mortality is above the average for Asia and about 50 mothers die each day, from pregnancy & childbirth. In Pakistan, 300 children die of diarrhea every day. Four tenth of the population has no access to safe drinking water with one quarter of the population

does not have access to health facilities. Furthermore, there is a high level of environmental degradation, deforestation and pollution (*mopw website*). The above facts show that the most pressing need over the next quarter century in Pakistan will be the management of the rapidly increasing population and provision of basic amenities. The increasing population will have a major impact on food, power and domestic water requirements.

Map # 4: Location of Pakistan in Asia



Source: FAO-Forestry 2005 (*fao website*)

Pakistan's total land area is 307,376 square miles (796,100 km²). About 50% of the land area includes mountainous terrain, narrow valleys and foothills and, as such, is of limited productivity (Khan, 1996). The areas of the provinces and their population are as follows:

NWFP has an area of 39,267 sq miles (101,700 km²) accounting 12.8% of the total area and a population of 22.4 million (15.9 % of total population). The Punjab province is 79,653 sq. miles (206,300 km²) accounting 25.9% of the total area with a population of 77.7 million (55.1 % of total population), Sindh has a total area of 54,402 sq miles (140,900 km²) or 17.7% of the total area and a population of 32.3 million (22.9 % of total population) and Balochistan _the largest province of the country is 134,055 sq miles (347,200 km²) accounting 43.6% of the total area with relatively sparse population of 6.9 million making just 4.9 % of total population (Khalid, 2005).

3.6.1 Water Resources and Watersheds

The renewable water resources of Pakistan include natural precipitation and surface water. Some quantity of rainfall and surface water soaks and recharges the groundwater aquifer from where it is pumped out and used for supplementary irrigation and meeting the needs of drinking water in urban and rural areas of the country.

Rainfall

According to the rainfall data in Pakistan, the natural precipitation is low and irregular. The average annual rainfall is about 9.37 inches (238 mm). Most of the rainfall occurs in the monsoon season of July and August. Both the intensity and volume in the monsoon season are high and cannot be fully utilized. The occurrence of rainfall varies widely. Based on 10 year average (1990-1999) of data from the Pakistan Meteorological Department average annual rainfall in different areas is as follows (*waterinfo website*¹):

NWFP

Peshawar 20.8 inches (528 mm)

D.I. Khan 12.2 inches (310 mm)

Punjab:

Rawalpindi 52.2 inches (1326 mm)

Lahore 28.5 inches (724 mm)

Multan 9.7 inches (247 mm)

Bahawalpur 7.2 inches (183 mm)

Sindh

Karachi 6.1 inches (155 mm)

Hyderabad 5.8 inches (147 mm)

Jacobabad 5.1 inches (130 mm)

Balochistan

Quetta 10.9 inches (276 mm)

Zhob 13.6 inches (346 mm)

Khuzdar 12.7 inches (322 mm)

AJ&K

Muzaffarabad 58.8 inches (1,495 mm)

Garhi Dopatta 55.6 inches (1,229 mm)

Kotli 48.2 inches (1,223 mm)

Northern Areas

Gilgit 5.1 inches (129 mm)

Sakardu 8.0 inches (204 mm)

Astor 18.8 inches (478 mm)

Chilas 6.8 inches (173 mm)

On the whole more than half the country receives less than 7.9 inches (200 mm) of annual rainfall. In non-irrigated areas (barani areas) rainfall is utilized for rain-fed agriculture and for meeting the drinking water needs of the people and livestock. It is estimated about 9.9 million acres (4 million ha) of the area is rain fed (GoP, 2000²).

3.6.2 Surface Water**The Indus and its Western Tributaries**

The Indus River and its tributaries (Jhelum, Chenab, Ravi, Sutlej and Beas on the east and Kabul River on the west), which drain an area of 364,700 sq.miles (944,569 sq. km) are the main source of surface water in Pakistan. The inflow to

these rivers is mainly derived from snow and glacier melt and rainfall in the catchment areas. Outside the Indus Basin most of the rivers are ephemeral streams, which only flow during the rainy season and do not contribute significantly to the surface water resources.

Pakistan shares the use of rivers in the Indus Basin with India. Under the Indus Basin Treaty of 1960, India was allowed exclusive use of three eastern rivers (Ravi, Sutlej and Beas) and Pakistan was allocated the three Western Rivers (Chenab, Jhelum and the Indus) with some uses allowed to India. The Indus Water Treaty was signed in Karachi on 19 September, 1960. Provisions call for an Indian and Pakistani engineer to constitute the Permanent Indus Commission, which will meet at least once a year to: establish and promote cooperative arrangements (*transboundarywaters website and storyofpakistan website*). In order to supply water to the irrigation systems that utilized water of eastern rivers prior to the Treaty, there was a need to transfer water from the western rivers to the eastern rivers. For this purpose, two large storage dams (Mangla and Tarbela), six Barrages and eight inter-river Link Canals were constructed. The average annual inflow of the Western Rivers during the post Tarbela period (1975-2001) at the rim stations (Indus at Kalabagh, Jhelum at Mangla and Chenab at Marala) is 143.18 MAF (176.63 BCM). Of this 117.46 MAF (144.90 BCM), or 82% of the total, flows in the Kharif season (April - September) and 25.72 MAF (31.73 BCM) or 18% of the total flows during the Rabi season (October - March). The flows of the Indus and its tributaries vary widely from year to year as well as within a year. A high inflow of 186.79 MAF (230.42 BCM) or 30% above the annual average was recorded in 1959-60 and a low of 97.74 MAF (120.57 BCM) or 32% below average was recorded in 1974-75 (GoP, 2002²).

Eastern Tributaries

The three eastern tributaries of the Indus - Ravi, Sutlej and Beas have been allocated to India for its exclusive use. India has constructed the Bhakra Nangal Dam to harness the Sutlej, Pong Dam on Beas and Thein dam for harnessing the Ravi. The spills from these dams and unutilized flows enter Pakistan at Madhopur on the Ravi and below Ferozpur on the Sutlej. During the last 11 years the inflows from the Eastern rivers have varied between 1.08 MAF (1.33 BCM) in 2000-2001 to 15.27 MAF (18.8 BCM) with an average of 8.40 MAF (10.37 BCM); 6.85 MAF

(8.45 BCM) in Kharif and 1.56 MAF (1.92 BCM) in Rabi (GoP, 2002²). Part of this flow is generated within Pakistan between the border and the rim stations, particularly on the Ravi where a number of streams (Deg, Basantar and Bein Nullahs) join the Ravi upstream of Balloki. No firm estimates of this contribution are available. Based on the data for 1976-1994, the combined contribution of the eastern rivers, generated in Pakistan, is estimated to vary between 1.53 MAF (1.89 BCM) and 9.67 MAF (11.92 BCM) with an average of 3.99 MAF (4.92 BCM). After incorporating the data of 1995-2001, during which period there have been some extremely dry years, this average is likely to reduce. There is a need to firm up the estimates of the flow on the eastern rivers that are generated in Pakistan. Pending such a confirmation, the average contribution from the eastern rivers may be taken as 3 MAF or 3.6 BCM (GoP, 2002²). This would compensate for the authorized uses by India on the Western Rivers. Sharing of water among the provinces is governed by the 1991 Water Accord (*presidentofpakistan website*).

3.6.3 Available Water in the Country

The Indus River and its tributaries on average bring about 151.58 MAF (187 BCM) of water annually (GoP, 2002²). This includes 143.18 MAF (173.63 BCM) from the three western rivers and 8.40 MAF (10.37 BCM) from the eastern rivers. Allowing for the reduction in the contribution from the eastern rivers and the allowable uses by India on the western rivers, the total long term surface water availability in the Indus Basin is effectively equal to the inflow of the western rivers i.e. 143.18 MAF (173.63 BCM).

According to Pakistan Water Gateway, the average annual flow-rates of major rivers has been calculated between 1922-61 to indicate water flows before the Indus Water Treaty, 1985-1995 to indicate the post-treaty flows and the 2001-02 flows to present the current situation of drought conditions. These are presented in the table below;

Table # 15: Water flows in various rivers of Pakistan

River	Average Annual Flow (1922-61) MAF	Average Annual Flow (1985-95) MAF	Average Annual Flow (2001-02) MAF
Indus	93	62.7	48.0
Jhelum	23	26.6	11.85
Chenab	26	27.5	12.38
Ravi	7	5.0	1.47
Sutlej	14	3.6	0.02
Kabul	26	23.4	18.9
Total	189.0	148.8	92.62

Source: Pakistan Water Gateway (*waterinfo website*²)

3.6.4 Aquifers

The Indus Basin is formed by alluvial deposits carried by the Indus and its tributaries and is underlain by an unconfined aquifer covering about 15 million acres (6 million ha) in surface area. In the Punjab about 79% of the area and in Sindh about 28% of the area is underlain by fresh groundwater, which is mostly used as supplemental irrigation water and pumped through tube wells (*waterinfo website*²). Some groundwater is saline and water from the saline tube wells is generally put into drains and, where this is not possible, it is discharged into the canals for use in irrigation after diluting with the fresh canal water.

Before the introduction of irrigation, the groundwater table in the Indus Basin varied from about 40 feet (12.5 m) in depth in Sindh and Bahawalpur areas to about 100 feet (31m) in Rechna Doab (the area between Ravi and Chenab Rivers). After the introduction of weir-controlled irrigation, the groundwater table started rising due to poor irrigation management, lack of drainage facilities and the resulting additional recharge from the canals, distributaries, minors, water courses and irrigation fields. At some locations the water table rose to the ground surface

or very close to the surface causing water logging and soil salinity, reducing productivity. In the late 1950s the Government embarked upon a programme of Salinity Control and Reclamation Projects (SCARPS) wherein large deep tube wells were installed to control the groundwater table (WAPDA, 1986). Over a period of about 30 years some 13,500 tube wells were installed by the Government to lower the groundwater table and, of these, about 9,800 tube wells were in the Punjab. These projects initially proved quite effective in lowering the water table but with time the performance of SCARP tube wells deteriorated. The development of deep public tube wells under the SCARPS was soon followed by private investment in shallow tube wells. Particularly in the eighties, the development of private tube wells received a boost, when locally manufactured inexpensive diesel engines became available. Most of these shallow tube wells were individually owned (IWASRI, 2000). According to the latest estimates, Pakistan has more than 300,000 private tube wells (Kijne, 1996). Now nearly 600,000 tube wells supply supplemental irrigation water mostly in periods of low surface water availability. These tube wells more than compensated the loss of pumping capacity of SCARP tube wells and helped in lowering the water table. In many areas the maintenance and operational costs of tube wells became a big issue and therefore, sub-surface tile drains have been installed like Mardan SCARP project in NWFP (Sarwar and Khan, 2001). The main sources of recharge to groundwater are rainfall, losses from the rivers, canal system, watercourses and from the irrigation fields (Ali, 1991). Estimates of groundwater recharge have been made by different agencies at different times and vary significantly. The estimates made during the last 15 years are summarized as follows;

NESPAK and Mott MacDonald International (1993) in their study titled "Drainage Sector Environmental Assessment - National Drainage Programme" estimated the total recharge as 45.58 MAF (56.19 BCM). This estimate includes 17.83 MAF (21.99 BCM) from the canals, 17.83 MAF (22 BCM) from the water courses and fields, 2.22 MAF (2.74 BCM) from the Link Canals, 6.319 MAF (7.79 BCM) from precipitation and 1.378 MAF (1.7 BCM) from the rivers. The recharge estimated for the provinces was 27.429 MAF (33.82 BCM) in Punjab, 16.75 MAF (20.65 BCM) in Sindh and Balochistan and 1.40 MAF (1.73 BCM) in NWFP.

However, the NESPAK and SGI in their 1991 study on "Contribution of Private Tube Wells in the Development of Water Potential" have estimated the total recharge as 50.47 MAF (62.23 BCM) which is about 10% higher than the one estimated in the "Water Sector Investment Planning Study" of 1990, conducted jointly by Sir Murdoch MacDonald, National Engineering Services Pakistan (NESPAK), Harza Engineering Co. International and Associated Consulting Engineers. The provincial estimates of recharge according to NESPAK and SGI (1991) study are: Punjab 31 MAF (38.22 BCM), Sindh 13 MAF (16.05 BCM), Balochistan 2.6 MAF (3.21 BCM) and NWFP 3.85 MAF (4.75 BCM). Moreover, in another Study carried out in February 2000 by Pakistan Water Partnership (PWP) (2000) for preparing "The Framework For Action (FFA)" for implementation by WAPDA, the groundwater storage capacity in Pakistan have been estimated as around 55 MAF (67.8 BCM).

According to another study, the total safe yield in Pakistan is estimated at 53.3 MAF (65.7 BCM): 40 MAF (49.3 BCM) in Punjab, 10 MAF (12.3 BCM) in Sindh, 2.4 MAF (3 BCM) in NWFP and 0.9 MAF (1.1 BCM) in Balochistan (Associated Consulting Engineers and Halcrow Group, 2001).

Based on the above estimates, 40 to 42 MAF (49 to 52 BCM) of groundwater is pumped for irrigation use and for urban and rural drinking water supplies.

Both the groundwater potential and use is very limited in AJ&K and northern areas as compared to other provinces of the country. The potential for groundwater exploitation in AJ&K is only 16,800 AF while existing usage is of the order of only 4,250 AF. In Northern Areas the potential for groundwater exploitation is virtually none. Groundwater use is nearing the upper limit in most parts of Pakistan. The groundwater table in most of the fresh water areas is falling therefore the potential of further groundwater exploitation is very limited. For future projections it is estimated that the additional contribution by groundwater may increase at best by 1-2 MAF (1.2 to 2.4 BCM). In Balochistan the water table has been declining continuously. A number of studies have estimated that the deficit in Quetta sub-basin is about 21,000 AF (26 million m³) / year and that the aquifer storage will be exhausted in 20 years (GoP, 2002²).

3.6.5 National Water Policy

Water is a precious and increasingly scarce natural resource in Pakistan and is literally the lifeline for survival, health and sustaining national economic development. Only a few decades ago, Pakistan was considered to have abundance of water. Now, as in many other areas of the world, population growth, economic development, rapid urbanization and industrialization, are applying added pressures on already limited resources of Pakistan and it is rapidly becoming a country of water scarcity (*waterinfo website*⁴). Hence the growing significant imbalance between water supply and demand has led to shortages of water for many valuable uses, unhealthy competition, and usually conflicts between shareholders using water resources, rising pollution and other natural hazards in the environment. Water shortage is also a key hurdle in continued economic development of Pakistan. Hence, there is an urgent need to address this matter in a forthright, comprehensive and effective manner.

The Government of Pakistan has set forth the target of sustained annual economic growth of around 6 percent, with agriculture to making a significant contribution (GoP, 2001). Water has always played an important role in the economic development of Pakistan and is likely to continue as such in the future.

However, the lack of political will, failure to take development initiatives and insufficient investments in the water resources sector has caused the failure to adopt a consolidated Water Policy at the National level. A National Water Policy is presently being prepared under the National Drainage Program (NDP). The objectives of the draft Water Policy (GoP, 2002²) include:

1. Strengthen the institutions and agencies responsible for development, planning and design of water resources and provision of service delivery across the water sector.
2. Improve the ability of water agencies to carry out their functions effectively and efficiently, including environmental protection.
3. Improve opportunities for and encourage private sector participation and community involvement at all feasible levels in the water sector.
4. Reduce public spending on provision of irrigation through cost sharing and irrigation management transfer.

5. Reduce public spending in urban and rural domestic water through effective and enforced charges for water services.
6. Ensure that water services in all sub-sectors are financially self-sustaining.
7. Improve the climate for private sector investment, especially in the urban and rural water supply and hydropower sub sectors.
8. Improve the data and information base and network for all water related information.
9. Improve public understanding of water issues as they affect the general public and special interests through public awareness and public education programs.
10. Promote and adopt the principles of Integrated Water Resources Management (IWRM).
11. Ensure that development and management of water storage facilities are carried out within the context of International Water Resources Management (IWRM).
12. Promote good management of watersheds to ensure sustainability of water resources.
13. Ensure best use of water for the economic and social development of the country.
14. Improve conditions of equity in access to irrigation water and urban and rural domestic water.
15. Improve the coverage, water quality, management and dependability of domestic water supply.
16. Improve the coverage, management and dependability of urban and rural sanitation.
17. Improve water quality in rivers and other surface water bodies and for groundwater through new legislation and enforcement of laws.
18. Ensure sufficient access to water to meet the needs of the people, especially in domestic water in the urban and rural sectors. Access to domestic water should be the first priority in water allocation.

19. Ensure sufficient water for agriculture to meet Pakistan's growing food requirements, with emphasis on targeting water to agricultural production and efficient use of water.
20. Improve agricultural productivity per unit of water.
21. Improve the efficiency of water use for agriculture.
22. Promote demand management in agricultural water use.
23. Improve the balance of expenditures in irrigation, either through management transfer to Farmer Organizations or improved cost sharing with irrigation service providers.
24. Ensure sufficient access to water to meet the needs of developing industry, which will be essential for Pakistan's continued economic development.
25. Promote the development of hydropower, with special consideration to the northern run-of-river schemes.
26. Reduce the problems of water logging, soil and water salinity and disposal of saline agricultural drainage.
27. Ensure there is sufficient water for the environment, including protection of the Indus Delta.

3.6.6 Development Plans

Development planning in Pakistan has previously been based on five-year plans. A total of seven Five Year Plans were implemented between 1955 and 1998. Between 1970 and 1978, no plans were prepared and development allocations were done on annual basis. (This period replaced the envisaged Fourth Plan). The Eighth Five Year Plan covered the period 1993 to 1998. The Ninth Plan was not issued. In September 2001, the Government has had approved the Ten Year Perspective Development Plan 2001- 2011 (GoP, 2001).

Ten Year Perspective Development Plan and Hydropower Generation

The Ten Year (2001-2011) Perspective Plan recognizes the need for development of water resources and increased hydropower. The Plan comprises a macroeconomic framework, a public sector development program and sectoral strategies including those for water, agriculture, energy (including hydropower),

the environment and other sectors of the national economy. The Ten Year Plan encompasses WAPDA's comprehensive integrated water resource and hydropower development Mega-plan, 'Vision-2025' for development of additional storage capacity and hydropower generation.

3.6.7 WAPDA Vision 2025

The goals of the Government with respect to development of water resources are further reflected in WAPDA's Vision 2025. WAPDA is undertaking engineering studies of storage sites having a total capacity of about 65 MAF (80.2 BCM) and hydropower capacity of 23,000 MW (*waterinfo website*⁴). The programme is proposed to be implemented in three stages. The estimated investment for Vision 2025 will be \$50 billion over the next 25 years. The fast track projects in Vision 2025 include construction of Gomal Zam Dam, Mirani Dam, Greater Thal Canal, Kacchi Canal, Raine Canal, Raising of Mangla Dam, Satpara Dam and the Right Bank Outfall Drain to discharge the saline drainage effluent from the Lower Indus Right Bank area to the sea. Feasibility study for the Basha Dam and detailed design of Sehwan Barrage has also been started (GoP, 2002²), Global Water Partnership, (1999) and Pakistan Water Partnership (PWP), 2000).

3.6.8 Energy in Pakistan

Pakistan due to its unique physiographic location has got enormous potential of its energy resources however, due to lack of appropriate policies for resource management and utilization and lack of strong political will; the country remains energy deficient and has to rely heavily on imports to meet its growing energy needs. Pakistan obtains its energy requirements from a variety of traditional and commercial sources. Oil supply from indigenous resources has been the weakest link in the energy supply system of Pakistan. Until early 1980 crude oil production was a nominal 13,000 barrels per day (BDP), which rose to 64,349 BPD in 1990-91. Since then, the production has been continually declining. The remaining oil reserves are estimated at 221 million barrels which, on the average production rate of 57,000 barrels per day, will be exhausted in about 10 years. The total primary energy consumption in Pakistan is currently estimated at around 60 million tons of oil equivalent (MTOE). Of this, two-thirds are met by commercial

energy resources with about one-third being based on non-commercial energy resources like fire-wood, charcoal and cow-dung (WEC (World Energy Council), 2000). Oil and gas account for more than three-quarters of the commercial energy consumption in the country. Gas has emerged over the years as the leading domestic source of energy. Pakistan has appreciable coal reserves of 1.7 billion tones of oil equivalent (TOE). Oil is by and large an imported source of energy. The imports of oil account for 85% of oil consumption in the country and 42.8% of commercial energy consumption. The production of indigenous oil is around 15% of total imports of oil products, which is likely to remain the case. Pakistani oil sector performance, unlike that of the natural gas sector, has not been satisfactory, both by way of exploration, exploitation and development of oil fields, and by way of refining of crude oil into various products, with the result that 70% of total demand of crude oil is being met through imports. It costs about US\$ 2.5 billion every year to import about 18 million tons of oil as both crude and refined products, representing a great burden on foreign exchange resources (*worldenergy website*²). Pakistan's energy consumption has nearly tripled in the last 20 years, from 0.6 quadrillion Btu in 1980 to 1.9 quads in 2001. Still, Pakistan accounts for less than 0.5% of total world energy consumption. In terms of per capita energy consumption, Pakistan's level of 12.9 million Btu in 2001 was higher than Bangladesh's (3.7 million Btu), but virtually on par with India's (12.6 million). In comparison, China's per capita energy consumption in 2001 was 30.9 million Btu, Iran's was 80.3 million Btu, and Russia's was 195.3 million Btu, while U.S. per capita consumption was 341.8 million Btu (*eia website*⁶).

Pakistan often faces shortages of power in peak seasons. Rotating blackouts ("load shedding") are, however, still necessary in some areas. Transmission losses are about 30 percent, due to poor quality infrastructure and a significant amount of power theft. Periodic droughts affect the availability of hydropower. In the short-run, Pakistan has some excess power, but after 2007, estimations are an annual shortfall of at least 1,000 megawatts (MW). Presently, much of Pakistan's rural areas does not receive electric power and about half of the population is not connected to the national grid (*eia website*⁷). According to Hydrocarbon Development Institute of Pakistan (2002), the main energy sources in Pakistan are oil, gas, LPG, coal, hydroelectricity and nuclear electricity. The annual growth rate

during 2000-01 was observed to be 6.55%. The primary energy supplies in Pakistan during this period have been shown below.

Table # 16: Energy generation from various sources for the Year 2000-01

No.	Source	TOE (Tones of Oil Equivalent)
1	Oil	19,320,611
2	Gas	18,410,007
3	LPG	143,514
4	Coal	2,009,552
5	Hydroelectricity	4,104,123
6	Nuclear Electricity	476,714
	Total	44,464,522

Source: Hydrocarbon Development Institute of Pakistan (2002)

According to WEC (World Energy Council), (2000), the transport, power and industry are the major oil consuming sectors of the economy. The sectoral consumption pattern is given in table # 17 below.

Table #17: The sectoral consumption of energy consumption (1998-99)

Sectoral Consumption	%
Transport	47.2%
Power	33.2%
Industry	12.9%
Agricultural	1.5%
Domestic	3.0%
Other Govt.	2.3%

Source: WEC, 2000

In Pakistan, the present primary energy supplies are not enough to meet the present requirements, as a result, Pakistan, like other developing countries of the region, is facing a serious challenge of energy deficit. Sources of renewable energy

available in the country can play an important role in meeting this challenge. The technologically viable renewable resources to be exploited commercially in Pakistan include micro-hydel, bio-energy, wind and solar energy.

The total power generation capacity in Pakistan is of the order of about 17,457 MW. This includes the hydropower generation capacity of 5,013 MW (excluding the recently added 1450 MW from the GBHPP), the thermal power generation capacity of 12,169 MW and the nuclear power generation capacity of 462 MW. Based on the present generation capacity, the hydro: thermal/ nuclear mix in the country is about 29: 71 (Hydrocarbon Development Institute of Pakistan, 2002), "Pakistan Energy Yearbook 2001", January 2002). The main sources of electricity generation in Pakistan are hydro, oil, gas, coal and nuclear power. Among these, hydro power is the only renewable source of energy; the others are mainly fossil fuels. Hydro power is also the least expensive form of electricity as shown in the previous table # 15 on page 78. The potential for hydropower generation in Pakistan is of the order of 40,000 MW (*waterinfo website*³). According to WAPDA (2001), the total installed capacity of power generation in Pakistan given in table 18 is to the tune of 17952 MW (excluding the generation of 1450 MW by Ghazi Barotha Hydropower Project). Adding the generation of Ghazi Barotha Hydropower Project, the total thus becomes 19402 MW.

Table # 18: The total installed capacity (as of September, 2001)

	Hydel	Thermal	Total
WAPDA	5042 MW	4750 MW	9792 MW
IPPs (WAPDA SYSTEM)	-	5680 MW	5680 MW
KESC	-	1756 MW	1756 MW
IPPs (KESC SYSTEM)	-	262 MW	262 MW
NUCLEAR (CHASNUPP & KANUPP)	-	(325+137) 462MW	462 MW
Total	5042 MW	12910 MW	17952 MW

Source: WAPDA (2001)

According to WAPDA (2002), the electricity generation in future is planned to increase to 25,703 MW and 37,825 MW by the year 2010 and 2015 respectively. Similarly the energy production may also increase to 117,257 GWh and 169,981

GWh by the year 2010 and 2015 respectively. This is explained in the table # 19 below;

Table # 19: Requirements of electricity generation capacity (MWe) in the Years 2005, 2010 and 2015

	2005	2010	2015
Installed Capacity (MW)	19,677	25,703	37,825
Maximum Demand (MW)	14,642	20,584	29,976
Energy Generated)	84,577	117,257	169,981

Source: WAPDA (2002)

3.6.9 Structure of the Electricity Sector in Pakistan

The integrated power system of Pakistan consists of two utilities, namely WAPDA and KESC. Pakistan Atomic Energy Commission (PAEC) owns nuclear power plants, which are connected to WAPDA and KESC networks. The Independent Power Plants (IPPs) are connected to the national grid at various locations. Their brief description is as follows;

The Pakistan Atomic Energy Commission (PAEC) owns the following two nuclear power plants:

- i. KANUPP (Karachi Nuclear Power Plant), a 137 MW, integrated in KESC network.
- ii. CHASNUPP (Chashma Nuclear Power Plant), a 325 MW connected to WAPDA grid since June 13, 2000.

The IPPs only generate electricity, the transmission and distribution is the responsibility of Transmission and Dispatch Company. The IPPs in operation as on 30th June, 2001 are given below:

- KAPCO (1466 MW)
- HUBCO (1292 MW)
- AES Pak. Gen. (365 MW)
- Gul Ahmad Energy (136 MW)

- Kohinoor Energy (131 MW)
- Tapal Energy (126 MW)
- AES Lalpir (362 MW)
- Japan Power (135 MW)
- Southern Electric Power (117 MW)
- Habibullah Coastal (129 MW)
- Fauji Kabirwala (157 MW)
- Rousch Pakistan (412 MW)
- Saba Power (134 MW)
- Uch Power (586 MW)

Table # 20: The installed electricity generating capacity and transmission voltages of all the utilities and IPPs (power plants and Grid of Utilities as on the 30th June 2001)

Utilities	Installed Capacity (MWe)				Transmission Voltage
	Thermal	Hydro	Nuclear	Total	
WAPDA	4,830	5,010	325	10,165	500,220,132 kV
KESC	1,756	-	137	1,893	220,132 kV
IPPs	5,593	-	-	5,593	500,220,132 kV
Total	12,179	5,010	462	17,651	

Source: Hydrocarbon Development Institute of Pakistan (2001) and WAPDA (2001)

3.6.10 Hydropower Generation vs Potentials in Pakistan

Although, there has been an enormous potential of hydro generation in the country, however, the successive governments have not been able to construct new reservoirs / dam since Tarbela dam. The failure to do so is due to lack of intra provincial agreements on water issues arising due to distrust among the provinces mainly on royalty and water distribution and other related environmental, socio-economic and resettlement issues associated with the huge reservoirs / dams projects. The country has, so far, been able to establish very few storage facilities for irrigation, power and water supplies.

The Pakistan WEC (World Energy Council) Member Committee reports that the country has an identified hydro potential of 40, 000 MW out of which 30, 000 MW is economically exploitable. The main potential sources of hydropower are on the rivers Indus and Jhelum, plus sites at Swat and Chitral. Both hydro and thermal power plants are being developed to meet the country's demand for electricity, as part of the state utility WAPDA's 'Vision 2025' programme. A programme for feasibility studies of small hydropower projects on canal falls and barrages was approved by the Government of Pakistan in 2001. A total of 591 sites with aggregate potential of 649 MW at various canal falls and barrages throughout the country were identified. Data for canal falls and distributaries having a discharge of 200 cusecs or more are being collected. Three sites, namely Machai, Pakpattan and Rohri, have been taken as pilot projects, for which feasibility reports have been completed. The feasibility of six other sites is under study. A Memorandum of Understanding has been signed between the Governments of Pakistan and China for the implementation of the above nine projects on a turnkey basis with financial facilities (*worldenergy website*²).

The existing storage facilities with their generation capacities, projects for the near future and the gross potentials of water storages in the four provinces of the country are shown in table # 21, 22 and 23 in the next pages.

Table # 21: The existing storage facilities in Pakistan

PROJECT	RIVER	HEIGHT OF DAM		LIVE STORAGE		POWER (MW)	PURPOSE
		FT	M	MAF	BCM		
TARBELA (1976)	INDUS	485	147.8	9.30	11.38	3478	I,P
MANGLA (1966)	JHELMUM	380	115.8	4.82	5.90	1000	I,P
CHASHMA (1971)	INDUS	-	-	0.61	0.75	-	I,P
WARSAK (1960)	KABUL	250	76.2	0.04	0.05	240	I,P
BARAN DAM (1962)	KURRAM	107	32.6	0.03	0.04	4	I,P
HUB (1983)	HUB	151	46.0	0.76	0.93	-	I,W
KHANPUR (1984)	HARO	167	50.9	0.09	0.11	-	I,W
TANDA (1965)	KOHAT TOI	115	35.0	0.06	0.07	-	I
RAWAL (1962)	KURANG	114	34.7	0.04	0.05	-	W
SIMLY DAM (1972)	SOAN	215	65.5	0.02	0.02	-	W
BKD KHAN (1900)	PISHIN	35	10.7	0.04	0.05	-	I
HAMAL LAKE	-	-	-	0.08	0.09	-	I
MANCHAR LAKE	INDUS	-	-	0.75	0.92	-	I
KINJHAR LAKE	INDUS	-	-	0.32	0.39	-	I,W
CHOTIARI LAKE	INDUS	-	-	0.78	0.95	-	I
		TOTAL		17.74	21.90	4722	

Source: Government of NWFP, (2005)

I - IRRIGATION

P - POWER

W - WATER SUPPLY

1 MAF = 1.224 BCM

Table # 22: The total storage potentials in Pakistan

Sr. No.	ITEM	TOTAL STORAGE CAPACITY	
		MAF	BCM
I	SURFACE STORAGES IN OPERATION	17.74	21.70
II	STORAGES, WHICH CAN BE INTEGRATED WITH EXISTING IRRIGATION SYSTEM		
	1. STORAGE SITES (RIVERS & TRIBUTARIES)	34.68	42.43
	2. OFF CHANNEL STORAGES	21.65	26.48
	3. RAISED MANGLA	2.90	3.33
	SUB TOTAL	59.23	72.24
III	STORAGE SITES OUTSIDE EXISTING IRRIGATION SYSTEM		
	BALUCHISTAN	1.73	2.11
	SINDH	0.20	0.24
	PUNJAB	0.25	0.30
	NWFP	3.24	3.96
	SUB TOTAL	5.42	6.61
	TOTAL	82.39	100.55

Source: Government of NWFP, (2005)

Table # 23: Projects of power generation and irrigation for the near future in Pakistan

PROJECT	RIVER	HEIGHT OF DAM		LIVE STORAGE		POWER (MW)	PURPOSE	STATUS
		Ft	M	MAF	BCM			
YUGO	SYHOK	540	164.5	4.82	5.90	1000	I,P	R
SKARDU	INDUS	755	230.1	15.52	18.99	4000	I,P	R
KATZARA	INDUS	-		35.00	42.82	15000		R
BASHA	INDUS	660	201.1	5.70	6.98	3360	I,P	PF
KALABAGH	INDUS	260	79.3	6.10	7.46	3600	I,P	C
KALAM	SWAT	450	137.1	0.26	0.32	110	I,P	R
MIR KHANI	CHITRAL	410	124.9	0.58	0.71	150	I,P	R
KHAZANA	PANJKORA	380	115.8	0.56	0.68	110	I,P	R
MUNDA	SWAT	700	213.2	0.67	0.82	740	I,P	F

Source: Government of NWFP, (2005)

I - Irrigation

P - Power

Ft - Feet

R - Reconnaissance Study Completed

F - Feasibility Study Completed

M - Meters

3.7 CONCLUSION

The relevant concepts, definitions and scientific advancements relating to environment and Environmental Impact Assessment (EIA) techniques used for water resources development projects are reviewed in this chapter. The political and development aspects such as the role of the world leaders; and the role of water as the most precious resource towards human development, especially in the context of cheaper and emissions free hydropower generation vis a vis unfavorable environmental alterations are also given due consideration in the literature review. Historically, the adverse impacts on the environment have arisen through the different important phases of development of the human civilization. However, the modern technological revolution posed serious threat to the planet earth; and hence, the importance and significance of the application of Environmental Impact Assessment (EIA) as decision making tool was realized in 1970s. The literature review has explored advancement in the EIA methodologies to date. These methodologies are grouped under (a) Ad hoc Methods (b) Checklists (c) Matrices (d) Networks (e) Cost Benefit Analysis (CBA) (f) Overlay Mapping and (g) Simulation Modeling. The GBHPP has become fully operational in 2004; therefore, the present study is focused on monitoring / post auditing. The actual impacts have been measured and interpreted quantitatively and qualitatively under the relevant parameters of the natural and human environment.

Moreover, the chapter has discussed the status of water resources projects in the global and regional context. It was revealed that due to increased utilization, many of the rivers are running dry and many lakes are disappearing in some countries. Many parts of the world has experienced underground water depletion; and shrinking seas in some key countries. In view of the grave situation about the water resources, the literature review also focused on the actions taken by the world leaders for water conservation such as under "Agenda 21" in 1992, Millennium Summit 2000, World Summit 2002 and the United Nations General Assembly session in December, 2003 proclaiming International Decade on "Water for Life, 2005-2015". The chapter has also discussed the role of running waters for hydro power generation vis a vis the adverse impacts associated with such projects. The status of water resources projects in few countries in the regional context have been explored as examples to give an overview of the water resources in the global

perspective vis a vis the per capita commercial energy consumption in the key Asian countries.

Lastly, in view of the adequate water resources in Pakistan, the draft National Water Policy of the country has outlined the scope of water resources development programs in the country. The "Vision 2025" of the country has prioritized projects worth about \$50 billion over the next 25 years to exploit the country's potentials for the live storage and hydropower generation. It was explored that the present storage capacity of about 17.74 MAF in the country can be enhanced to 82.39 MAF with the implementation of the proposed projects. The literature review has identified the potential sites such as Skardu, Kalabagh, Basha and Katzara on river Indus; Yugo on river Syhok, Kalam on river Swat and Mir Khani on river Chitral. It was found that despite huge potentials of the hydropower in the country; only up to 6,000 MW is generated from the hydro. The remaining 12,179 MW electricity is generated from the thermal and 462 MW from the nuclear energy. Despite some local ill effects of the water resource projects, the per KWh generating cost of the hydropower in Pakistan has been significantly lowest, which is about 6.71 paisa for Dargai, 12.01 paisa for Mangla, 16.73 paisa for Malakand and 21.73 paisa for Tarbela reservoir; marking the hydropower as the most economical for the country.

CHAPTER # 4

PRE-PROJECT ENVIRONMENT

4.1 OVERVIEW

This chapter describes the background information about the natural and human environment of the study area, which existed prior to implementation of Ghazi Barotha Hydropower Project (GBHPP). A comprehensive description of the natural and man-made environment prior to construction and operation of GBHPP is significantly required in order to focus on the alterations of the environment emerged out of the project construction and operation. Eventually, an analysis based on the comparison between the pre-project and post-project conditions of environment in the study area has helped draw useful conclusions about the effects of the project on the flood-plains ecology of river Indus.

Over the last two decades, there have been serious concerns voiced globally / regionally and locally about the adverse impacts of rivers diversions and / or water impoundments in terms of unfavorable impacts on the local environment and socio-economic values. To give a comprehensive summary description of the baseline information, a systematic approach is adopted to explore the pre-project physical and ecological resources associated with the braided channel of river Indus. Nevertheless, the study also elaborates the key role of these resources in the past in the socio-economic well-being especially of the local peoples in the vast study area extending from the barrage up to its confluence with river Kabul at Attock. Various techniques and methods have been used to determine the way these resources served the locals and their level of livelihood associated directly and / or indirectly with these invaluable resources of the river Indus and its floodplains.

As the GBHPP covers a vast area in two provinces of the country namely NWFP and Punjab, therefore, the impacts of the project are potentially extended to larger remote areas of Swabi and Haripur districts in NWFP and Attock district in Punjab. However, the scope of this research study is limited to investigate the beneficial vs adverse impacts of GBHPP on the flood-plains of river Indus, which has experienced significant water withdrawals from its braided channel into the concrete power channel.

4.2 EXTENT OF THE STUDY

Keeping in view the scope of the study, the discussion in this chapter is focused on delineating the pre-project conditions of the natural and human environment of the aforesaid flood-plains of river Indus and the adjacent areas under its influence. The floodplains of river Indus constituting the study area is divided into the following three main regions as shown in map # 5 in the next page;

- The right bank side of river Indus comprising active and old floodplains of district Swabi (NWFP)
- The left bank side of river Indus consisting area of Tehsil Ghazi known as Khari Plain of district Haripur (NWFP)
- The left bank side of river Indus consisting Chhachh region of district Attock (Punjab)

Water resources development projects including dams and barrages causing water impoundments and or flow diversions are among the most sensitive of all water resources development projects in terms of scale, magnitude and pervasiveness of their impacts on the physical and human environment. They usually result in the alterations of hydrologic regimes, water quality and changes in the terrestrial and aquatic ecosystems. Therefore, the impacts extend from the on-site local to regional level including project's closed vicinity to remote catchments areas. For through analysis of the environmental effects of such projects, attention is focused on ensuring the adequacy and quality of basic data of all environmental parameters before and after the execution of the project. Thus the net values, both quantitatively and qualitatively, for impacts are calculated for "with project" and "without project" and so the short term gains and losses vs the long term; and reversible vs irreversible impacts on the natural and human environment are evaluated.

The three regions referred to above are discussed to represent the pre-project natural and man-made environment of the study area on the basis of the following main components of the environment;

- A. Physical Resources
- B. Ecological Resources
- C. Human Use Values and
- D. Quality of Life Values

4.3 HISTORICAL BACKGROUND

The historical aspect of the study area is described to give information about the history of the inhabitants in the study area, the dominant clans and races and their cultural traditions and customs.

4.3.1 *Right Bank Area of Swabi Region*

The Swabi region was administered as a Tehsil of Mardan district during the British rule. It was in 1897, when Mardan district was devolved naturally to the new province, the North West Frontier Province (NWFP). The Right Bank Area of Swabi region is located on the eastern boundary of Swabi district and is dominantly occupied by Pukhtoon Yousafzai and especially by their collateral Utmanzai tribe. The historians believe that ancestors of Yousafzai migrated from Afghanistan in the thirteenth century A.D (sixth century A.H). They relate their arrival in this region by moving in over the pre-existing groups of Tanolis, Awans, Mughals, Dilzaqs and Moarangi who after defeat became their tenants. The Moarangis live closed to river Indus and earn their livelihood by running boats for river crossing between the two provinces of NWFP and Punjab. Yousafzais generally have robust built full stature with fair complexions.

4.3.1.1 Dress

People of this area wear the traditional Pukhtoon dress of *Shalwar* and *Kameez*. Male, particularly the old, wear *turban* and *chadar*. The women folk also wear *Shalwar* and *Kameez* and a long *chadar* inside their houses and observe *Parda* (covering body) when they go outside.

4.3.1.2 Marriages

The area is popular for the interesting marriage ceremonies as elsewhere in the Pukhtoon society. Marriages, in majority, are arranged by parents and the girls observe *Parda* to avoid appearing before fiancé. Usually, engagement is held first and the *Rukhsati* (departure) of the girl take place after 1-3 years. The marriage ceremony is marked by the marriage procession called "*Janj*" carrying "*Doli*" (Palanquine) to girl's house. Meal called "*Walima*" is served to the participants of the marriage at noon or in the after noon.

4.3.1.3 Social Gatherings

The area is characterized largely a traditional society and a variety of local customs and traditions exist. The social gatherings usually take place in a common place called "*Hujra*". Usually each sub-clan or "*Mohallah*" own its own *hujra* and *Masjid* (mosque). The elders of the village or Mohallah get together in *hujras* or mosques and discuss crucial issues face by them. The elders enjoy a peculiar respectable position and the youths usually listen to their discussion with due reverence. In some cases mosques are also used as a place to decide certain issues particularly for bringing compromises and settlements called "*Sulah*" between warring factions. The death ceremony is also held in a unique sorrowful way in this Pukhtoon society. The people of the village jointly prepare grave for the deceased and assemble at the deceased's *hujra* / mosque for *Taziat* (mourning) up to three consecutive days to offer *Fatiha* (condolence prayer for the deceased). During the mourning days, the closed relatives serve meal to the deceased's family and guests. After the mourning is over, the family of the deceased give food to the poor and relatives called "*Khairat*".

4.3.1.4 Land Rights

The Peshawar valley was taken over by the British in 1848 A.D from the Sikh kingdom of Lahore. They recognized the claims of Pukhtoons in the Swabi region and confirmed their rights to land in their early land settlement in 1870 A.D. The grant of proprietary rights to Yousafzai over the land including the vast riverain islands (*Belajats*) in the active flood-plains of the river Indus has had resulted into disputes over the rights to *Belajats* during the project implementation.

Under the British system, the proprietary tenures were applied to cultivated lands called *Shamilat-e-Tal*, where as the pastures areas including riverain islands (*Belajats*) were declared as village commons or *Shamilat-e-Deh*. The resources of *Shamilat-e-Deh* would divide according to the proportion of share in the *Shamilat-e-Tal* to individual owners. This system has been continued under the existing Pakistan.

4.3.1.5 Conflicts over Riverain Islands (*Belajats*)

The conflicts over land resources of *Belajats* between the local Pukhtoons and tenants living in villages along the bank of Indus exist due to two main

reasons. The first due to passage of land rights to persons / tenants holding lands on mortgage (rehn). The hold on mortgage land (Murtaheen land) by the tenants was strengthened by the adoption of the Law of Adverse Possession (Qabza Mukhalifana) in 1939, 12 years after the second land settlement in 1927. As a result of this Law, the land that was being held on mortgage (rehn) became transferable to tenants as the "time-barred" after the lapse of 60 years. The Superior Courts have given judgment for the transfer of ownership of such lands to tenants. However, this transfer did not include the natural transfer of the village commons' land or Shamilat-e-Deh on the basis of its proportion contrary to as is for the Shamilat-e-Tal of the local Pukhtoons.

The other problem exists due to the courts' numerous decisions in light of the land settlements under the British, wherein some limited right of access to riverain islands (*Belajats*) was granted to tenants. The courts in their decisions have observed the right of the tenants to *Belajats-e-Karghisht* (having grasses only), for grazing their animals. The courts denied them any right to *Belajats-e-Darakhtan* (having forests). Thus the time-barred murtaheen lands coupled with courts decisions on accepting certain limited rights of tenants to use *Belajats-e-Karghisht* (*Belajats* with grasses on them) have created confusion amongst the original landowners and the tenants.

4.3.2 Left Bank Area of Khari Plain

The Khari Plain, a part of Tehsil Ghazi (district Haripur) is located on the western side of district Haripur. On its south, the Chhachh region of district Attock is located, while on the north-west is district Swabi. On the north is district Mansehra and in the east is Haripur Tehsil of district Harpur. The river Indus makes the boundary between the Khari Plain and Swabi region, while Haripur Tehsil is separated by Ghandghar Mountains. The Khari Plain is not separated from the Chhachh region by any natural features except administratively at the Ghureghushti town of Chhachh region.

The History of Haripur district is traced back to 1822 A.D, when the foundation of Haripur city was laid by Sardar Hari Singh Nalva, the Sikh Governor of Kashmir, after whom it is named. In 1848, the Sikhs were defeated by the Britishers and thus the Sikh regime came to an end. Major Abbott, the first Deputy

Commissioner of Hazara raised the status of Haripur town to Tehsil in 1849. Later on, its Tehsil status was raised to the status of district on July 1st 1991, comprising two Tehsils namely Haripur and Ghazi.

The Khari Plain is fertile oval shaped plain locked by the Ghandghar hills in the south and the river Indus in the north. It is densely populated area of river Indus flood plain, which is locally called as Khari Plain. It can be divided into active flood-plain and old flood-plain. The active flood plain lies adjacent to the river and is inundated almost in every rainy season. When there is high discharge, the erosion and depositional activities of the river go on simultaneously. Embankments have been built in many places along its outer margins to protect neighboring areas from the floods and erosion. The soil is composed of coarse-texture sand and silt. The old flood plain covers all the flood-plain area of Tehsil Ghazi. It is extended up to four kms southeast of the river Indus up to the Ghandaghar piedmont. The material consists of quaternary alluvium, unconsolidated conglomerates, siltstone and loess. Mostly, loess has been eroded by the torrents and wind action. The bedrocks are composed of metamorphic rocks. The Khari Plain is predominantly alluvium deposited by the river Indus.

4.3.2.1 Races and Tribes

The inhabitants are to larger extent mixed by origin. Although, the inhabitants are less conservative socially, the area presents similarity to Pukhtoon culture in the western part of the Khari Plain. While the east and north has similarity to Punjabi and Kashmiri culture. The construction of Tarbela dam has brought drastic changes in the area in terms of socio-economic and culture values. Due to influx of outsiders after Tarbela construction, foreign remittances by people working overseas, the prices of land have multiplied significantly in this region.

There are various tribes of Pukhtoons such as Mishwani, Jadoons and Tarkheli, living mostly in Tehsil Ghazi. Their culture is mostly similar to Swabi region. The other groups concentrated in Ghazi are the oldest tribe of Gujars and Awans. The other groups less significant are Syed.

4.3.2.2 Dress

The area has seen a marked difference in dress between the ordinary people and the high classed educated people. There is tendency towards the use of western

dress in the educated class while the ordinary people wear typical Pukhtoon dress of Shalwar and Kameez. The wedding and death ceremonies are almost similar to Pukhtoon culture of the Swabi region.

4.3.3 Left Bank Area of Chhachh Region

The Chhachh region lies in district Attock (Punjab province) extends from the historic town of Ghureghushti to the Grand Trunk (G.T) road. Attock district owes its name from the famous Attock Fort situated on the left bank of river Indus just below its confluence with river Kabul. The name was accorded to it by the Mughal Emperor Akbar. The Chhachh region has no any sharp demarcation from the Khari Plain.

The area is very fertile and particularly famous for the livestock and cultivation of Tobacco and vegetables. The Chhachh region is traditionally popular amongst the farmers of Swabi region and the adjacent areas for the good breed of buffalos. Like the Khari Plain, a good fraction of the people are settled abroad particularly in the United Kingdom (UK) and USA.

4.3.3.1 Races and Tribes

The Attock district in general is inhabited by different tribes and races namely Awan, Pathans (Pukhtoons), Gujars, Mughals and Syeds etc. However, the Chhachh region has relatively more concentration of Pukhtoons, Awans and Gujars etc. Most of the inhabitants claim to be the descendants of the invaders who came from Central Asia and Afghanistan.

The Chhachh region is almost in front of the Swabi region across the Indus. The river Indus being comparatively narrower at this point remained historically the crossing point between the Frontier province (NWFP) and Punjab, and onwards to India before the construction of Attock Bridge. Thus the inhabitants of this region claim that almost all the wars between the local warlords / rulers and foreign aggressors were fought at the Chhachh region.

4.3.3.2 Dress

The inhabitants mainly wear the typical Punjabi dress; however, the Pathans (Pukhtoons) tend to wear the Pukhtoons' dress of *shalwar kameez*. The educated people of this region also wear western dress like the educated class of

Khari region. The area is socially moderate to slight conservative relatively to other parts of Attock district.

4.4 BASELINE / PRE-PROJECT ENVIRONMENT

The water resources development projects like river diversion, as in GBHPP, are amongst the most sensitive projects in terms of scale, magnitude and pervasiveness of their impacts on the physical and human environment. They usually result in the alteration of hydrologic regimes, water quality, land use changes and many other environmental changes. Alterations in the hydrologic regimes invoke drastic changes in the basic ecosystems of the area, which being life supporting for the local peoples are called life supporting systems. Furthermore, the impacts extend from the project's vicinity to far flung areas of the watershed and even to the downstream communities. For analysis of the environmental effects of such projects, adequacy of basic data of all relevant environmental parameters before and after the execution of the project is needed.

The baseline levels of the important environmental parameters are described in detail in this part of the chapter in order to understand the pre-project conditions in the study area. Knowledge about the baseline conditions in the study area help analyzes the changes that have arisen due to project implementation. The baseline description has been made in respect of the important / relevant environmental parameters existed in the study area prior to project implementation.

The environmental parameters selected in the study for determination of their baseline levels and their application for the eventual analysis of the impacts / changes caused by GBHPP (discussed in next chapter) fall into the following main components of the environment:

- i. Physical Resources
- ii. Ecological Resources
- iii. Human Use Values and
- iv. Quality of Life Values

4.4.1 Physical Resources

4.4.1.1 Surface Water Quantities in River Indus (Hydrology)

4.4.1.1.1 River Morphology

The river Indus attains braided shape in its flow between Tarbela reservoir and its confluence with the river Kabul near Attock bridge. During this reach, the river flows from east to west covering a distance of about 49 Kilometers. Immediately down the Tarbela reservoir, the channel is narrow; however, it begins widening as it flows down and down. The widest shape is attained down the Ghazi-Gallah where the river widens and divides into numerous channels extending up to 3-5 Km in breadth.

The meandering activity of the river along its downstream-reach creates small and large river islands called *Belajats* locally. The braided channels of the river through the scouring and deposition effects during the annual high and low cycles reshape the channels over time. Due to this phenomenon, the river Indus does not flow over permanent course and instead has been redirecting its channels since it started flowing in this part of the world.

4.4.1.2 Surface Water Quantities

As the hydrologic regime of the river system is considerably changed by the construction of a barrage and the consequent diversions of waters. Therefore, data has been obtained for the average discharges of river Indus for the normal and flood conditions covering all the months of few years. This makes the researchers draw useful conclusions about the impacts of water resources projects including the GBHPP after their implementation.

This section provides the basic baseline information about the average discharges of river Indus in the braided channels below Tarbela reservoir in the study area that existed before implementation of GBHPP. The river Indus is originated from lake Mansar in China and passes through the disputed territories of Kashmir before entering into northern Pakistan and down into the Tarbela reservoir. It is mainly fed by the melting of huge glaciers in the extensive watersheds of river Indus and its tributaries, which as said, are lying partly in the northernmost parts of the country and partly across the borders.

The watersheds of Indus and its tributaries cover the huge mountain range of Karakoram, Himalayas and Hindukush chain. The Karakoram's huge glacial ice, which is the largest in expanse too outside the Polar Regions, is the main source of waters in the mighty river Indus. Therefore, the surface water quantities fluctuate in the Indus and its tributaries due to climatic variation, particularly temperature, in their vast watersheds areas. Consequently, the months from October-April experience the natural low discharges, while the months from May-September show the highest discharges due to melting of glaciers and monsoon rains in this region.

The evaporation of water from the surface of the braided channels and water seepage through the soil is considered to cause considerable loss of surface water quantities; however, the seepage of water through the soil course texture leads to enormous recharge of groundwater quantities in the surrounding areas.

The monthly water discharges in the braided channels of the river in the study area are displayed in the figures and tables in the next pages. The data are given for the 10 year pre-project water discharges to make the comparison with the post-project situation and analyze the net changes due to implementation of GBHPP. The eventual changes in the surface water quantities caused by GBHPP in the study area have been further elaborated in detail in chapter # 5.

Figure # 4: Mean discharge in January in Indus river in the study area before GBHPP (1994-2003)

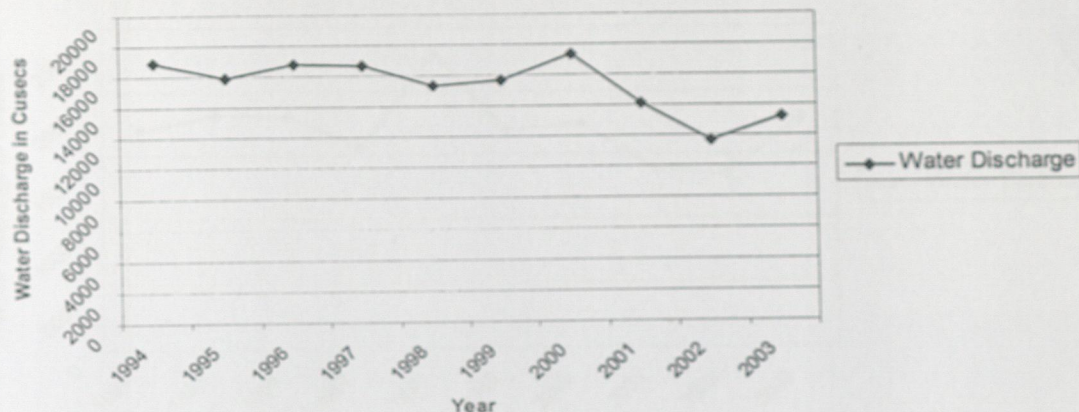


Table # 24: Mean discharge in January in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	16900	15933	16733	16700	15367	15633	17333	14133	11667	13233

Source: Derived from WAPDA Reports

The figure # 4 shows that although, there is relatively reduced water discharge during the month of January. However, this quantity has been proven enough to support the aquatic ecosystem and the related resources in the braided channels below the barrage of the GBHPP. The 10 year (1994-2003) data displayed reveals that the highest mean discharge for the month of January was 17,333 cusecs in the year 2000 while the lowest recorded mean discharge of 11,667 cusecs in the year 2002. The river, with these surface quantities, remains capable to retain its homeostasis and recharge the groundwater reservoir in the sample villages and serve the surrounding communities in respect of wide ranging services. The human environment benefit in terms of use of the surface water for washing clothes, milk churning and watering livestock by the women folk; besides use for the water mills, other socio economic returns and recreational utilities of the fascinating scenes along the braided channels of the river in the study area.

Figure # 6: Mean discharge in March in Indus river in the study area before GBHPP (1994-2003)

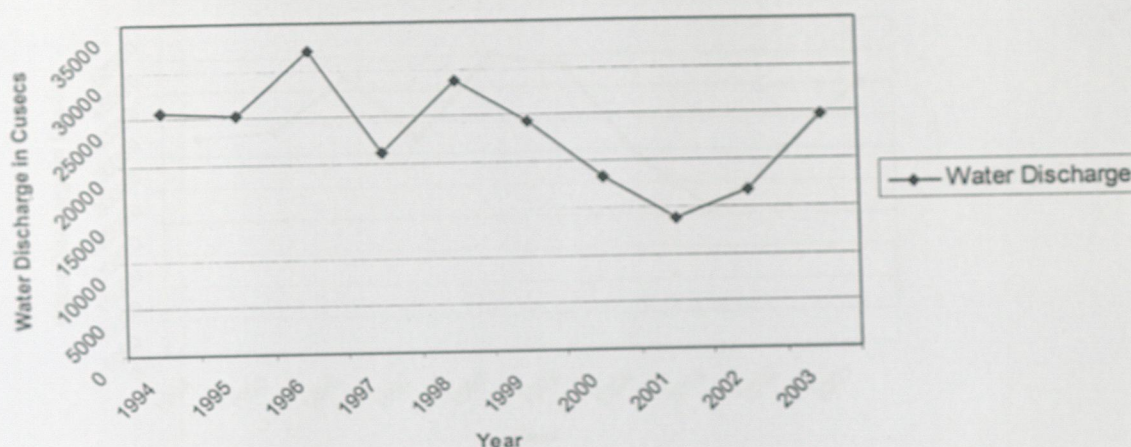


Table # 26: Mean discharge in March in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	25733	25200	32067	21200	28833	24367	18333	13800	16667	24633

Source: Derived from WAPDA Reports

The data shows that sufficient water was flowing in the river before GBHPP during the month of March for sustaining aquatic life in the river, the terrestrial flora and fauna in the river's Islands (*Belajats*) and other socioeconomic services for the local communities. The minimum discharge recorded for the month March is 13,800 cusecs in the year 2001, while the maximum recorded discharge was 32,067 cusecs in 1996. The variation in the discharge is related to changes in the climatic conditions in the upstream watershed areas of river Indus river and its tributaries.

Figure # 7: Mean discharge in April in Indus river in the study area before GBHPP (1994-2003)



Table # 27: Mean discharge in April in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	32900	33567	42067	32633	45367	43233	28733	20567	29833	40133

Source: Derived from WAPDA Reports

The figure # 7 shows that the mean discharge has gradually increased due to rise in temperature and the subsequent melting effect of the snow in the northernmost parts of the watershed areas. The watersheds of Indus and its tributaries cover the vast areas, partly in the country and partly across the country's borders. Like the month of March, April has also experienced minimum discharge during the year 2001. However, the gross discharge has increased from 13,800 cusecs in March to 20,567 cusecs during the month April. The highest discharge during the month of April has also occurred in the same year of 1996 as was for the month of March in 1996. The highest discharge has increased to 42,067 cusecs, which was 32,067 cusecs in the preceding month of March. The rise in surface water quantities contributes further to beneficial impacts on the terrestrial ecology of *Belajats* (river's islands), constituted by the river's meandering course during the high discharge seasons.

Figure # 8: Mean discharge in May in Indus river in the study area before GBHPP (1994-2003)

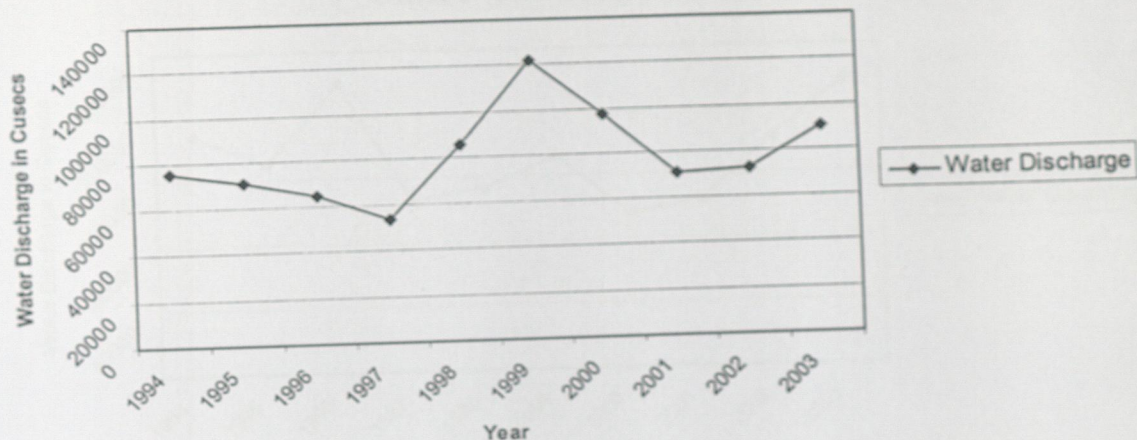


Table # 28: Mean discharge in May in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	75200	70400	64400	53533	85533	122067	97500	71033	72433	90500

Source: Derived from WAPDA Reports

As increase in the temperature continues, the surface water quantities rise up in the river Indus and its associated tributaries. The minimum discharge of 11,667 cusecs in January, 2002 is noticeable for comparison with the minimum of 53,533 cusecs during the month of May, 1997. The figure shows that the highest average discharge during the month of May during the 10 year discharge data before GBHPP has been 122,067 cusecs in the year 1999. The high discharges contribute to rivers resources as well as to safeguard of *Belajats* and the eventual fast growth of the forests and natural vegetations. The periodic rise and fall in water discharges acts as an effective natural mechanism for the growth / regeneration of flora during high discharge season followed by their utilization / exploitation during the low discharge season.

Figure # 9: Mean discharge in June in Indus river in the study area before GBHPP (1994-2003)

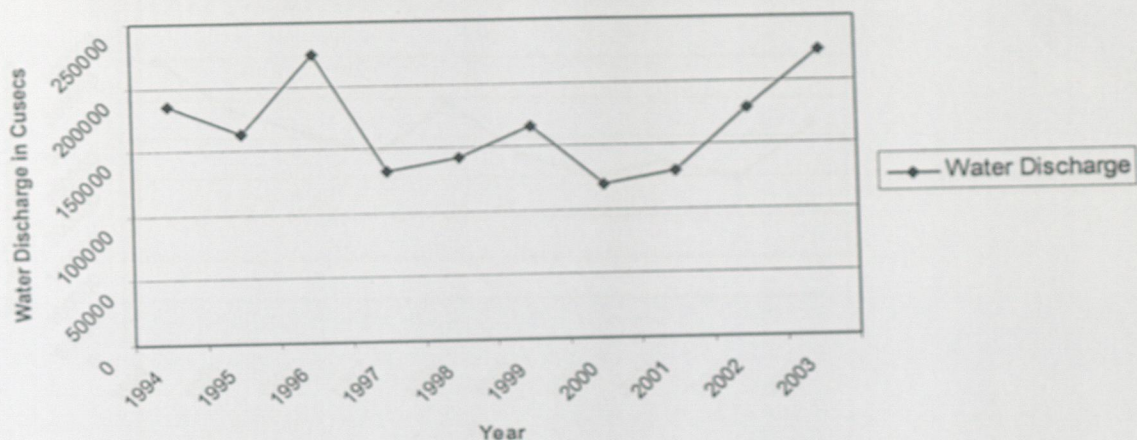


Table # 29: Mean discharge in June in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	184700	162767	224733	131533	141667	166300	119900	129600	178133	223467

Source: Derived from WAPDA Reports

The high temperature coupled with increase in precipitation due to advent of monsoon rains in this region, result into further rise in the river discharge during the month of June. The minimum water discharge for June, thus recorded, is 119,900 cusecs during the year 2000 over the 10 year water discharge data before GBHPP. The maximum water discharge in the month of June during the same period i.e 10 year data before GBHPP is 224,733 cusecs during the year 1996. The river during the month of June is fully capable to extend all the potential to active floodplains and the *Belajats* constituted by the river.

Figure # 10: Mean discharge in July in Indus river in the study area before GBHPP (1994-2003)

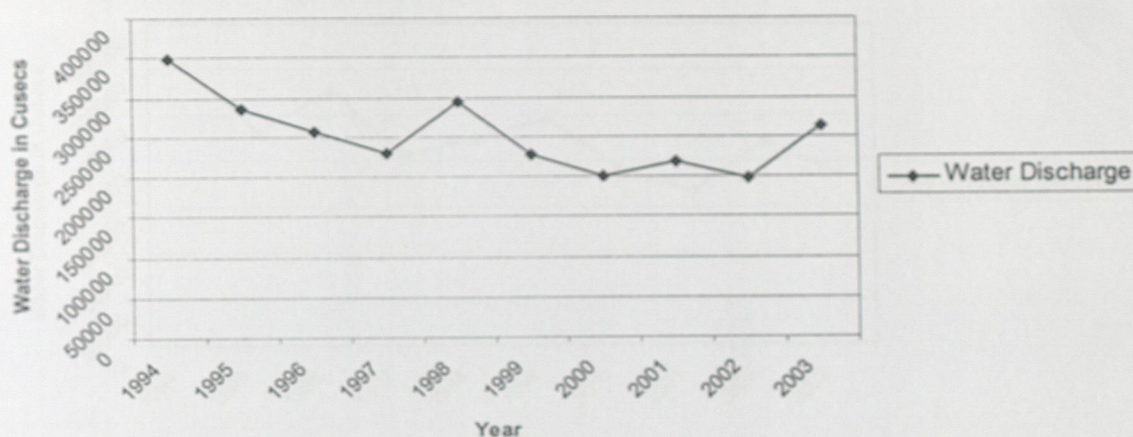


Table # 30: Mean discharge in July in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	349400	285900	255200	229267	293400	227300	200600	218167	198233	262033

Source: Derived from WAPDA Reports

The figure # 10 shows that increase in the surface water quantities continue over the month of July due to persistent trend towards extremeness in the temperature and monsoon pouring in the upstream watersheds of Indus. The watersheds being the largest in extent spread over the gigantic mountain range of Karakoram, Himalayas and Hindukush chain. The Karakoram's huge glacial ice, which too is the largest in expanse outside the polar regions; is the main source of this mighty river. Thus the greater the watersheds in size and favorable temperature for ice melting and monsoon rainfalls. the highest discharge occur in Indus, especially in summer. The minimum average discharge has been 198,233 cusecs in July during the year 2002 and with the maximum of 349,400 cusecs in the year 1994 over the preceding 10 year discharge data before GBHPP.

Figure # 11: Mean discharge in August in Indus river in the study area before GBHPP (1994-2003)

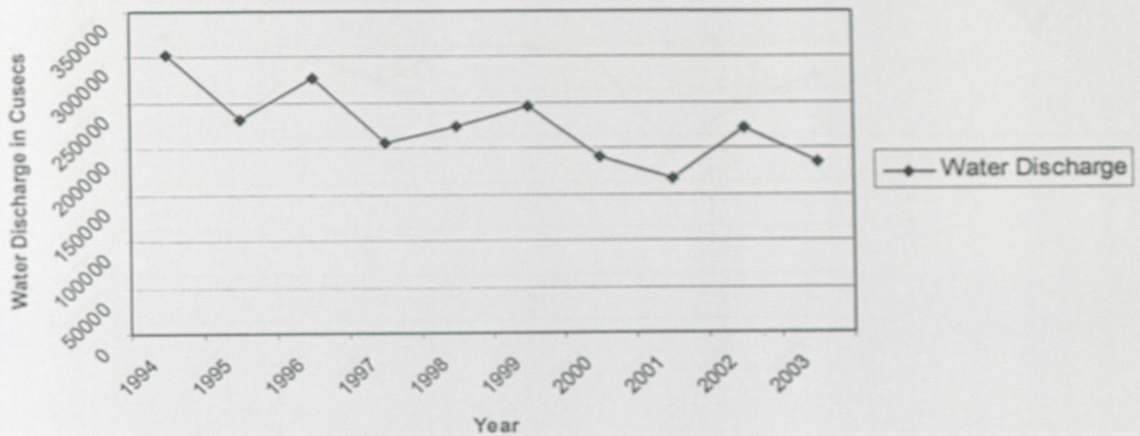


Table # 31: Mean discharge in August in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	303667	232333	278000	206900	224967	245733	190100	166967	221367	184933

Source: Derived from WAPDA Reports

The figure # 11 reveals that the month of August has recorded a downward trend in the surface water quantities in the river over the 10 year (1994-2003) data of water discharges. It is interesting to note that the reversal of the climatic extreme causes decrease in the discharge of the river. Hence the minimum discharge of 198,233 cusecs during the previous month of July has decreased to 166,967 cusecs in August in the year 2001. Furthermore, the maximum discharge has declined from 349,400 cusecs in July during the year 1994 to 303,667 cusecs in August during the same year. However, decrease in the river discharge on the other hand, marks the beginning of yet another period in form of the historic utilization of the resources of *Belajats* by the local communities. Hence the rise and fall of water discharges in the river is blessing for the local populations, which historically rely on the resources of the river and its *Belajats* for their socio-economic development.

Figure # 12: Mean discharge in September in Indus river in the study area before GBHPP (1994-2003)

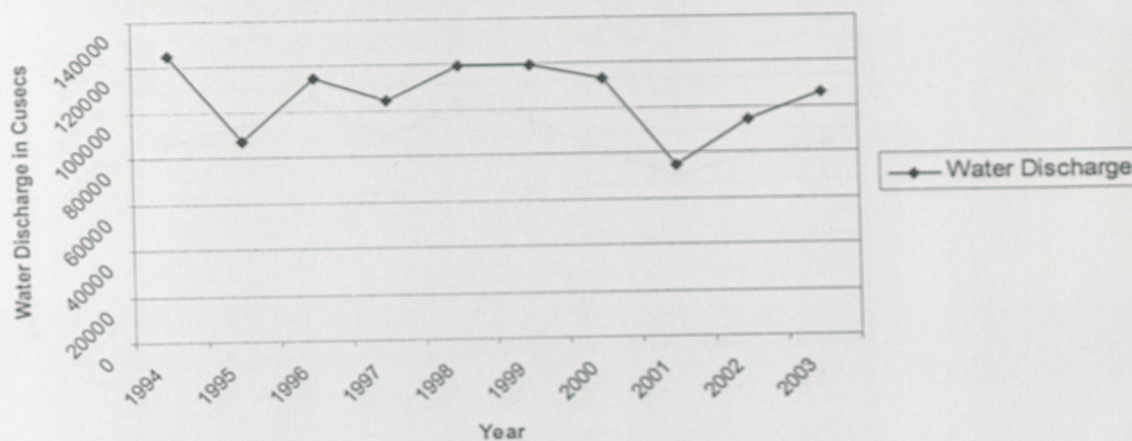


Table # 32: Mean discharge in September in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	124733	87667	115033	104833	119200	119367	113367	75033	94367	106033

Source: Derived from WAPDA Reports

The figure # 12 shows that further decrease has occurred in the average discharge of Indus during the month of September. The data reveals that the minimum discharge has declined from 166,967 cusecs in August, 2001 to 75,033 cusecs in the month of September of the same 2001 year. Similarly the maximum discharge has decreased from 303,667 cusecs in August to 124,733 cusecs during the one and same year of 2001. As described earlier, the reversal of the climatic extreme of summer directly influences the surface water quantities in the river Indus river and its associated tributaries in the upstream watershed areas.

Figure # 13: Mean discharge in October in Indus river in the study area before GBHPP (1994-2003)

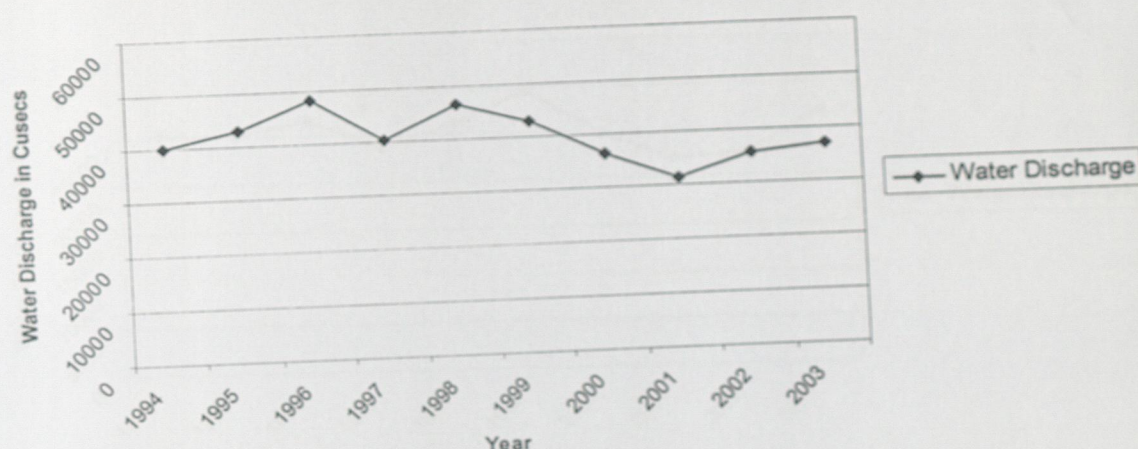


Table # 33: Mean discharge in October in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	40000	42933	48200	40367	46633	42867	36333	31300	35633	37133

Source: Derived from WAPDA Reports

As shown by the discharges data in the figure # 13 and table # 33, the month of October is in fact the beginning of the low discharge season of the river Indus. The data reveals that the mean discharge during the month of October was more closed to the mean discharges of April, especially of the late April. This is interesting to note that generally a resemblance exists between the climatic conditions of October and April and consequently so are the similarities in the discharges of the two months. The month of October is marked with the minimum discharge of 31,300 cusecs in the year 2001 and 48,200 cusecs as the maximum discharge during the year 1996 during the 10 year discharges data interpreted in the figure for analysis of the pre-project conditions.

Figure # 14: Mean discharge in November in Indus river in the study area before GBHPP (1994-2003)

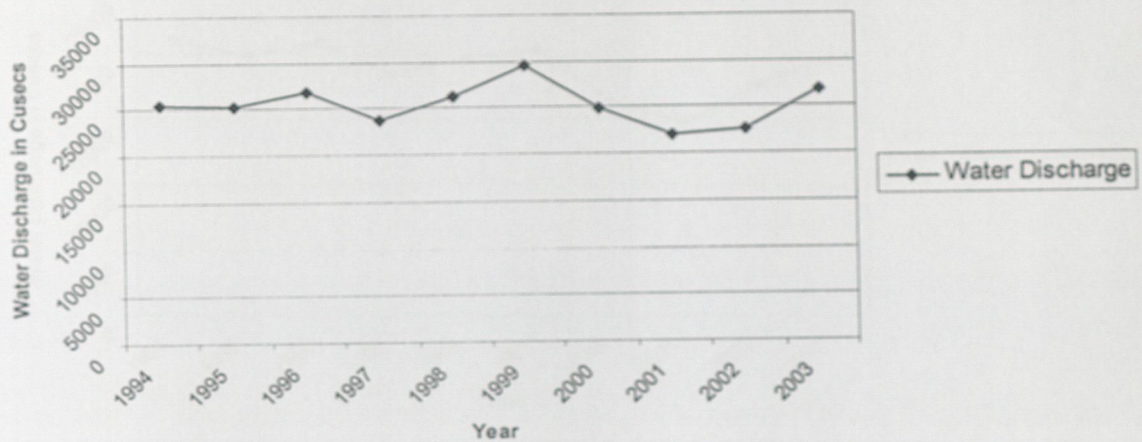


Table # 34: Mean discharge in November in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	25400	25267	26900	23767	26233	29633	24800	22000	22600	26900

Source: Derived from WAPDA Reports

The data shows that decline in the water discharges continue in river Indus in the study area to portray the salient characteristics of its morphological settings during the alternating low discharge season. The highest mean discharge of 34,400 cusecs recorded for the month of July, has decreased to the highest mean discharge of 29,633 cusecs during the month of November for the year 1999. Similarly the minimum discharge has declined from the minimum 198,233 cusecs of July to 22,000 cusecs for November during the year 2001. However, with this quantity of surface water in the braided channels, the river is found fully capable to extend the potential benefits in terms of physical, ecological, human use values and quality of life values for the local communities.

Figure # 15: Mean discharge in December in Indus river in the study area before GBHPP (1994-2003)

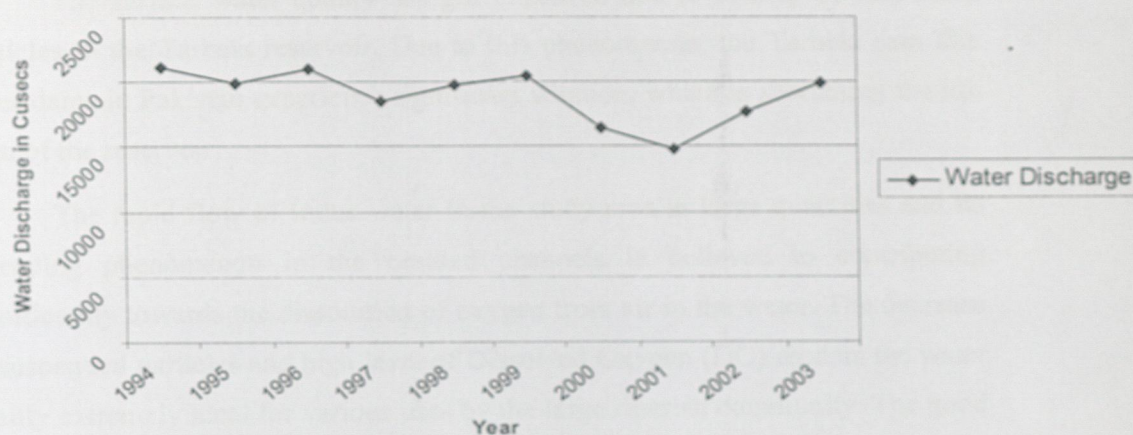


Table # 35: Mean discharge in December in Indus river in the study area before GBHPP (1994-2003)

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Water Discharge (in cusecs)	21133	19833	20967	18567	19700	20400	16400	14800	17700	19933

Source: Derived from WAPDA Reports

As the low discharge season continues through the month of December, the minimum and maximum discharges have decreased further in the river. The figure shows that the mean minimum discharge has decreased from 22,000 cusecs for the month of November during the year 2001 to 14,800 cusecs in the same year. Similarly the mean maximum discharge that was recorded 29,633 cusecs during the month of November has declined to 21,133 cusecs during December in the year 1994. As discussed earlier, the decrease in surface water quantities to this level has not affected the services extended by the river for the natural and human environment in the study area. Thus the local populations have been able to exploit the variety of terrestrial and aquatic resources associated with the braided channels of the river during the prevailing low discharges season.

4.4.1.3 Surface Water Quality

The surface water quality has got improved due to settling of suspended particles in the Tarbela reservoir. Due to this phenomenon, the Tarbela dam like other dams in Pakistan experience significant siltation, which is shortening the life span of the reservoir.

The rapid flow of Indus water in the study area in large quantities and its spreading phenomenon in the braided channels is believed to contributing significantly towards the dissolution of oxygen from air in the water. The decrease of suspended particles and high level of Dissolved Oxygen (DO) renders the water quality extremely ideal for various uses by the large riparian community. The good quality of water in the braided channels of river Indus in large quantities constitute its traditional use for fishery, watering animals and other uses like drinking and bathing. Moreover, due to good quality of water, the women folk of the surrounding villages use the river for washing and milk churning at designated spots along the river banks called *Gudders* locally. *Gudders* are the popular meeting points and are separate for male and female culturally. The male usually avoid visiting or passing near the *Gudders*, which are meant for the women folk except for the minors. The cold breeze gives pleasant sensation during the summer's hottest months and large numbers of people visit the river banks for recreational purposes.

4.4.1.4 Ground Water

The ground water quality and quantity generally depends on the nature of the surface water flowing over an area, infiltration and seepage rate through soil. In most cases, the dams and reservoirs in Pakistan have caused a rise in the water table in the immediate vicinity and depletion of water in the mountains foothill due to increase in run-off following loss of vegetation and deforestation.

The water-flow of Indus especially in its braided morphology in the study area is the main source of ground water recharge in the closed vicinity. Thus the seasonal variation in the water quantities in the river has a direct relationship with the groundwater table or aquifers in the study area. The good water quality of river Indus leads to significant recharge of ground water reservoir. The rich ground water reservoir, in turn is used for drinking purposes as well as for withdrawing

ground water from the dug wells for irrigating the farm lands. The area is adopted with the historic system of withdrawing ground water from the dug wells through using the power of animals, which is called "Persian Wheal" / or "*Arat*" in the local language. The dug wells in the residences and in the farm lands show distinctive marks of variation of ground water table resulting due to variation in the surface water quantities during the annual high and low flow seasons.

4.4.1.5 Soils

Alluvium soil is found in the deltaic terraces and in the *Belajats* (small river islands) constituted by the meandering activity of river causing successive bed erosion and deposition during the high and low flow season along the study area. Areas in the active flood plain lying higher but low enough to be inundated during high flow season are made up of sand and gravels. The sand and gravels are replaced by the cobbles and boulders in the active beds of the river channels.

The surrounding villages lying on river bank / or in the closed proximity possess good agricultural land. The type of soil varies from silt to sandy in composition. Most of the agricultural land is rain-fed or otherwise is provided with water through the traditional Persian Wheals. However, a good proportion of agricultural land in the right bank areas of Swabi receives irrigation water from the canal system. The remaining land in this region is either rain-fed or irrigated through the animals run Persian Wheals, most of which too, are now replaced by electric pumps.

4.4.1.6 Geology / Seismology

The huge mass of water impounded in a barrage / reservoir can cause the instability in earth's strata. This effect may be accelerated if there is already any seismological problem in the site of reservoir/dam. Due to inadequate attention to this problem, the upstream Tarbela reservoir has been constructed on earthquake's belt; which is one of its remarkable drawbacks. This aspect is believed to have been neglected due to non-provision of adequate environmental impact analysis (EIA) of Tarbela reservoir during the detailed feasibility study of the project.

4.4.1.7 Climate

The area being located in the tropical region, there is significant evaporation of water from the surface of water. The evaporation and the local breeze passing over the cold water of the Indus bring some microclimate change in the vicinity. As the original source of water in Indus is primarily from the melting of glaciers located in the extreme north, the local breeze in contact with cold water of the river bring favorable sensation in the hottest months of the summer.

4.4.2 Ecological Resources

4.4.2.1 Fisheries

The study area is exceptionally popular for its richest resource of fishery in the entire lengths of river Indus. The abundance of fishery is related to the ideal ecological conditions that exist in this area. The clear crystal water of Indus and its vast expansion downstream Tarbela reservoir up to its confluence with river Kabul at Attock provide unique habitat for the fishery resource. The area is also popular for the traditional extravagant fishermen who practice fishing in river Indus as their sole profession since their forefathers in the area.

The morphology of the river downstream Tarbela manifests its division into small and bigger channels and their repeated reunion and re-division provide vast area for the rapid growth of fishery. The inaccessible deep creeks in some of the channels act as significant stocks for the relatively shallow wide channels which are increasingly accessible by the local fishermen and where huge fishing is undertaken. The river Indus in this reach is home to a few useful species of fish. However, the economically abundant species are "*Mallah*" (*Shizothorax sp.*), "*Mahsheer*" (*Barbus putitora*) and "*Chaina*" (*Mystus oar*). During the survey, this was revealed that as more as 80% of the fish catch is comprised of *Mallah*. The *Mallah* fish is very popular for its delicious taste. To majority of the people, it tastes as delicious as the popular trout fish of the northern coldest water. The fishermen (locally called *Mahimar*) usually practice fishing in groups. The individual group of fishermen is called "fishing party" locally and its members vary from 3-5 to as many as 15-20. The rich supply of fishery, particularly to the local and remote urban areas in general, has been playing a significant role in

supplementing the protein component of the daily diet. The profile of local fishermen is shown in the table # 36.

Table # 36: Profile of fishermen in the study area and their income

Sample Villages		Total No. of fishermen in the village	Average household size of fishermen	Average income per month per family of fishermen in PKR
Dist Swabi	Gallah	10	8	9,000
	Bata Kara	97	9	10,000
	Hund	70	7	7000
Dist Haripur	Khalu	Negligible	NA	NA
	Jammu	Negligible	NA	NA
	Qazi Pur	30	8	7000
	Aldo-Jabbi	Negligible	NA	NA
Dist Attock	Jalalia	Negligible	NA	NA
	Daman	Negligible	NA	NA
	Formali	Negligible	NA	NA

Source: Field Survey, 2007-08

The average fish catch per fishing party and the average total in the sample villages is shown in table # 37 below.

Table # 37: Daily fish catch per fishing party and the total catch in the sample villages

Sample Villages		Average fish catch per day per fishing party before GBHPP (in Kg)	Total average fish catch per day in the village (in Kg)
Dist Swabi	Gallah	10-100	20-200
	Bata Kara	50-200	200-1000
	Hund	10-40	50-200
Dist Haripur	Khalu	Nil	NA
	Jammu	Nil	NA
	Qazi Pur	20-50	50-100
	Aldo-Jabbi	Nil	NA
Dist Attock	Jalalia	Nil	NA
	Daman	Nil	NA
	Formali	Nil	NA

Source: Field Survey, 2007-08

NA: Not Applicable due to non-presence of fishermen in the village.

The perception of the fishermen and the residents about the abundance of various species and the price of fish in the local market is described in the table # 38 below.

Table # 38: Common fish species in river Indus and the average fish price in the study area

Sample Villages		Peoples' perception about abundant species in river in the study area			Price of fish per KG
		<i>Mallah</i> (<i>Shizothorax sp.</i>)	<i>Chaina</i> (<i>Mystus oar</i>)	<i>Mahsheer</i> (<i>Barbus putitora</i>)	
Dist Swabi	Gallah	90 %	7 %	3 %	25
	Bata Kara	95 %	3 %	2 %	30
	Hund	90 %	8 %	2 %	30
Dist Haripur	Khalu	80 %	17 %	3 %	35
	Jammu	87 %	10 %	3 %	35
	Qazi Pur	80 %	15 %	5 %	25
	Aldo-Jabbi	85 %	12 %	3 %	30
Dist Attock	Jalalia	70 %	20 %	10 %	40
	Daman	75 %	15 %	10 %	45
	Formali	70 %	15 %	15 %	35

Source: Field Survey, 2007-08

4.4.2.2 Forests in *Belajats*

The winding course of river Indus along its downstream-reach, below the Tarbela reservoir, creates small and large river islands or bars called *Belajats* locally. In this reach, the river tends to rework actively, somewhere erode and somewhere deposit and reshape its morphology. This phenomenon happens through the processes of bed scouring by the river and the following sediment deposition during the annual high and low-flow cycles of the river. Over the span of years, this activity of the river has resulted in the development of a series of river-islands (*Belajats*) of varied ages.

The river islands (*Belajats*) can be further categorized into two broad

I. The permanent *Belajats* are the islands, which have terraces lying permanently above the active flood plains of the river. These islands usually remain un-inundated by the river during the seasonal high flows. However, there are a few, which are inundated during exceptionally very high floods in the river. These *Belajats* have thick vegetation cover and are comprised of specific plant species. In the permanent *Belajats*, some are usually grazed by the livestock, while a few remain inaccessible and un-grazed. The vegetation consists of a mixture of trees, shrubs and grasses, which show distinct strata in the islands. The *Dalbergia sisso* is the dominant specie found and is potentially of greater economic value. The other common species of trees are *Acacia nilotica* and *Acacia modesta*. The *Zizyphus nummularia* is the dominant specie amongst the shrubs in these islands.

The presence of thick layers of grasses is remarkable feature of these islands, which signify the utility of these vast terraces for the local communities living within the reach of these islands. The *Saccharum grifithii* is believed to be the pioneer grass in the early succession stage of habitat development. The other common grasses are *Imperata cylindrical*, *Saccharum munja* and *Saccharum spontaneum*. The grass species, which contribute progressively to grazing, are *Cynodon dactylon* and *Cenchrus ciliaris*. Moreover, there are some grass species either un-liked by the livestock or uneatable. Amongst them the *Cymbopogon jawarencusa* is dominating in some places.

Some of the permanent *Belajats*, which are usually inundated and grazed, grasses like *Cynodon dactylon*, *Poa supina*, *Cenchrus ciliaris*, *Desmostachya bipinnata*, *Indigofera linifolia*, *Imperata cylindrica* and others are the common species.

II. The temporary *Belajats* can further be divided into;

- i. Temporary *Belajats* with vegetation cover, and
- ii. Temporary *Belajats* without vegetation cover

i. These *Belajats* are primarily transitional in their course of development. Some of them may transform into permanent *Belajats* if they experience repeated deposition of sediments / silt while some may disappear through the process of acute erosion during high flood flows. The *Saccharum grifithii* is the only specie which can nourish on the gravel substratum of these islands. However, the

Polygonum barbatum can thrive in places where the substratum is sandy loam and rich in nutrients.

ii. These *Belajats*, which are without any vegetation cover, are in fact consisted of the gravel and sand bars. These are formed recently and are relatively small in size. Very often, these bar change their position due to the river processes of erosion and deposition and are so liable to be washed away during the high flood flows in the river.

4.4.2.3 Wildlife in the *Belajats* (Terrestrial Fauna)

The braided channels created by the sinuous course of river during this reach constitute ideal habitats for the terrestrial fauna. Similarly being guarded by the persistent flows in the river, the human access has been sufficiently restricted to these valuable wildlife habitats. The study area carries special significance for the variety of wildlife species native to the favorable environment in this area. Thus the *Belajats* created by the river possess rich genetic diversity of avian, reptiles and mammals.

The *Belajats* provide habitats for a variety of species, most of which stay permanently the whole year in this area whereas some species i. e the Waterfowl and other water-related birds use this area temporarily as stopover during their seasonal migration from the colder areas to the temperate / tropical regions. The cranes visit this area in large number during their migration from Siberia on their onward journey to the south of the country. Similarly many other species of water-birds stay temporarily on their way to the coastal wetlands of the south.

The Herons, Terns and Kingfishers depend upon open water for feeding on small fish, whereas the Ducks use the area for feeding on plant life and resting. The Wagtails and some Larks are also abundant in these *Belajats*. Other common species are House Crow, Common Mynah, Red-vented Bulbul, and Collared Dove. The Bee-eaters, Woodpeckers, Parakeets, Warblers and Thrushes are also found during this reach.

Moreover, the good numbers of *Belajats*, which are above flood level and are permanent in nature, are home to wild Boar, Jackals, Rabbits and Rodents species. The wild Cats are also present in the permanent *Belajats* and a number of attacks by them have been reported by the local population.

4.4.2.4 Forest Management in *Belajats*

The *Belajats* of the study area are rich in the natural flora and possess variety of trees, shrubs and grasses. There are great beneficial uses of these resources as fuel-wood and forage for the livestock. For the distribution of the earnings from the forests of *Belajats*, the village share-system is used.

This is an old system and is the legacy of the British system before the creation of Pakistan. As discussed previously, under the British system, the proprietary tenures were applied to cultivated lands called *Shamilat-e-Tal*, where as the pastures areas including riverain islands (*Belajats*) were declared as village commons or *Shamilat-e-Deh*. The resources of *Shamilat-e-Deh* would thus divide according to the proportion of share in the *Shamilat-e-Tal* to individual owners of the *Tal*. This system has been continued with under Pakistan till to-date.

As per decisions of the Superior Courts, however, the *Belajats* can be used for forage collection without any restrictions to any individuals of the village (tenants), whether or not the individuals own any land in the *Shamilat-e-Tal* or cultivated land of the village. The *Belajats* and its related resources, particularly the forests, are managed by the village committees of elders. The village committees usually hire the services of a guard locally called *kakhey* locally to look after the forests of the village in *Belajats* and prevent any illegal cutting in the forests. The village committees impose fines as punishment for illegal logging in their respective forests in the *Belajats*.

4.4.3 Human Use Values

4.4.3.1 Water Supply

The river benefits the local communities both directly and indirectly in many ways. The settlements, which are situated on-bank or very closed to the river, use the river water directly for potable water. The women folk usually collect water from the river in big earthen-pots and take them home for use in homes.

The women use a common collective point on the river bank for filling water from the river for use in home, washing clothes and a good number of them also use the cold water of river for churning milk. Such common points of a village are called *Gudders* locally. The gents strictly avoid passing through the villages' *Gudders* where the women freely perform their routine works and amuse by

gossiping among themselves. The river has another significant use by the local community. The villagers use the river for watering their domestic animals, particularly the animals, which for the time being are not taken to *Belajats*.

The braided channels of the river are observed to contribute significantly to ground water recharge in the settlements lying within the closed proximity to relatively remote from the river channels. The study has revealed that the water table of ground water of villages lying within a distance up to 3 km from the river fluctuates drastically by the seasonal variation in quantities of water in the river. The effects keep decreasing with the increase in distance from the river. Nevertheless, the river performs its significant key role in the consistent, safe and regular supply of water for the people of the study area. The table # 39 summarizes the aforesaid benefits of the river in terms of water supply for the local communities as given below.

Table # 39: Use of river by the women folk and livestock in the study area

Sample Villages		No. of <i>Gudders</i> on the river	Women visiting village's <i>Gudders</i> daily in average	Average No. of domestic animals watered with the river per day
Dist Swabi	Gallah	2	100 per day	200
	Bata Kara	4	20 per day	150
	Hund	2	30 per day	200
Dist Haripur	Khalu	2	15 per day	15
	Jammu	Nil	NA	20
	Qazi Pur	4	30 per day	70
	Aldo-Jabbi	2	25 per day	100
Dist Attock	Jalalia	Nil	NA	50
	Daman	Nil	NA	60
	Formali	2	30	200

Source: Field Survey, 2007-08

4.4.3.2 Aquaculture

The vast braided channels of Indus provide great potential for the propagation of fishery resource in the project area. The consistent supply of good water quality round the year can contribute to reproduction of fisheries and the eventual huge fish supplies. However, there have been no efforts so far on part of

the government or private stakeholders to initiate such programs for maximizing fish reproduction in the area. Nevertheless, the river acts as a great natural repository of fish resource in the study area. The study showed that the dominant specie is *Mallah* (*Shizothorax sp.*), which is basically a running water specie. *Mallah* is popular for its rapid growth and its delicious taste. Other species are *Chaina* (*Mystus oar*) and *Mahsheer* (*Barbus putitora*). The significant supply of fishery is described in detail in the preceding section under the category of "Ecological Resources". The effective management of this invaluable resource aiming to launch new aquaculture activities can give sufficient boost to fishery reproduction and supplies.

4.4.3.3 Flood Control

The braided shape of the river provides natural mechanism for distributing the high flood water in the vastly spread numerous channels of the river during the flood conditions. This phenomenon reduces the intensity of high floods on the surrounding settlements. There have been no evidence of engulfing the settlement or agricultural land lying within the closed vicinity of the active floodplain in the study area.

Although, there have been devastating floods in the history of Pakistan, the river Indus during this reach has not caused any significant loss to standing crops, built properties, wildlife and most importantly the human lives. This is believed to be due to distribution of flood water in the braided channels and their re-division in numerous channels along the downstream of the river. The eroding effects of high flood water during high floods are largely controlled by the natural vegetations including thick cover of trees in the river islands or *Belajats* in the study area.

4.4.3.4 Mineral Development

The study area is famous for an old profession of gold panning in the sands deposited by the river. Gold panning is practiced by some members of the local community who claim expertise in the profession as legacy of their forefathers. The sand deposited by the river Indus in the study area is comprised of significant quantity of gold mineral.

The community members, who are holding expertise in gold panning profession, practice the traditional manual method of sieving the bed-sands

repeatedly. They use the traditional tools and collect the end product "gold". During this process, they also recover yet another by-product in the form of heavy sand, having particular black texture. The heavy sand so separated during the gold panning, is used as raw resource for iron manufacturing in the iron industries. The heavy sand recovered, is sold to particular agents, who onward sell it to iron industries.

The field study revealed that the gold panners are few in number in the study area, as shown in the table # 40 below, and they practice gold panning when the river is receded after the high flood season of summer. The traditional method of gold panning is shown in the plates # 10-13 in chapter # 5.

Table # 40: Profile of gold panners in the study area and the average recovery of gold

Sample Villages		Total No. of gold panners in the village	Average house hold size of gold panners	average gold recovery per day per person	Average income per family before GBHPP (in PKR)
Dist Swabi	Gallah	Nil	NA	NA	7,000
	Bata Kara	25	10	0.84 gm	15,000
	Hund	15	8	0.48 gm	7,000
Dist Haripur	Khalu	150	9	0.7 2 gm	10,000
	Jammu	Nil	NA	NA	NA
	Qazi Pur	Nil	NA	NA	NA
	Aldo-Jabbi	10	8	0.5 2 gm	8,000
Dist Attock	Jalalia	Nil	NA	NA	NA
	Daman	Nil	NA	NA	NA
	Formali	Nil	NA	NA	NA

Source: Field Survey, 2007-08

4.4.3.5 Industries

A huge industrial estate known as Gadoon Amazai Industrial Estate (GAIE) has been established in the closed vicinity of the study area. The GAIE is located about 7 km east of Tarbela reservoir at Gadoon Amazai, the area which once remained popular for poppy cultivation. The industrial estate was established in the early 1980s to provide alternative jobs to the local population and hence discourage and eventually ban poppy cultivation. The site was provided with tax

rebates to attract industrialists for investment. In the beginning, many industries including chemical, textile, steel and petro-based industries were established. However, after the withdrawal of the tax rebate, many of the industries have been closed. The estate has been provided with electricity, gas, roads and other telecommunication facilities.

The industrial estate has not been provided with any treatment facility for the treatment of the effluents generated by the industries. The effluents generated by the industries are discharged directly into a stream locally called "*khwar*". The receiving stream finally joins the river, and the industrial waste water and effluents ultimately get away into the river waters. The presence of the adequate network of telecommunication, roads and other facilities at the site can prove a core of nucleus for further development of the industries and especially establishing agro-industries in the area.

Pakistan is an agricultural country having plenty of agricultural products but no consideration has been given to the important sector of agro-industries in the planning of development programs. Fruits, vegetables, variety of crops and animal hide are the essential agricultural products of the northern province of Pakistan which needs proper processing for local use and export.

4.4.3.6 Highways / Railways

The construction of Tarbela reservoir and later the establishment of the prestigious engineering institute called as Ghulam Ishaq Khan Institute (GIK Institute), has caused attention to provision of necessary communication facilities in the form of roads and other telecommunication facilities. However, despite the establishment of aforesaid industrial estate, the area has not been provided with railways facility so far. Although, the railway line used during the construction of Tarbela reservoir could have connected the GAIE but unfortunately it has been dismantled and abandoned. This needs to be redeveloped for fast and convenient communication. Presently, the area linked by the local roads are Jahangira-Swabi, Mardan-Swabi; Ghazi-Topi, Hazro-Ghazi and Ghazi-Lawrampur for the main communication and movement in the three regions. The area has also been linked by the newly constructed M1 motorway between Islamabad and Peshawar, through its interchanges at Swabi and Attock. However, the local roads provided are of

medium quality and keeping in view the strategic location of the area, there is dire need to upgrade their status to the highways.

4.4.3.7 Land Uses

The area presents the typical land use pattern of rural environment. The dominant use of land is for agricultural, followed by settlements and minute use for commercial and infrastructure facilities. The agriculture is primarily dependent on using underground water from the dug wells / Persian Wheels as irrigation source for the agricultural farms. The rest of the land is rain-fed. The survey shows that about 80% of the cultivated land is irrigated by the traditional method of Persian Wheel in the three districts. Nevertheless, about 15% is irrigated by the only canal system in the right bank side of river i. e. district Swabi and the remaining 5% there is rain-fed. While no agricultural land is irrigated by the canal system in the left bank side of river i.e Khari region (district Haripur of NWFP) and Chhachh region of district Attock (Punjab) and as such the area remains rain-fed. The study area shows forest cover in the river's islands called *Belajats*. The description of the vegetation in the *Belajats* is provided in detail in the previous paras of Ecological Resources.

4.4.4 Quality of Life Values

4.4.4.1 Socio-Economic

The study area largely portrays the socio-economic profile of a typical rural set up. The three regions constituting the study area, show the socio-economic indicators, which usually characterize rural populations. The study showed that a great number of people are engaged in agriculture with the proportion of 57.1% in Swabi region, 41.3 % in Khari region and 53.1% in Chhachh region. Maize, sugarcane and groundnut in kharif, while wheat and mustard are the dominant crops in rabi in district Swabi region. The dominant crops in Khari region are maize, jowar and groundnut in kharif and wheat in rabi. The dominant crops in Chhachh region are groundnut, jowar and maize in kharif while wheat, tobacco and oilseeds in rabi.

The study revealed that about 70% population in the study area of Swabi region (right bank areas of the river) derive economic benefits directly from the river related resources like fisheries, livestock keeping in *Belajats*, fuel wood

supplies from the *Belajats* and reliance on river-recharged ground water reservoir for domestic and irrigation use. Some professionals practice gold panning too in the sands deposited by the river in this region, however, their number is negligible in this region than the number of gold panning professionals in the Khari region.

The local community in the Khari region (left bank of the river) use the river related resources of fisheries, fuel wood supplies, gold panning in the river beds and river-recharged ground water for domestic and agricultural purposes. However, the direct uses of river's resources are comparatively low in the Chhachh region (left bank) than the Swabi region and the significant uses are confined to ground water utilization for domestic and agricultural use that is mainly recharged by the river.

The literacy rate is variable in the three regions of the study area. The Swabi region represents 39.3 % (57.7 % male : 42.3 % female) literacy rate, the Khari region 55.2 % (69.3 % male : 30.7 % female), while it is 47% in the Chhachh region (61.9 % male: 38.1 % female).

The study shows that Swabi region has the highest household size and the number of persons per housing unit is 7.9, followed by the Khari region of 6.7 persons per housing unit. The Chhachh region shows comparatively low household size, which is 6.3 persons per housing unit. Moreover, as higher as 91.3 % in the Chhachh region, 87.1 % in Khari and 87.2 % population in Swabi region own their houses in the study area. The study showed the largest population of 91% use wood, 3% LPG as source of fuel in Swabi region, while their uses in the Khari and Chhachh region are 70.3 %, 20.7 % and 81.5 %, 15.2 % respectively. The detailed description of the socio-economic condition and the role of the river based resources in the daily life of the local communities is discussed in separate tables # 41-44.

Table # 41: Broad socio-economic characteristics of the study area

Name of District	Literacy rate (%)			Household size	Status of ownership of houses (%)	Source of fuel (%)	
	Both Sexes	Male	Female			Wood	LPG
Swabi (Left Bank Region)	39.3	57.7	42.3	7.9	91.3	91	3
Haripur (Khari Plain)	55.2	69.3	30.7	6.7	87.1	70.3	20.7
Attock (Chhachh Region)	47	61.9	38.1	6.3	85.2	81.5	15.2

Source: Field Survey, 2007-08

There is significant role of river in the profession of gold panning and fishing. The fish catch is huge in quantity and is supplied to remote areas of NWFP and the capital city Islamabad. The gold recovery through gold panning in the river's sand deposited during the high flows contributes towards the gold stock of the country. However, gold panning is highly specialized profession and is therefore, limited to a few families who have been practicing gold panning as their ancestral profession. The details are as given in the table # 42.

Table# 42: Use of river as direct source of income in the study area

Sample Villages		No. of gold panners	Average gold recovery per day per person	No. of professional fishermen	Average fish catch per day (in Kg)
Dist Swabi	Gallah	Nil	NA	10	20-200
	Bata Kara	25	0.84 gm	97	200-1000
	Hund	15	0.48 gm	70	50-200
Dist Haripur	Khalu	150	0.7 2 gm	Negligible	NA
	Jammu	Nil	NA	Negligible	NA
	Qazi Pur	Nil	NA	30	50-100
	Aldo-Jabbi	10	0.5 2 gm	Negligible	NA
Dist Attock	Jalalia	Nil	NA	Negligible	NA
	Daman	Nil	NA	Negligible	NA
	Formali	Nil	NA	Negligible	NA

Source: Field Survey, 2007-08

The *Belajats* are traditionally used for wood supply to villages located adjacent to the river. There is a large public, which use these *Belajats* for the

rearing of their livestock and earn their livelihood by sale of their animals. There is also the practice of keeping livestock permanently during the high flood seasons for about 4-5 months. However, keeping livestock permanently in the *Belajats* during the high flood season is confined to the left bank area i. e the villages of Swabi region. The river is also playing role for watering livestock both, which is kept at home or reared in the *Belajats*. The role of *Belajats* and river water is shown in the following table # 43 and 44.

Table # 43: Role of *Belajats* (river's bars) in wood supply and support of livestock

Sample Villages		Public perception about fuel wood supply in % by <i>Belajats</i>	Average No. of animals per household rearing in <i>Belajats</i>	Average No. of domestic animals watered with the river
Dist Swabi	Gallah	100	7-8	200
	Bata Kara	100	6-7	150
	Hund	100	5-6	200
Dist Haripur	Khalu	50	Negligible	15
	Jammu	45	Negligible	20
	Qazi Pur	60	2-3	70
	Aldo-Jabbi	70	4-5	100
Dist Attock	Jalalia	55	3-4	50
	Daman	60	2-3	60
	Formali	65	7-8	200

Source: Field Survey, 2007-08

The numbers of Gudders in the sample villages, used by the women are described in the table # 44.

Table # 44: Number of women using the river daily at *Gudders* in the study area

Sample Villages		No. of <i>Gudders</i> on the river	Average number of women visiting village's <i>Gudders</i> daily
Dist Swabi	Gallah	2	100 per day
	Bata Kara	4	20 per day
	Hund	2	30 per day
Dist Haripur	Khalu	2	15 per day
	Jammu	Nil	NA
	Qazi Pur	4	30 per day
	Aldo-Jabbi	2	25 per day
Dist Attock	Jalalia	Nil	NA
	Daman	Nil	NA
	Formali	2	30

Source: Field Survey, 2007-08

This was also discovered during the baseline study that there were about 90 water mills (locally called "*jranda*") in the Pontia village lying just below the sample village of Gallah in the floodplains. However, most of them were abandoned for being affected by the Tarbela reservoir. However, 3 water mills in Pontia village are operational and the local populations derive benefits from their sustained cheaper cost.

4.4.4.2 Recreation and Aesthetics

The river Indus has great distinction amongst the prominent rivers of the country to carrying away clean, unpolluted and coldest water in huge quantities since the time immemorial. The huge flows striking the rocky banks create thrilling tune to human ears and charming scenes to eyes. The fascinating environment created thus, has been praised magically in poetry by the local poets. The poets have used the vast meaningful term "*Abaseen*" for the river Indus, which literally means "father of rivers". The river is also popular with this terminology amongst the local elders and others having literary taste.

The large quantities of cold waters in the unique physiographic surroundings, appearing bluish in the day under the clear sky, constitute a significant source for recreational purposes. As the area is devoid of any other spot

for deriving pleasures, the significance of river Indus multiply many fold for the local community. Thus the entire river banks of the braided channels become a common and convenient spot for deriving pleasures and mental satisfaction for the surrounding large community.

The air passing over the cold water in braided channels give the sensation of cold breeze and the eventual wonderful feelings during scorching heat of summer. People from the surrounding as well as from the far flung areas visit the river banks to take refuge from the hassle of busy life and enjoy themselves for few precious moments of time. Some stay over night to enjoy for longer time. There have been ordinary huts constructed for relaxation and over night stay on the river bank. The nights are extremely wonderful along the river during the summer. Some huts serve as commercial hotels and fresh fish of the river are fried there on demand of the visitors / tourists. Recently, a long bridge has been constructed on the newly built M1 motorway (Islamabad-Peshawar) over river Indus at the sample village of Hund, which has linked this area with the rest of the country. The bridge along with the motorway, present a beautiful scenic view amid the mighty river Indus passing through the lush green *Belajats* in the area.

The local population also invites their friends from the remote areas of the country to take them out to riverside particularly during June to August. The college and schools students of the near enough areas visit the riverside in groups in their one day picnic program. However, there has been no attention by the state owned departments for promoting tourism in this wonderful vast strip of land. Due patronage of the Tourism department of the government and the subsequent facilities like decent rest houses, boating and sport fishing facilities are lacking.

4.4.4.3 Archaeological and Historical Resources

The river Indus constitutes a narrower course along the western part of the study area, especially at village Hund on the left bank; and offers thus, a relatively convenient crossing point for the traders, general public and adventurers. Hence the area has a brilliant history for serving as an important corridor between the Central Asian region and subcontinent. The area witnessed both the prosperity and awful miseries in its long history. The trade opportunities between the two regions and its transit through this area brought social and economic well being for the

local people. However, the military adventurism, which has had happened frequently between rulers of the two regions left the area into war fields and the locals suffered heavily. The area has two very popular sites, which has great reflections in writings of the historians and archeologists. As the area remained a passage tract between the two aforesaid regions, the following sites were selected for the construction of forts in the past.

- i. Hund Fort on the right bank of river Indus
- ii. Attock Fort on the left bank of river Indus

i. Hund Fort: The Hund Fort lies at village Hund on the right bank of river Indus in district Swabi and above Attock across the river. The strategic significance of this area was realized when Alexander the Great crossed the Indus at this point. The historians and elders have reported the prosperity of the people of this area on account of transit trade through this point between the Subcontinent and Central Asia in the past. They have mentioned abundant rainfall, streams, orchards and beautiful houses made of wood and dressed stones. Some authors have described that Hund remained winter capital of the Hindu Shahi rulers in about A.D. 800. There have been many wars in the past between the Central Asian rulers and Hindu Shahi Dynasty. However, their description and details is not the scope of this section.

The Hund Fort was constructed on the mounds of Hund by the Great well-known Mughal Emperor Akbar to secure this strategic crossing point on river Indus. Throughout the remaining Mughal period, it served as strategic military base. The construction of Attock Fort on the left bank of river Indus, however, reduced the significance of this great fort forever. There are still some remains of the Hund Fort, although the major portions and buildings have disappeared due to neglect on part of the government and expansion of the village Hund itself.

ii. Attock Fort: The Attock Fort lies on the left bank of river Indus in district Attock opposite to the aforesaid Hund Fort across the river. The Attock Fort was completed in 1583 under the supervision of one of the ministers of Emperor Akbar naming Khawaja Shamsuddin Khawafi. The sole objective of the construction of the fort was to guard the crossing of the Indus from rebels in Kabul and other outside aggressors. The construction of the Attock Fort decreased the strategic

significance of the Hund Fort, as, the route (the present Highway) passing through it, leads straight to Khyber agency. The Khyber agency onward, has been serving as opening corridor to Central Asia. The Khyber agency has become the flash point for the international media in the current scenario of Afghanistan war between Taliban and US led NATO forces. Moreover, it is due to all this geo-strategic significance that Peshawar lying in the foot step of Khyber agency is considered as the gateway city between Central Asia, South East and Far East Asia.

Owing to unfading strategic importance, the Attock Fort has still been kept in good condition. The fort has been rendered inaccessible to wider public / tourists and is still in use of the military forces as prison and barracks.

4.5 CONCLUSION

The baseline data show that the natural and human environments along the right and left bank of the study area are primarily shaped and influenced by the Indus river. The river is originated from Lake Mansar in China and passes through the huge watersheds that are mainly covered by massive glaciers of Karakoram, Himalayas and Hindukush mountain ranges. The huge glaciers being the main source of waters, the discharges fluctuate highly in river Indus. The local people are largely traditional and share many of the customs and values. However, majority of the people in the right bank of Swabi and the Pukhtoons tribes of Ghazi and Attock on the left bank, show great similarities in dress and customs etc, comparatively, to greater extent. The overall natural environment of the floodplains of river Indus in the study area is largely similar to the valley of Peshawar.

The mean discharges of river Indus before GBHPP show that it has the lowest discharges during the months of October to April, and, the highest during the months of May to September. The lowest mean discharge of 11,667 cusecs was recorded in January during the year 2002, while the highest mean discharge of 349,400 cusecs in July during the year 1994. The water quality of Indus in the study area is highly good owing to settling of suspended materials in the Tarbela reservoir. Due to the distributaries and unique meandering, the river has created small and large bars / islands called *Belajats* locally; which are of great socioeconomic value for the local communities.

Although, the river Indus is home to many useful species of fish, however, the economically abundant species are *Mallah* (*Shizothorax sp*), *Mahsheer* (*Barbus putitora*) and *Chaina* (*Mystus oar*) on which large number of professional fishermen depends. The area is popular for the huge fish catch, which varied from 50-100 Kg per day to 200-1000 Kg per day in various villages. The analysis revealed that the *Belajats* have significant role in the fuel wood supplies varying from 50 to 100 % and livestock rearing varying from 2-3 to 7-8 in number per family in various locations. The *Belajats* provided shelter to many species of birds, reptiles and mammals.

The river was found to recharging the groundwater reservoir, which is the principal source of drinking water and irrigation in the study area. Besides, the water mills operate in various locations along the channels. The river also extends many other social services, especially to women folk, such as gathering points called *Gudders* along the river channels on both sides of the river with varying frequencies. Similarly the river is also used for watering livestock where their numbers vary from 15 to 200 animals per day in various villages. Another important feature of the study area is the sands deposited by the river are used for gold panning, which is a significant source of income for the professional gold panners. These professionals are found all along the river channels who recover up to 1 gram of gold per person per day.

The unique physiographic surroundings, lush green *Belajats* and the clear crystal water appearing bluish in the day under the clear sky, constitute a significant and a sole source for recreational utilities in the study area. The study also revealed that the river Indus at the sample village Hund attain narrower shape and thus provides a convenient crossing at this point. The recently constructed motorway, linking the North West Frontier Province (NWFP) with the southern part of the country also crosses the river Indus at this pint. Historically, the area has been an important corridor between the Central Asian region and subcontinent, and onward, to east and far East Asia. Therefore, two strategic forts namely Hund and Attock have been built by the Great well-known Mughal Emperor Akbar in the past to safeguard. Both the forts are considered valuable archeological treasures, the Hund fort has, unfortunately, experienced severe damage due to neglect by the locals and concerned government department. Consequently, some remnants including a few walls of the Hund fort exist in the area, whereas the Attock fort has been kept protected and is still in use by the military establishment.

CHAPTER # 5

ENVIRONMENTAL IMPACTS OF GHAZI BAROTHA HYDRO POWER PROJECT

5.1 OVERVIEW

This chapter highlights and evaluates the changes caused by GBHPP on the floodplains ecology of river Indus in the study area. These changes have been determined in terms of adverse vs beneficial impacts that have arisen on the physical and human environment of the study area. The study area is mainly comprised of the vast number of bars and braided channels of river Indus stretching from barrage of the GBHPP to its confluence with river Kabul at Attock and the surrounding settlements, as shown in map # 1, 2 and 4 and figure # 1 and 2. The study has revealed that the main cause of the alterations in the environment is due to diversion of the huge quantities of Indus water into the concrete power channel constructed for the conveyance of water for power generation downstream at Barotha village, district Attock. The diversion has brought significant alterations in the hydrologic regimes of surface water and the eventual changes in the terrestrial and aquatic ecosystems.

The reduced discharges especially during the months of November to April (natural low discharges season of river Indus) have further been reduced by GBHPP. This, as a result, has deprived the vast braided channels of river Indus of water, which act historically as a bountiful resource to generate variety of resources for the larger population of many villages in the study area. The study has also discovered that most of the impacts are primary in nature. However, the primary impacts, in turn, have invoked the secondary, tertiary and others high order impacts on the physical, ecological, and socio-economic components of the environment.

The selection of the environmental parameters / indicators to analyze the environmental alterations in terms of adverse and beneficial changes associated with the GBHPP in the study area is mainly based on the following four criterions;

- i. Magnitude of the impacts
- ii. Extent

iii. Significance and

iv. Special sensitivity

The magnitude of the impacts means to quantum of change that the study area has experienced due to the project; whereas the extent of the impacts refers to the total area that has been affected due to project implementation.

The significance of the impacts looks beyond the magnitude to the actual effects. The final criterion is region / country or local area specific and has special relevance due to some particular environmental sensitivity. This means that one particular impact, although, very small in terms of magnitude and may be of no significance to local communities in some areas but it may be of special significance to other community due to environmental sensitivity to that impact in another area.

5.2 ENVIRONMENTAL CHANGES BY GBHPP

The environmental parameters selected in the study for determination of their baseline levels (discussed in the preceding chapter) and their application for summary description to analyze the impacts / changes caused by GBHPP fall into the following 4 main components of the environment:

- A. Physical Resources
- B. Ecological Resources
- C. Human Use Values and
- D. Quality of Life Values

5.2.1 *Physical Resources*

5.2.1.1 Surface Water Quantities in River Indus (Hydrology)

The hydrologic regime of the river system has considerably been changed in the study area due to implementation of the GBHPP. The diversion of water into the concrete power channel has caused significant reduction in water quantities in the braided channels of the river. This reduction is the main cause of all the adverse alterations in the floodplains ecology of the river. Water reduction has significantly affected the wide range utilities associated with the historical large quantities of water in the braided channels of Indus in this reach.

The pre project data about the surface water quantities as shown in the previous chapter # 4, confirms the huge water quantities in the river round the year. Although, the water depletes naturally during the winter owing to the precipitation in the form of snow fall and its accumulation in the high mountains range in the watershed areas of Indus and its related tributaries. Although, data was obtained for about the past 30 years, however, monthly and yearly averages were calculated for the past 10 years before the project implementation so as to make data comparison easier for the pre and post project situation analysis.

The pre project 10 years data analysed thus depicts the lowest average discharges of 15,360 cusecs water during the month of January for the low discharges season (October - April). The lowest average of 11,667 cusecs was recorded for the month of January during the year 2002 and the average highest discharges of 251,950 cusecs for the month of July during the past 10 years before the project implementation. The lowest discharges were followed by the lowest average of 18,943 cusecs during the month of December for the 10 years pre project period. It is worthwhile, however, that the average low discharges before GBHPP was found good enough for the support of aquatic life in the river. Similarly this quantity also proved adequate for deriving other utilities from the river.

Due to diversions of huge quantities of waters into the power channel of GBHPP, significant decreases have arisen in the surface water quantities in the braided channels of the river. The data show that the project has caused drastic decreases in water discharges in the low as well as in the high flood seasons of the river. The figures presented in tables 45 to 56 reveal that quantitatively, highest reductions have happened in the high discharges season, however, the percentages of the decreases are highest during the low discharges season, and as a result, most of the channels become dry as shown in the plates # 1 - 4 in the next pages.

The highest percentages of decreases during the low discharges months (October-April) manifest the critically highest significance of the water reductions in the low flood season in the river. The month-wise decreases in the low and high discharges seasons due to implementation of GBHPP and the eventual changes in discharges in the river in the study area are shown in figures 16 to 32 and tables 45 to 59.

Plate # 1: Dry channel of Indus river due to waters diversions in the low discharges season

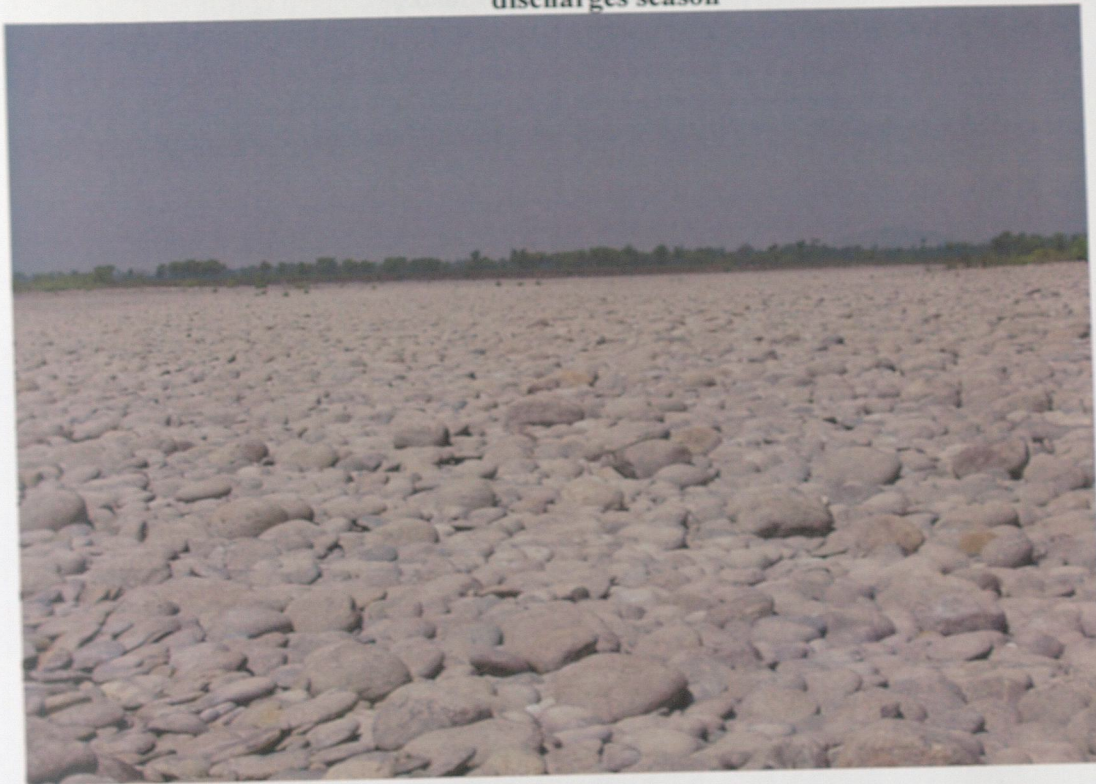


Plate # 2: Dry channel with thin forests in a *Bela* in the background



Plate # 3: Dry channels with insufficient compensatory waters flowing in one of the channels



Plate # 4: One of the creeks as drying up during the low discharges season due to water diversion into the power channel of GBHPP

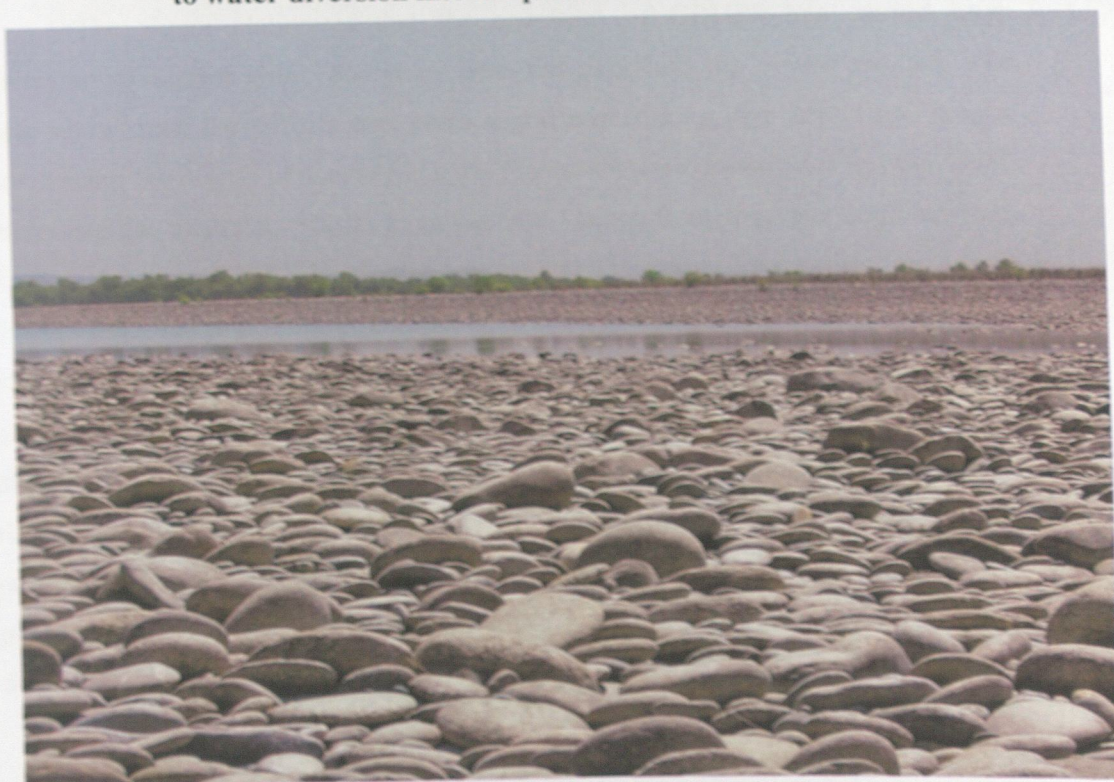
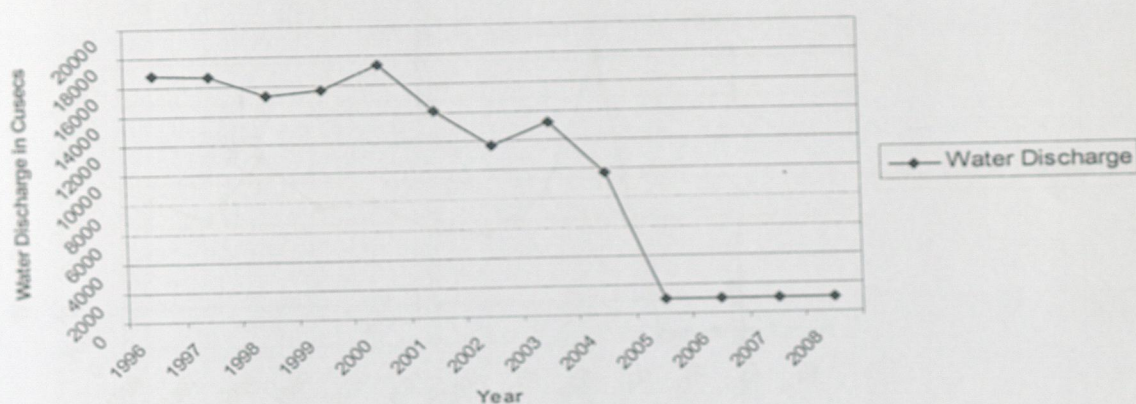


Figure # 16: Comparison of Mean discharges in January in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

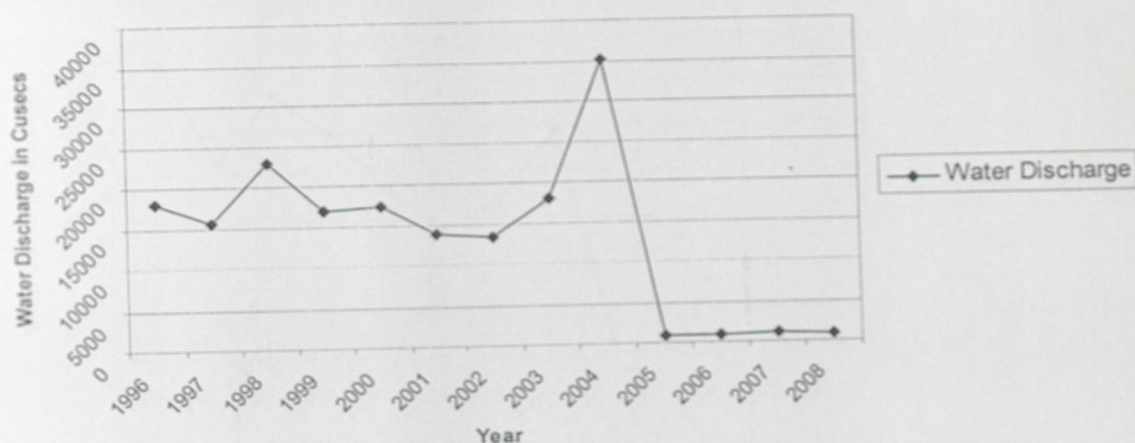
Table # 45: Comparison of Mean discharges in January in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	16733	16700	15367	15633	17333	14133	11667	13233	9713	991	991	1034	989

Source: Derived from WAPDA Reports

The figure elaborates that the operation of GBHPP has caused huge diversion of surface water quantities from the river into the power channel. The data show that the effects are more significant during the low flow season comprising the month of January. As the project became operational in May 2004, therefore, the diversion effects have become visible from the year 2005 onward. Excluding the year 2004, in which experimental operation of the project took from time to time, the minimum discharges of 11,667 cusecs in 2002 have decreased to 989 cusecs in the year 2008 showing 91.52 % significant decrease in the post-project discharges in January. As the river is vastly braided in the study area, the diversions of huge quantities of waters into the power channel leave most of the river channels dry. The small quantity of water shown in the figure in the post project scenario is released as compensatory water for the aquatic life. The photographs taken after implementation of the GBHPP show the dry river channels during the low discharges season.

Figure # 17: Comparison of Mean discharges in February in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

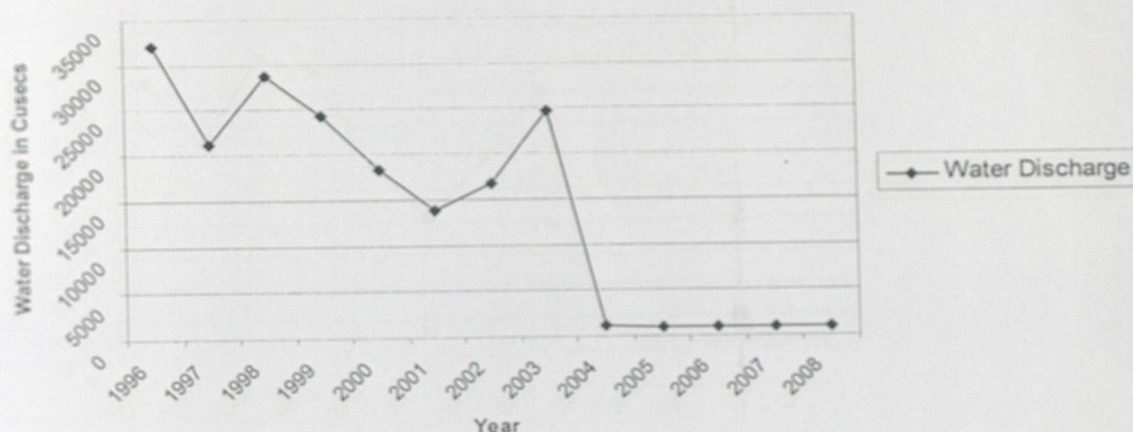
Table # 46: Comparison of Mean discharges in February in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	18100	15567	22867	17000	17433	13800	13367	17900	35172	952	954	1007	989

Source: Derived from WAPDA Reports

The data shown in the figure explains that, due to water diversions into power channel for power generation, there is sharp decline in the discharges from the year 2005 and onward. The water quantities, which were proving sufficient for the floodplains ecology during the February's low discharge season before implementation of GBHPP, is now increasingly inadequate for supporting the aquatic and terrestrial resources associated with the extensive braided channels of the river. The minimum discharges of 13,800 cusecs in the year 2001 have decreased to 952 cusecs during the year 2005 recording 93.1 % decrease in the discharges. The discharge of compensatory waters is insufficient to keep water flowing in the vast braided channels and as a result most of the river channels remain dry during the low discharge season.

Figure # 18: Comparison of Mean discharges in March in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

** Experimental hydropower generation in March, 2004

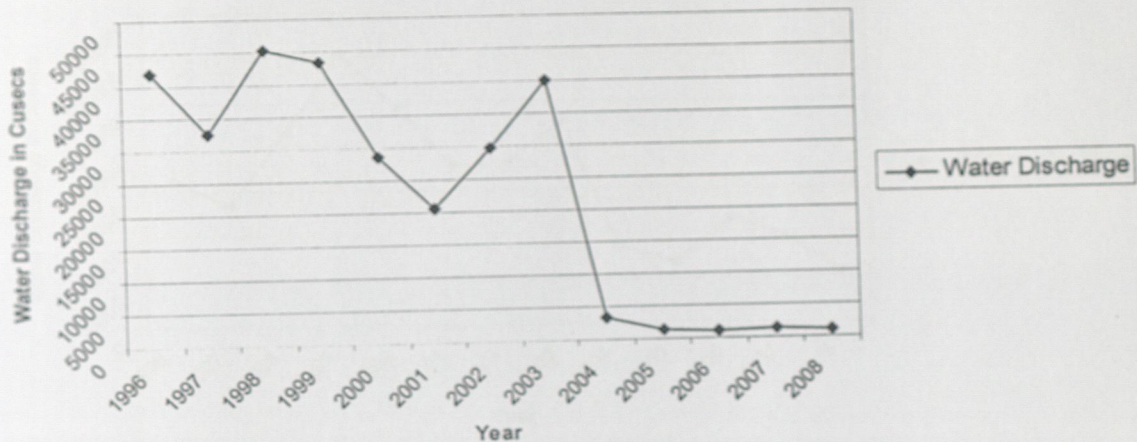
Table # 47: Comparison of Mean discharges in March in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	32067	21200	28833	24367	18333	13800	16667	24633	1233	1048	989	989	989

Source: Derived from WAPDA Reports

The figure describes that situation like the months of January and February exists during the month of March in the post project scenario in the study area. As discussed earlier, the river is more extended in width due to repeated divisions into channels (see the satellite images in chapter 1). The discharge of compensatory waters is far insufficient to reach all the river's channels and hence enable the entire channels to flow. The data show that the minimum discharges of 13,800 cusecs in 2001 have decreased to 989 cusecs in the post-project situation recording 92.83 % decrease. As the month of March is inclusive of the low discharge season, the diversions of huge quantities of water has rendered the braided channels dry and unable to extend beneficial impacts to the natural and human environment in the study area.

Figure # 19: Comparison of Mean discharges in April in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

** Experimental hydropower generation in April, 2004

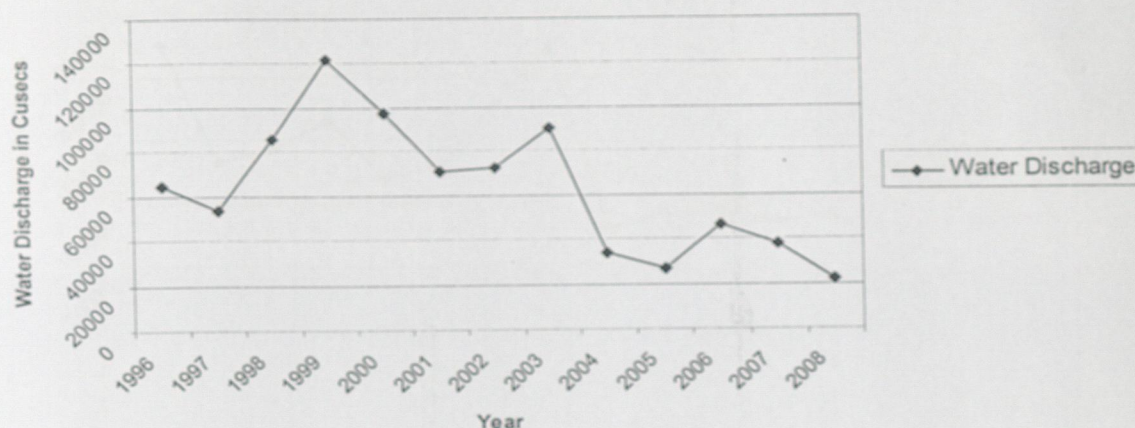
Table # 48: Comparison of Mean discharges in April in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	42067	32633	45367	43233	28733	20567	29833	40133	3375	1520	1141	1316	989

Source: Derived from WAPDA Reports

The figure shows that although, fluctuations in water discharges happen during the month of April due to climatic changes, prevalent over vast watershed areas of Indus and its tributaries. However, the month of April has shown sharp decline in discharges after the project has become operational. The minimum discharge of 20,567 cusecs in 2001 before GBHPP has decreased to 989 cusecs in the year 2008 showing 95.19 % decrease in the discharges. The low surface quantities in the month of April exist due to release of compensatory waters for the aquatic life. However, like the preceding months, the compensatory waters during the month of April has proved inadequate to cover and flow into the entire braided channels and therefore, most of the river's beds in the braided channels remain dry.

Figure # 20: Comparison of Mean discharges in May in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

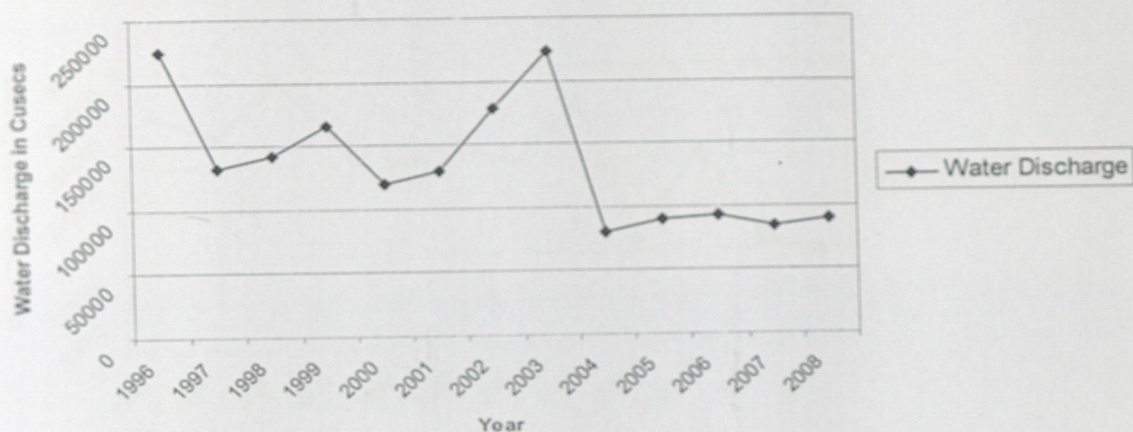
Table # 49: Comparison of Mean discharges in May in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	64400	53533	85533	122067	97500	71033	72433	90500	33484	26825	46287	38096	21779

Source: Derived from WAPDA Reports

The data obtained for the month of May shows that the low discharges season approach towards its end during May and the surface water quantities get increased. Therefore, after diversions of the required quantities of waters into power channel for power generation, some water is left redundant, which is discharged into the river. The data reveals that in the post project situation, the surface water quantities during the month of May have increased than the compensatory waters of the preceding months. However, these are far less than surface water quantities during the month of May before GBHPP. The minimum 53,533 cusecs in the year 1997 have decreased to the minimum 21,779 cusecs in the year 2008 recording 58.75 % decrease in the discharges.

Figure # 21: Comparison of Mean discharges in June in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

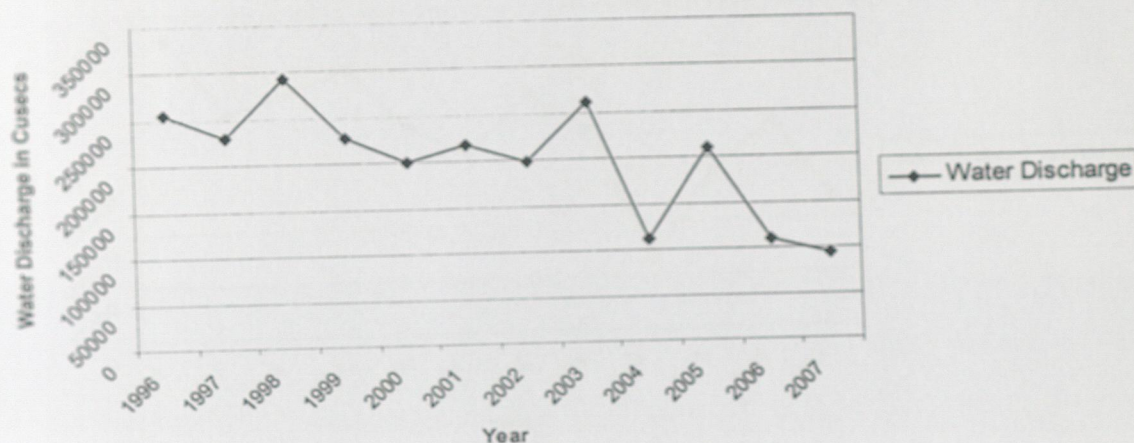
Table # 50: Comparison of Mean discharges in June in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Water Discharge (in cusecs)	224733	131533	141667	166300	119900	129600	178133	223467	79502	89377	93266	84741	89379

Source: Derived from WAPDA Reports

The figure shows that the surface water quantities continue to increase during the month of June as the high discharges season continues bringing more water quantities in river Indus and its tributaries. However, the data reveals that significant reductions have occurred in the surface water quantities during the month of June due to water diversions into the power channel of GBHPP. The minimum discharges of 119,900 cusecs in the year 2000 have decreased to 79,502 cusecs in the year 2004 showing a decrease of 33.69 % due to implementation of GBHPP.

Figure # 22: Comparison of Mean discharges in July in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

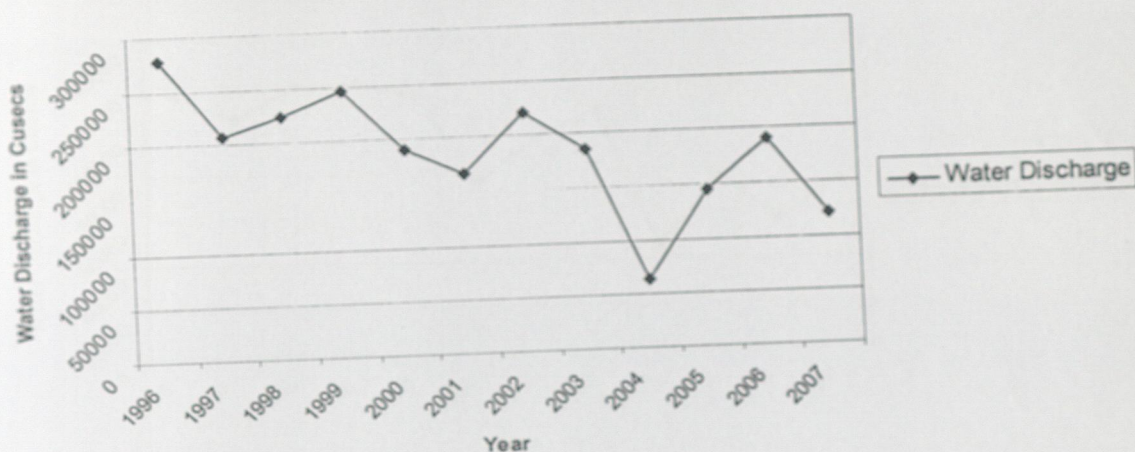
Table # 51: Comparison of Mean discharges in July in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	255200	229267	293400	227300	200600	218167	198233	262033	112487	210614	109769	94670

Source: Derived from WAPDA Reports

The data show that the month of July records fair reductions in surface water quantities due to diversion effects after the project became operational. Although, sufficient quantities of water exist in the river during the month of July in the post project scenario, the braided channels of the river with this quantity have lost their utility to extend the potential favorable impacts of safeguarding the *Belajats* for regeneration during the high discharges season. The minimum discharges of 200,600 cusecs in the year 2000 have decreased to 94,670 cusecs in the year 2008 showing a decrease of 52.8 % in discharges in July. As discussed earlier, the high discharges in summer provided natural protection to these *Belajats* before GBHPP.

Figure # 23: Comparison of Mean discharges in August in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

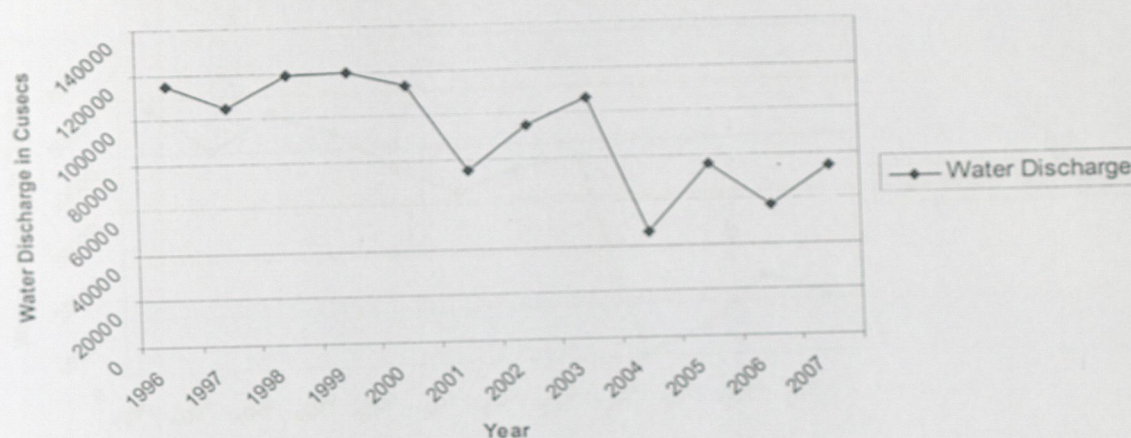
Table # 52: Comparison of Mean discharges in August in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	278000	206900	224967	245733	190100	166967	221367	184933	63413	144258	190912	121166

Source: Derived from WAPDA Reports

The figure reveals that the trend of increase in the Mean discharges continue during the month of August. However, due to diversion of huge surface water quantities into the power channel has caused reduction in the braided channels of the river. The data show that the minimum discharges of 166,967 cusecs in the year 2001 have decreased to 63,413 cusecs in the year 2004 showing a decrease of 62 % in discharges in July. As discussed in the previous figure for the month of July, the utility of the huge quantities of water that existed before implementation of the project has been impaired due to significant reductions of waters in the braided channels in the post project scenario.

Figure # 24: Comparison of Mean discharges in September in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

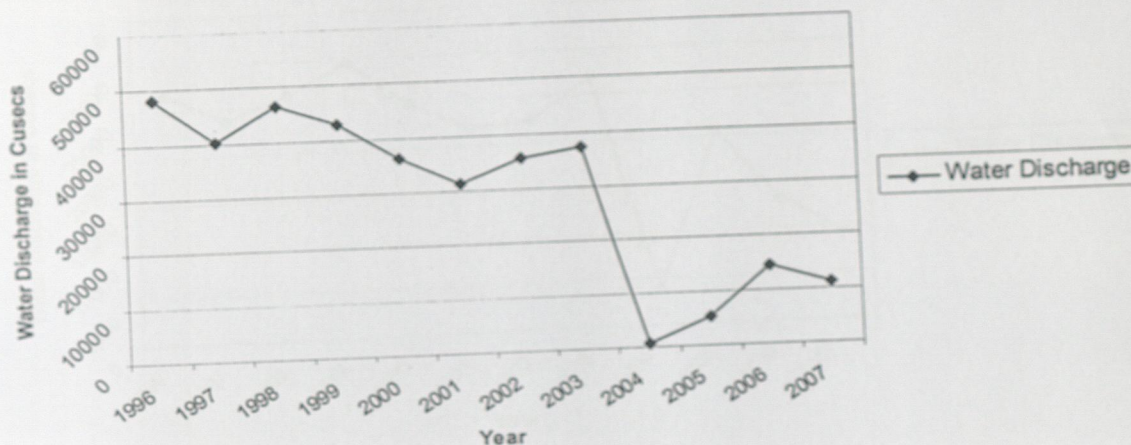
Table # 53: Comparison of Mean discharges in September in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	115033	104833	119200	119367	113367	75033	94367	106033	45787	75599	56717	74132

Source: Derived from WAPDA Reports

The month of September marks the end of the high discharges season in the river Indus and its tributaries. The figure shows that the surface water quantities get a sharp decrease in discharges during the month of September after the project became operational. The month of September is the beginning of diverse ill-effects of GBHPP on the floodplains ecology in the natural low discharges season in the vast braided channels. The minimum discharge of 75,033 cusecs in 2001 before GBHPP has decreased to the minimum of 45,787 cusecs in the year 2004, accounting about 38.97 % decrease in the post-project discharges. The diversion of huge quantities of water, especially during the low discharges season, accentuates the unfavorable alterations of the natural ecological settings in the study area.

Figure # 25: Comparison of Mean discharges in October in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

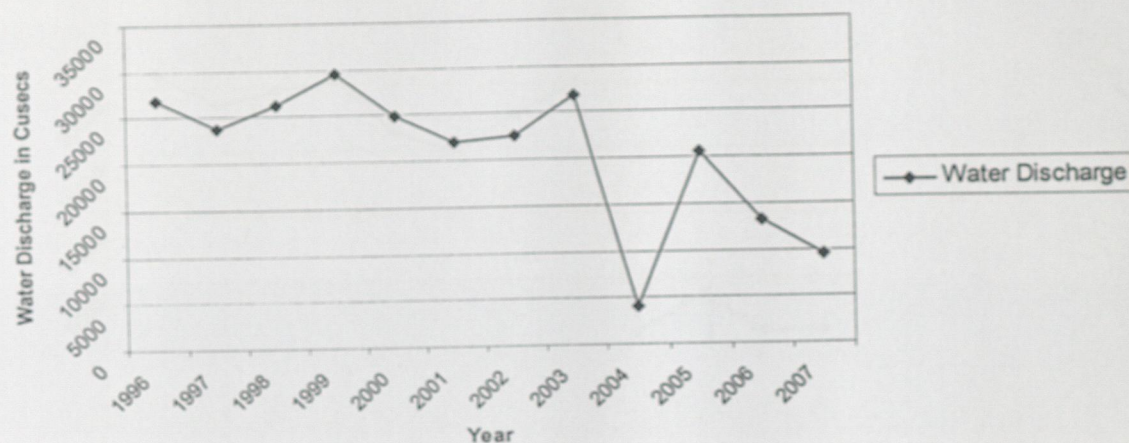
Table # 54: Comparison of Mean discharges in October in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	48200	40367	46633	42867	36333	31300	35633	37133	649	5295	14367	11101

Source: Derived from WAPDA Reports

The figure shows that the month of October gets further reduction in water discharges owing to beginning of the low discharges season. The diversions of waters into power channel have caused significant decrease in the surface water quantities in the post project situation. As the project became operational in May, 2004, perhaps more waters were diverted for operating and testing all the newly installed turbines of the project. The month of October shows the least ever water discharges during the year 2004. The decrease from the minimum 31,300 cusecs in the year 2001 before GBHPP to the minimum discharge of 649 cusecs in the year 2004 is 97.92 % huge decrease and the discharge even far less than the compulsory compensatory discharges during the low discharges season.

Figure # 26: Comparison of Mean discharges in November in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

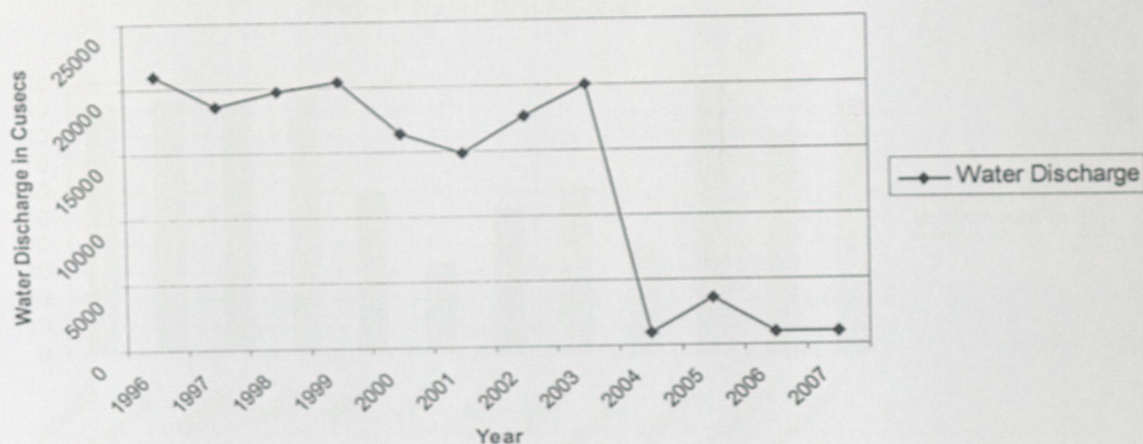
Table # 55: Comparison of Mean discharges in November in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	26900	23767	26233	29633	24800	22000	22600	26900	4144	20670	13160	9445

Source: Derived from WAPDA Reports

The month of November has shown the similar pattern like the preceding month of October in respect of continued decrease in water discharges due to low discharges season. Similarly it has shown comparatively the lowest discharge during the year 2004 after the project became operational. The pre-project minimum discharge of 22,000 cusecs during the year 2001 has decreased to the post-project minimum of 4,144 cusecs during the year 2004. This decrease being 81.16 % has been found extremely significant to have caused unfavorable alterations in floodplains ecology of the braided channels.

Figure 27: Comparison of Mean discharges in December in Indus river in the study area before and after GBHPP



* Project became operational in May, 2004

Table # 56: Comparison of Mean discharges in December in Indus river in the study area before and after GBHPP

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	20967	18567	19700	20400	16400	14800	17700	19933	952	3589	1030	1003

Source: Derived from WAPDA Reports

The month of December has shown the highest decline in water discharges, especially in the post-project scenario. The situation has arisen due to peak of the low discharges season, coupled with the diversions of waters into the power channel of GBHPP. The data show that the minimum discharge of 14,800 cusecs in the year 2001 before GBHPP has reduced to the minimum discharge of 952 cusecs during the year 2004 recording 93.56 % decrease in the discharges. As discussed earlier, the project is designed to discharge a minimum 1000 cusecs as compensatory waters for the support of water-dependent aquatic and terrestrial ecosystems of the vast braided channels in the study area. However, the discharge of 1000 cusecs compensatory waters has been found extremely insufficient to extend waters to majority of the braided channels, which thus remain dry during the low discharges season.

Figure # 28: Decrease in the Mean minimum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)

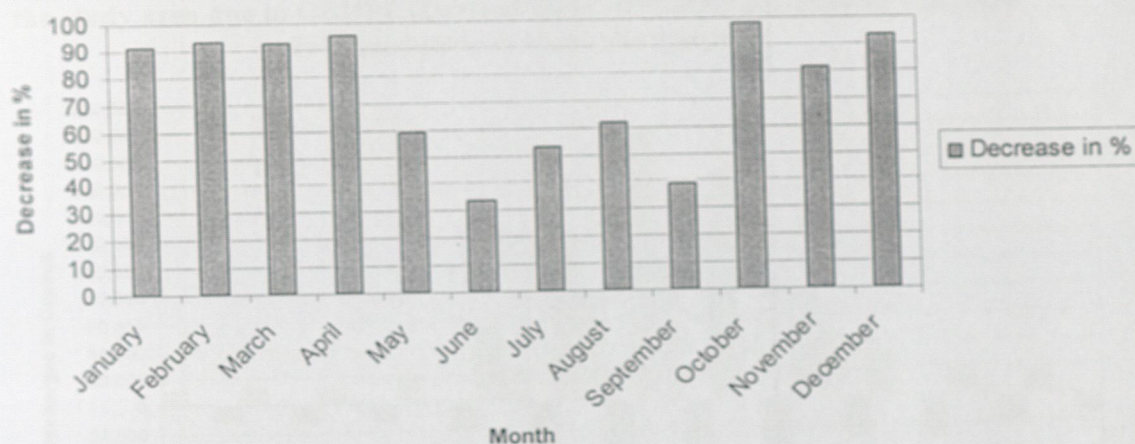


Table # 57: Decrease in the Mean minimum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)

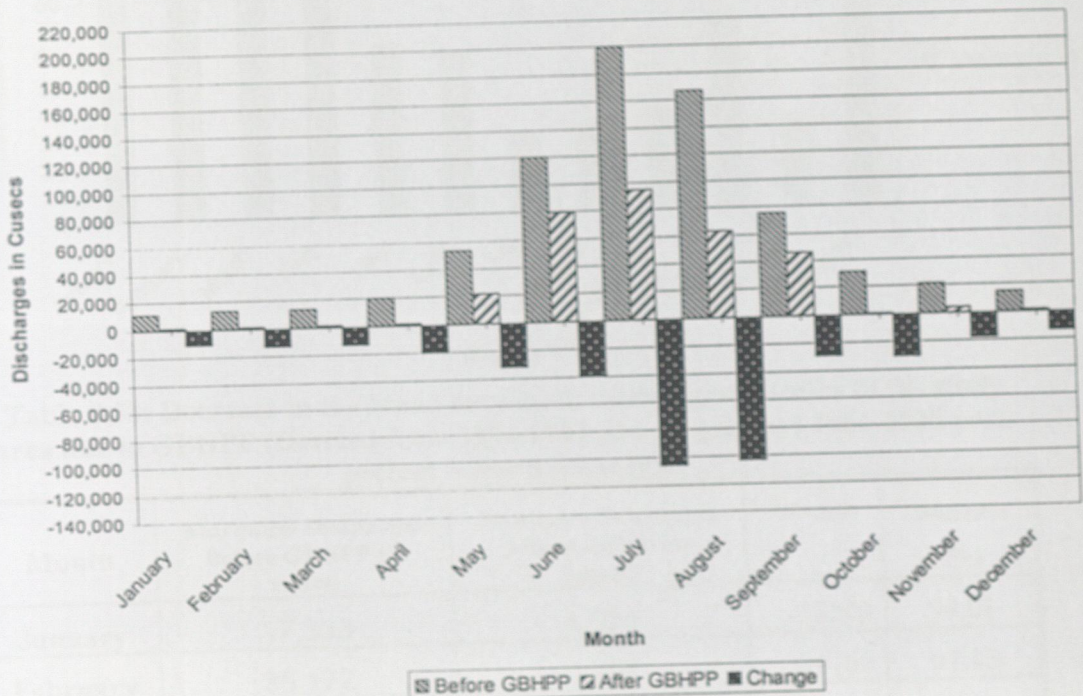
Month	Minimum Discharges Before GBHPP (in cusecs)	Minimum Discharges After GBHPP (in cusecs)	Change	Decrease (%)
January	11,667	989	-10,678	91.52
February	13,800	952	-12,848	93.1
March	13,800	989	-12,811	92.83
April	20,567	989	-19,578	95.19
May	53,533	21,779	-31,754	58.75
June	119,900	79,502	-40,398	33.69
July	200,600	94,670	-105,930	52.8
August	166,967	63,413	-103,554	62
September	75,033	45,787	-29,246	38.97
October	31,300	649	-30,651	97.92
November	22,000	4,144	-17,856	81.16
December	14,800	952	-13,848	93.56

Source: Derived from WAPDA Reports

The data show that the project has caused more than 90 % decrease (e. g 97.92 % in October) during the low discharges season from October to April. This explains that the significance of the decrease is more during the low discharges

season. The actual decrease is elaborated in the figure # 29 to depict the net change in the actual discharges due to GBHPP.

Figure # 29: Net change in the Mean minimum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)



The figure reveals that the actual decrease is quantitatively more in the months of high discharges season. Although, the relative decrease in percentage as shown in the previous figure is less in the high discharges season. The drastic decrease in surface water quantities during the high discharges season has caused unfavorable impacts on the river's islands (*Belajats*) and the associated resources. The table given on the previous page shows the actual change that has arisen in the surface water quantities due to implementation of GBHPP. The data show that the highest actual decrease of 105,930 cusecs has occurred during the month of July, followed by 103,554 cusecs in August.

Figure # 30: Net change in the Mean minimum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)

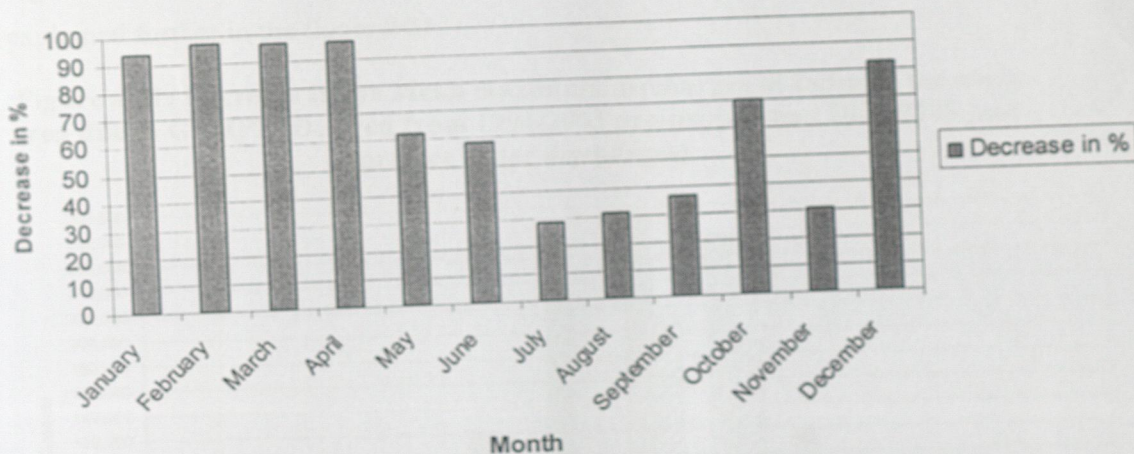


Table # 58: Decrease in the Mean maximum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)

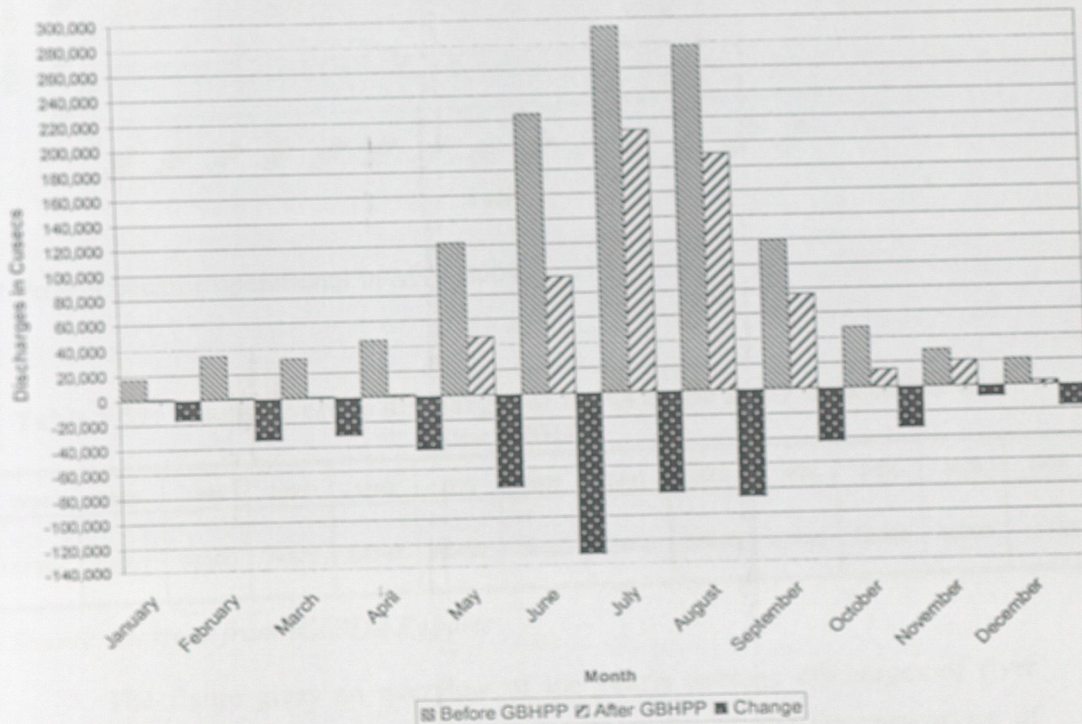
Month	Maximum Discharges Before GBHPP (in cusecs)	Maximum Discharges After GBHPP (in cusecs)	Change	Decrease (%)
January	17,333	1,034	-16299	94.03
February	35,172	1,007	-34165	97.13
March	32,067	1,048	-31019	96.73
April	45,367	1,520	-43847	96.64
May	122,067	46,287	-75780	62.08
June	224,733	93,266	-131467	58.49
July	293,400	210,614	-82786	28.21
August	278,000	190,912	-87088	31.32
September	119,367	75,599	-43768	36.66
October	48,200	14,367	-33833	70.19
November	29,633	20,670	-8963	30.24
December	20,967	3,589	-17378	82.88

Source: Derived from WAPDA Reports

The figure given for decrease in the maximum discharges also show that GBHPP has caused more than 90 % decrease (e. g 97.13 % in February) during the low discharges season. Thus the significance of the decrease is more

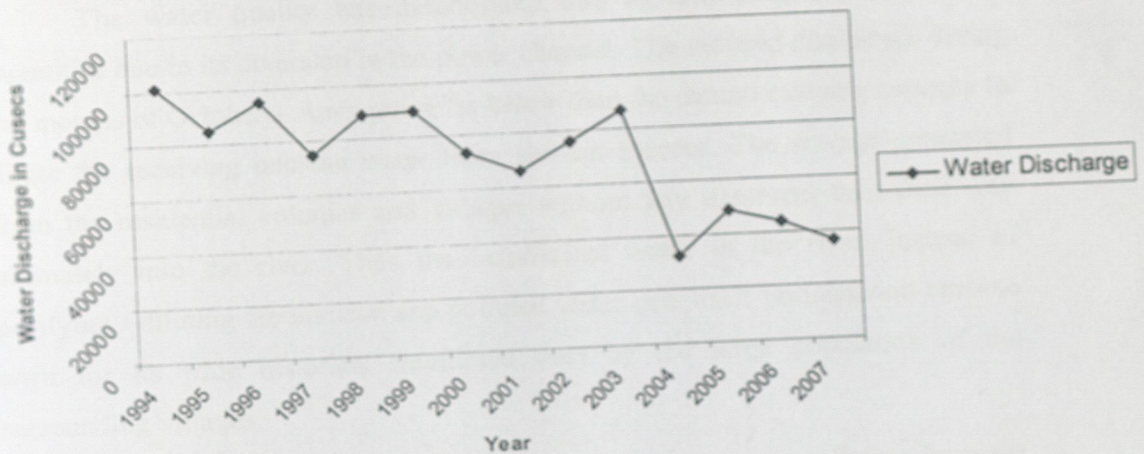
during the low discharges season of the river. However, the actual decrease is the highest during the high discharges season. The month of June has recorded the highest decrease of 131467 cusecs in the month June. The actual change is explained further in the figure # 31.

Figure # 31: Decrease in the Mean maximum discharges of Indus in the study area due to GBHPP (Derived from 1994-2003 pre-project and 2004-2008 post-project water discharges)



The figure reveals that the highest actual decreases in the surface water quantities have happened during the months of high discharges season. As the figure shows, the highest decrease of 131,467 cusecs has arisen in the month of June followed by August and July. The data show that the project has caused drastic decrease in the actual discharges and the surface water quantities have decreased more in the braided channels of the river, especially during the months of high discharges season.

Figure # 32: Yearly Average discharges of Indus in the study area before and after GBHPP



* Project became operational in May, 2004

Table # 59: Yearly Average discharges of Indus in the study area before and after GBHPP

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Water Discharge (in cusecs)	101394	84997	95200	74572	89147	89492	73403	65933	76000	87236	32493	48395	44132	36558

Source: Derived from WAPDA Reports

The figure gives an overview of the yearly average discharges of river Indus before and after GBHPP. The data derived thus depict the comparison of yearly discharges of the river before and after the project for analyzing the impacts on the floodplains ecology in the study area. The table shows that the maximum average discharge was 101,394 cusecs in the year 1994 before GBHPP; and the maximum 48,395 cusecs in the year 2005 after GBHPP. The maximum discharges record a decrease of 52.27 % on the yearly averages basis. Moreover, the minimum average discharges of 65,933 cusecs in the year 2001 have decreased to the minimum 32,493 cusecs in the year 2004 showing 50.71 % decrease in the minimum discharges.

5.2.1.2 Surface Water Quality

The water quality has deteriorated due to drastic decrease in water quantities due to its diversion in the power channel. The reduced discharges during the months of October – April prove far below than the natural carrying capacity to dilute the receiving unclean water from various sources. The sewage generated from the residential colonies and villages without any treatment take their way ultimately into the river. Thus the insufficient water in the river, instead of purifying / diluting the unclean and polluted water gets itself polluted and become unfit for its wide historical traditional uses by the large population of the surrounding villages.

There also runs a very high level risk of serious water pollution from the effluents generated by the Gadoon Amazai Industrial Estate lying in the closed proximity. The industrial waste and effluents are disposed without treatment into drains. All the drains of the individual industries join a large collecting drain, which is designed to open into a local stream called *khwar* locally.

The *khwar* carrying the storm water during the rainy season, household sewage from the upstream and surrounding villages and effluents from the aforesaid industries join river Indus near the sample village of Batakara on the right bank of the river. However, most of the industries, especially the organic and inorganic chemical industries are closed at present. Therefore, at present the risk of contamination of river by the industrial effluents from the aforesaid industrial estate is negligible. Nevertheless, the resumption of the existing industries of the Gadoon Amazai Industrial Estate or any new industry in future without proper treatment facility is more likely to pose serious threat to water quality of the river, which is flowing in its depleted state quantitatively due to water diversion in the concrete power channel.

5.2.1.3 Ground Water

The diversion of water has caused serious impacts on the ground water reservoir in the study area. The ground water is mainly recharged by the huge surface water quantities of the river. This recharge is influenced more in proportion due to the unique morphology of the river. The braided shape of the river increases the surface area of its water many folds. Thus the increase in the surface area of

water leads to more infiltration and so more recharge of the ground water in the study area.

The dug wells surveyed showed distinctive marks of fluctuation in the ground water table due to seasonal fluctuation in the water discharges of the river. However, the seasonal fluctuation has been accentuated by the drastic reduction of water by the GBHPP. Consequently, significant decrease in ground water table was noticed in the dug wells of the villages in the study area. The decrease in ground water table is directly proportional to distance from the river and the quantities of the water released in the floodplains of the river. It was found during the survey that few dug wells go dry during the low discharges season (October – April) as shown in plate # 5 and 6 in next page. The decrease in water table in various sample villages is shown in the table # 60 and figure # 33. Similarly the plate # 5 shows that due to drastic decrease in the groundwater table, the gravels / stones can be seen in the bed of the dug well.

Table # 60: Depletion of water table in the sample villages during the low discharges season

Sample Villages		Distance of village from the river (Km)			Average decrease in water table of dug-wells during Nov-April (feet)
		On Bank	1 – 3 km	4-6 Km	
Dist Swabi	Gallah	√			10
	Bata Kara		√		6
	Hund	√			9
Dist Haripur	Khalu	√			4
	Jammu		√		5
	Qazi Pur	√			7
	Aldo-Jabbi		√		5
Dist Attock	Jalalia			√	2
	Daman			√	5
	Formali		√		5

Source: Field Survey, 2007-08

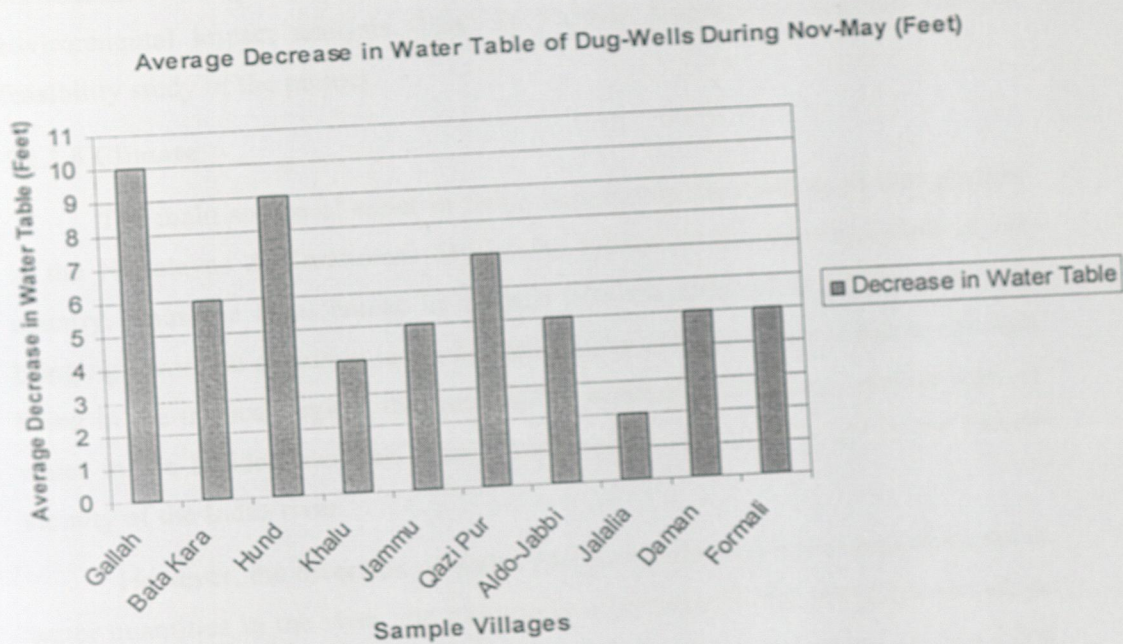
Plate # 5: Little water in the dug well (Persian Wheel being used for irrigation in the sample village, Qazipur



Plate # 6: View of the dried dug well in the sample village, Hund



Figure # 33: Decrease in water table in the study area during the low discharges season



5.2.1.4 Soils

The deposition of alluvium soil has affected in the deltaic terraces and in the *Belajats* (small river islands). The deltaic terraces and *Belajats* have been constituted by the meandering activity of the river during the significantly high and low discharges season along the study area in the past. However, the diversion of huge quantities of water into the power channel has affected the inundation of some of the low lying *Belajats* during the high discharges season. The absence of inundation has thus affected deposition of alluvium soils on these *Belajats*.

However, the study revealed that so far no large significant impacts have been caused on the soils by the project in the study area, but in future monitoring will be needed to find out the potential change

5.2.1.5 Geology / Seismology

As the Tarbela reservoir has been constructed on earthquake's belt due to neglect of this aspect in the planning process, further impoundment of huge mass of water in the barrage, just very close below Tarbela reservoir at Ghazi can cause instability in earth's strata. Thus the already existing risk may be accelerated due to

seismic fault line at the site of Tarbela reservoir and Ghazi barrage. The seismic risk carries the potential disaster for the area, which is one of its remarkable drawbacks. The neglect of seismological aspect is believed due to lack of adequate environmental impact analysis (EIA) of Tarbela reservoir during the detailed feasibility study of the project.

5.2.1.6 Climate

The main source of water in Indus is primarily the melting of vast glaciers in the Himalayas & Karakoram Mountains located in the extreme north of the country. Thus the local breeze in contact with the cold water of the river was bringing favorable sensation in the hottest months of the summer. Further, the area being in the tropical region, the evaporation effect from the large surface area of water in the braided channels would bring micro climatic change in the closed vicinity of the Indus river.

However, the diversion of water into power channel has caused decrease in water quantities in the river and eventually a decrease in the rate of evaporation. Moreover, due to decrease in water quantities in the river's braided channels, the phenomenon of local breeze passing over the cold water of the Indus and to bring microclimate change in the closed vicinity has been affected significantly by GBHPP. The climatic effect in the closed proximity to river is considered a significant adverse alteration in the physical environment of the study area.

5.2.2 Ecological Resources

5.2.2.1 Fisheries

The diversion of water in the GBHPP has significantly affected the large river based resources like fisheries, availability of abundant water and other beneficial uses of the floodplains of river Indus. As discussed in the previous chapter, the river Indus in this reach was home to many species of fish due to ideal ecological conditions before the GBHPP. However, the economically abundant / productive species included *Mallah* (*Shizothorax sp*), *Mahsheer* (*Barbus putitora*) and *Chaina* (*Mystus oar*).

The unique morphology of the river downstream Tarbela in the shape of small and bigger channels and their repeated reunion and re-division constituted vast area for the rapid growth of fishery. Moreover, the presence of large number

of inaccessible deep creeks in some of the channels acted as significant stocks for the relatively shallow wide channels, which remained increasingly accessible by the local fishermen for fishing in huge quantities. Due to such ideal conditions, the study area remained extremely popular for the traditional extravagant fishermen.

Majority of the fishermen were practicing fishing in the river Indus as their sole profession since their forefathers. They were performing a worthy role for supplying fishery at reasonable price not only to local population but also to some of the remote areas of the province and the capital territories of Islamabad. The historic role of the fishery resource in the socio-economic conditions of the local fishermen and the afterwards effects of GBHPP on the fishery resource are illustrated in the tables # 61 to 62.

Plate # 7: *Mallah* fish caught in one of the creeks by the local fishermen in small uneconomic quantity



Table # 61: Profile of fishermen in the study area and their monthly income

Sample Villages		Number of fishermen in the village	Average household size of fishermen	Average income per month per family in PKR before GBHPP	Average income per month per family in PKR after GBHPP
Dist Swabi	Gallah	10	8	9,000	6000
	Bata Kara	97	9	10,000	7,000
	Hund	70	7	7000	6000
Dist Haripur	Khalu	Negligible	NA	NA	NA
	Jammu	Negligible	NA	NA	NA
	Qazi Pur	30	8	7000	5000
	Aldo-Jabbi	Negligible	NA	NA	NA
Dist Attock	Jalalia	Negligible	NA	NA	NA
	Daman	Negligible	NA	NA	NA
	Formali	Negligible	NA	NA	NA

Source: Field Survey, 2007-08

Table # 62: Fish-catch in the sample villages before and after GBHPP

Sample Villages		Abundant specie in the river	Average fish-catch per day per fishing party before GBHPP (in Kg)	Total average fish catch per day in the village before GBHPP (in Kg)	Total average fish catch per day in the village after GBHPP (in Kg)
Dist Swabi	Gallah	<i>Mallah (shizothorax sp.)</i>	10-100	20-200	Negligible
	Bata Kara	-do-	50-200	200-1000	8-10
	Hund	-do-	10-40	50-200	6-8
Dist Haripur	Khalu	-do-	Nil	NA	NA
	Jammu	-do-	Nil	NA	NA
	Qazi Pur	-do-	20-50	50-100	2-4
	Aldo-Jabbi	-do-	Nil	NA	NA
Dist Attock	Jalalia	-do-	Nil	NA	NA
	Daman	-do-	Nil	NA	NA
	Formali	-do-	Nil	NA	NA

Source: Field Survey, 2007-08

5.2.2.2 Forests in *Belajats*

The forest resources and other natural vegetation that existed in the river's small islands (*Belajats*) before GBHPP are fully described in the preceding chapter. The meandering activity of the river during this reach has had constituted permanent and temporary river islands (*Belajats*) as described in detail in chapter 4. Most of the permanent river islands (*Belajats*) remained inaccessible for grazing by the livestock or for wood cutting due to high discharges of water for most of the time before GBHPP. Such *Belajats* remained covered by the lush green vegetation including the valuable timber tree of *Dalbergia sisso*, besides fuel wood trees of *Acacia nilotica*, *Acacia modesta* and *Zizyphus nummularia*.

The previously inaccessible *Belajats*, however, have become largely accessible by the public due to drastic reductions in river discharges caused by the diversion of huge quantities of water into the concrete power channel of GBHPP. The regenerating capacity of natural vegetation has been exceeded due to overgrazing and excessive trees cutting by the surrounding communities. Some of the *Belajats* were auctioned to private contractors by the villages' elders-councils and the money procured was distributed among the clans on the basis of their legal share.

Some of the *Belajats* were inundated in the barrage of the project, which is spreading over an area of 1,140 hectares. These *Belajats* were largely comprised of the popular timber wood tree (*Dalbergia sisso*) and other species of the fuel wood (principal species included *Acacia nilotica*, *Acacia modesta* and *Zizyphus nummularia*).

The permanent *Belajats* have largely been affected due to overgrazing by the livestock and excessive trees cutting by the villagers. The survey showed that about 70% of all the permanent *Belajats* have been severely affected due to overgrazing and uncontrolled wood cutting. A small fraction of some of the *Belajats* have been retaken for proper management by the villages' committee, however these may contribute to only 5% of the total land of *Belajats*. Some of the *Belajats* have been declared as firing range by the Pakistan Air Force for training exercises. During the field visits, it was found that about 25% of the *Belajats* were affected to

moderate level. However, such *Belajats* were largely used for livestock grazing and fodder supplies.

The temporary *Belajats*, which are transitional by the mode of transformation into permanent *Belajats* have severely been affected due to drastic reductions in the surface water quantities. The detailed description of the effects of GBHPP on vegetations in the *Belajats* is given in the table # 63 and plate # 8.

Table # 63: Description of Impacts of GBHPP on Vegetation and Forest in *Belajats*

Forests / Vegetation	Area of <i>Belajats</i> affected	Reversible impacts			Irreversible impacts
		Low	Moderate	Severe	
Barrage's <i>Belajats</i>	100 %	NA	NA	NA	√
Permanent <i>Belajats</i>	70 %	5 %	15 %	80 %	Nil
Temporary <i>Belajats</i>	95 %	5 %	5 %	90 %	Nil

Source: Field Survey, 2007-08

5.2.2.3 Wildlife in the *Belajats* (Terrestrial Fauna)

The rich genetic diversity of the vast river islands (*Belajats*) has been affected from moderate to severe impacts. These impacts have caused directly due to degeneration of the formerly ideal habitats for the terrestrial fauna. Furthermore, the previous natural mechanism in the form of high discharges in the river guarding against the increased human access to these habitats has been eliminated.

The increased access of humans has caused significant adverse impacts on the variety of native species of avian, reptiles and mammals. The drastic decrease in the surface water quantities has caused the elimination of the resting spot that was used as a temporary stopover by many of the Waterfowl and other water-related birds during their seasonal migration from colder areas to the temperate / tropical regions. The local populations have pointed out the loss of cranes visits to this area that would take place in large number before the water diversion during their migration from Siberia on their onward journey to the south of the country.

Similarly the winter visits of many other species of Water-birds have been largely affected as they would use the vast braided channels as their temporary stay on their way to the coastal wetlands of the south. The Herons, Terns and Kingfishers, which depended upon open water for feeding on small fish, have been decreased in number. This impact has also arisen on the Ducks population due to direct impacts on plant life, which they use as feed and for resting purposes. Small number of ducks in one of the channels in-flow due to compensatory waters is shown in plate # 9. The Wagtails and some Larks, which once were abundant in these *Belajats* have been reduced. However, there have been from insignificant to moderate impacts on the common species of House Crow, Common Mynah, Red-vented Bulbul, and Collared Dove. The Bee-eaters, Woodpeckers, Parakeets, Warblers and Thrushes have been affected due to decrease in vegetation cover and trees in *Belajats* during this reach. Moreover, amongst the mammal species, secondary impacts have also arisen on the wild Boars, Jackals, Rabbits, Rodents species and the vulnerable specie of wild Cats that existed in good numbers in the permanent *Belajats* above the flood level. The barrage site was an important habitat of the wild Boars, which after the inundation have spread all over the area, causing heavy damages to the standing crops. The tabular description is given in table # 64.

Plate # 8: View of the degraded *Bela* due to increased human access



Plate # 9: Water Ducks (*Ellayy*) gathered to the compensatory waters
**Bela* with a few trees left can be seen in the background.



Table# 64: Description of adverse impacts of GBHPP on wildlife in the *Belajats*

Categories	Principal species	Purpose of use of <i>Belajats</i> / open water	Reversible vs irreversible	Magnitude of impacts
Water Related Species	Ducks, Herons, Terns and Kingfishers	As Feed and Resting	R	Moderate
Migratory Species	Principally Cranes	Temporary Stop-over	R	High
Common Species	House Crow, Common Mynah, Red-vented Bulbul, and Collared Dove	As Feed and Shelter	R	Low
Reptiles	Snakes, Lizards etc	Shelter	R	Moderate
Mammals	wild Boars, Jackals, Rabbits, Rodents, wild Cats	Shelter	R	High

Source: Field Survey, 2007-08

5.2.2.4 Forest Management in *Belajats*

The management system to regulate the use of forests in *Belajats* has been affected due to increased human access in wake of the drastic decline in the surface water quantities in the braided channels of the river. The easy access to *Belajats* has accelerated wood cutting and livestock grazing. As discussed above, in some villages, the elders' council (village's elders committee) auctioned off the *Belajats* to private contractors who mercilessly cleared the respective strip of land in the *Belajats*. Some of the *Belajats* have been regenerated by the villagers and the proper care and management has led to the revival of the natural vegetation and fuel / timber wood trees. However, their proportion to the degenerated *Belajats* is significantly negligible in the study area.

5.2.3 Human Use Values

5.2.3.1 Power Generation

The GBHPP has contributed enormous supply of hydropower to the country's national grid system. The hydropower generation to tune of 1450 MW is highly significant in view of the country's severe ever shortfall in the energy sector. The utility of generating 1450 MW is considerably high since it is

generated at its peak at a time when other hydro units are at their lowest generation capacity due to seasonal fluctuations in the water releases from the dams/barrages. Hence GBHPP plays a critical role to help overcome the serious shortfall in the power sector. The 1450 MW hydro generation therefore, can be evaluated as hugely beneficial in the national context and its sole positive impact in the Human Use Values. The information supplied by the office of the project show that it has contributed 31646.19 million KWh up to June 2008 since its experimental operation in 2003. The yearly power generation is depicted as given below:

Table # 65: Total power generation by GBHPP up to June, 2008

Year	Power generation (Million KWh)
2003 (experimental generation)	2377.12
2004 (operational in May, 2004)	6214.81
2005	6682.35
2006	6770.23
2007	6948.30
2008 (up to June)	2653.38
Total	31646.19

Source: Data derived from office of GBHPP, WAPDA, Hattian

5.2.3.2 Water Supply

The river Indus during this reach is not used as the principal source of water supply for the domestic or any other commercial use. The study showed that the main source of water supply is dug wells (about 50%), followed by pipe (30%) and hand pump (20%) supply. However, the recharge of the groundwater reservoir takes place by the surface water of the river; besides little infiltration of water from the precipitation that normally occur low in quantity. Hence the diversion of water has caused serious impacts on the natural recharge of groundwater reservoir by the braided channels of the river in the sample villages of the study area.

The surface water quantities of the river have been found to be greatly influencing the water table of the dug wells surveyed. The dug wells showed distinctive marks of fluctuation in the ground water table due to seasonal fluctuation in surface water quantities in the river. The diversion of water into the concrete power channel of GBHPP and the eventual reduction in surface water

quantities has accentuated the seasonal fluctuation more in magnitude. As a result, significant decline in ground water table has occurred in the dug wells of the sample villages. The decrease in groundwater table of the dug wells is directly proportional to distance from the river and surface water quantities in the river.

The post-project scenario reveals that water table has depleted to the greater extent within the closed vicinity of the river. It was also found during the field survey that few dug wells go dry during the low discharges season of the river (October – April) due to water diversion in GBHPP. The decrease in water table in various sample villages was shown in detail in table # 60 and plate # 5 to 6 in discussion of the adverse impact on groundwater. Thus water diversion and its direct impact causing decrease in the surface water quantities have invoked the adverse secondary impacts on groundwater reservoir. The depletion of groundwater reservoir has, eventually, caused significant adverse impacts on water supply for domestic and agricultural uses in the study area.

The decrease in the surface water quantities have also deserted most of the women' gathering points called *Gudders* locally. Thus the use of river at *Gudders* by the women folk for washing clothes and churning milk (as in plate # 10) has been diminished during the low discharges season. The opportunity of watering domestic animals with the river (as seen in plate # 11) has also been lost during the low discharges season.

Plate # 10: View of the women gathering at *Gudder* for daily uses of river's water



Plate # 11: Watering livestock with the compensatory waters present in one of the channels



5.2.3.3 Aquatic Biology

The surface water quantities have been drastically decreased in the river, which has caused adverse impacts on the aquatic life in the vast braided channels. Due to decrease in the surface water in the river, the quality of the river has also been affected during the low discharges reach in the study area. The local streams carrying household sewage join the river along the whole of the study area contaminate the river and thus renders the river unsuitable for fishery and other aquatic species. The effects on the surface water quality due to decrease in the surface water quantities has been elaborated in detail previously in the discussion of impacts of GBHPP under the heading "Surface Water Quality". The decrease in the water quantities in the river coupled with the discharge of untreated sewage, originating mainly from the settlements poses serious threat to aquatic life in the braided channels of the river.

5.2.3.4 Reservoir's Ecology

The creation of reservoir in the form of a barrage in the project for regulating water releases has caused the terrestrial ecology to change into the new aquatic ecology. Thus the terrestrial species have been replaced by the new aquatic species in the barrage.

The barrage constituting a huge surface area of 1,140 hectares has provided ideal habitat for fish propagations. The fish supply from the barrage shall prove a significant source for supplementing the protein nutrition in diet of the local population. The fishery is sustained in the barrage through proper regulation and the contractor awarded the contract in the open auction process, observe due adherence to the terms and condition to avoid over-fishing or fishing in the breeding seasons. However, there is no system of awarding fishing licenses on priority to the local fishermen, who have been adversely affected by the project due to deprivation of the vast braided channels of water in the river.

The fishing license to private contractor is awarded for three fishing seasons beginning from 1st September through the three years ending on 31st May. Fishing is prohibited during the breeding months of June, July and August. According to Directorate of Fisheries, WAPDA, the present license for fishing in the barrage was awarded to private contractor on 28th July, 2008 for Rs. 14, 50,000 for the three fishing seasons till 31st May, 2011.

5.2.3.5 Mineral Development

The study area constituted a significant productive site for recovery of the precious mineral such as gold etc, which deposit as a natural constituent in the sand of the active floodplains along the river. The long history of the river shows that the sand deposited by it is comprised of significant quantity of gold. The whole study area in general and few sites in particular, remained famous for the old profession of gold panning in the sands deposited by the river.

The reduced discharges due to water diversion have however, affected sand deposition and so the deposition of its natural constituent _the gold. Consequently, the recovery of significant quantity of gold ranging from 0.84 gm to 0.48 gm per person before GBHPP has been lost. The loss of gold through this activity, thus, has diminished the contribution of a fair quantity of gold to the existing stock of gold in the country. The impacts on gold panning profession have also affected the related professionals i.e. the gold panners. The gold that would recover in the sample villages before the project and the impacts of GBHPP on the socio-economic conditions of the gold panning professionals are shown in table # 72 in discussion on impacts on the socio-economic.

Due to GBHPP, the recovery of the byproduct during the gold panning activity in the form heavy sand has also been lost. The heavy sand is the natural raw material of iron and is used as raw resource in the iron manufacturing industries. The traditional manual method of gold panning is shown in plates # 12-15.

5.2.3.6 Industries

The generation of cheap power to the tune of 1450 MWs can ensure consistent supply of power for the industries in the region. However, this opportunity has not been exploited so far for the establishment of the new industries in the surrounding project's vicinity in the region. Similarly, there have been no supplies to the already established industries in the aforesaid nearby Gadoon Amazai Industrial Estate (GAIE) on priority basis.

The availability of power generated through GBHPP, along with the presence of the adequate network of telecommunication, roads and other facilities in the area can contribute progressively for the establishment of new industries, especially the agro-industries in the area. Although, Pakistan being an agricultural

Plate # 12: The traditional manual method of gold panning in the sands deposited by the river



Plate # 13: The gold as recovered from the sand

*the black heavy sand to be sold to the iron industry can also be seen.



Plate # 14: The simple tools used in the traditional method of gold panning



Plate # 15: Gold collected as the end product through Mercury



country; has enormous potential for establishing agro-based industries and hence to generating significant opportunities for employment in this area, however, the availability of power through GBHPP and variety of agricultural products has not been used so far for industrialization in the area.

5.2.3.7 Highways/Railways

The implementation of GBHPP has caused provision of a shortest route between villages of the left bank area (Swabi region) and the right bank strategic town of Ghazi. The previous longest route passing through Tarbela reservoir and the cumbersome security check posts at the Tarbela reservoir has been avoided by the construction of bridges over river Indus in the project. The alternate road, thus, has facilitated easy movement of the public between the left bank and right bank area. The route has also become a shortest possible way between the two provinces of NWFP and Punjab as well as between the northern parts of NWFP and the capital Islamabad.

All development projects launched in the country are usually devoid of planning the most efficient, environment friendly and least costly means of railways to and from the projects' localities. The GBHPP is also no exception in this context and no planning has been undertaken in the project for providing railways to this increasingly ever becoming strategic area of the country.

5.2.3.8 Land Uses

The study area is largely rural in nature and the major segment of the population is engaged in agriculture. The proportion of the agricultural profession is 57.1% in Swabi region, 41.3 % in Khari region and 53.1% in Chhachh region. The agricultural land is irrigated mainly through the traditional method of Persian Wheels, using the power of animals for withdrawing water from the dug wells. Due to availability of power, few Persian Wheels have had been replaced with the electric power run tube wells. Moreover, a small portion of land (about 15 %) is irrigated through canals in the left bank region of Swabi. The remaining land of Swabi region (80 %) and the whole of land in Khari and Chhachh region (100 %), thus, is dependent on irrigation either through the Persian Wheels / tube wells or remain rain-fed.

Due to diversion of water into the power channel and the subsequent decrease in the ground water, serious impacts have occurred on irrigation of the agricultural lands, lying within the closed proximity of the river Indus. As discussed previously in discussion on Forests in *Belajats*, the forest cover in *Belajats* has been severely affected due to increased human access following water diversion and the resulting drastic decrease in the surface water quantities in the braided channels of the river. The high water in the braided channels that was a natural guard against easy access to the *Belajats* (river' islands) has been done away with due to GBHPP. The Ghazi town and its surrounding villages, lying closed to the barrage are experiencing rapid transformation from the agricultural land into the commercial and built up areas.

5.2.4 Quality of Life Values

5.2.4.1 Socio-Economic

The socio-economic impacts of GBHPP are mixed and variedly carry significant harms and benefits by their magnitude in the context of national versus local / regional. The study has evaluated both the beneficial socio-economic impacts as well as the ill effects associated with the water diversion into the concrete power channel and its utilization for the power generation. GBHPP has contributed significantly to the existing electric capacity of the country and to minimizing the critically larger ever gap between the demand and availability of power at the national level.

The water diversion into the power channel and deprivation of the vast braided channels of the river of water has caused adverse impacts of greater magnitude on the local population of the study area. The local populations in surrounding of the braided channels on both side of the river have suffered their income from the traditional use of river based resources.

The country is also enabled to save the hard earned foreign exchanges of the country, from otherwise their spending on import of fuel oil for thermal generation. The significance of 1450 MW is enormous since it is generated at its peak and at a time when other hydro units in the country are at their lowest generation capacity due to seasonal fluctuations in the water releases from the dams/barrages.

The energy estimates of the project shows that it has contributed 31646.19 million KWh up to June 2008 since its experimental operation in 2003. On the economic front, the country has benefited about Rs. 126.58 billion on the present market rate of power and has as said above, indirectly saved huge foreign exchanges of the country on oil imports for thermal generation. The details of power generation and revenue earned from GBHPP are delineated in the tables # 66 to 67.

Table # 66: Total Power generation by GBHPP up to June, 2008

Year	Power Generation (Million KWh)
2003 (experimental generation)	2377.12
2004 (operational in May, 2004)	6214.81
2005	6682.35
2006	6770.23
2007	6948.30
2008 (up to June)	2653.38
Total	31646.19

Source: GBHPP WAPDA, Hattian

The financial contributions of GBHPP are shown in the table # 67.

Table # 67: Total revenue generated from GBHPP up to June, 2008

Pricing Criterion	Rate/KWh	Total Units	Amount (Rs. Billion)
At PC-1 Rate	Rs. 0.75	31646 Million KWh	23.42
Market Rate	Rs. 4	---do---	126.58

Source: GBHPP WAPDA, Hattian

The barrage of the project has constituted an aquatic environment of 1,140 hectares, which provides an ideal habitat for the propagation of fishery. Nevertheless, the fishery production in the barrage cannot substitute the previous huge production of fishery in the vast braided channels of the river before the project. Moreover, the quality and taste of the fish species in the barrage is regarded of inferior quality and taste as compared to the fish species of the running water. Yet the barrage has been used for commercial harvest of the fishery, which

though not significant in amount, constitutes another source of financial return from GBHPP.

The Directorate of Fishery has awarded contract for fishing in the barrage for three consecutive fishing seasons, from 1st September, 2008 to 31st May, 2011 for Rs. 1.45 million. A single fishing season spans over a period of 9 months beginning from 1st September to 31st May. Fishing during the months of June, July and August is prohibited due to breeding seasons of fish during these months. Despite huge financial contributions by GBHPP, no fraction of the revenues generated by it, has been allocated for the welfare of the local affectees.

GBHPP provided employment opportunity to skilled, non-skilled and semi-skilled individuals of the local as well as non local population. However, more than 80 % of the respondents were of the opinion that they were not provided employment during the construction phase of the project.

The project is considered significantly beneficial for initiating various schemes for socio-economic uplift for some of the local communities in the study area. The project proponent launched various socio economic development programs as an integral component of GBHPP. The program was executed through the Project Non Governmental Organization (PNGO) called Ghazi Barotha Taraqiati Idara (GBTI). The basic mandate of GBTI has been to assist in land acquisition / compensation, resettlement; safeguard of the environment and to execute the task of promoting socio economic uplift of the affected communities.

The GBTI schemes benefited the local communities through its Integrated Regional Development Plan (IRDP). These schemes were launched with the active participation of the local communities through the principles of Social Mobilization and Participatory Approach. Through the IRDP, several schemes comprising micro credit facility, human skills enhancement through vocational trainings, community infrastructure development, natural resources management, community health and education have been launched in the area. Despite the IRDP schemes, the project has distributed about Rs. 4.56 billion as land compensation to project affectees. The area wise details of the IRDP are given in the table # 68.

Table # 68: Summary of community uplift schemes launched by GBHPP up to June 2005

Nature of Scheme		Swabi	Haripur	Attock (Chachh)
I R D P (Number of Schemes)	Communication	9	4	16
	DWSS	3	6	1
	Education	3	2	9
	Health	2	0	1
	Irrigation	1	0	0
	Protection Works	0	0	3
	Sanitation	10	6	25
Types of Trainings		3	3	3
Credit Disbursement		Rs. 18,662,000	Rs. 4,895,300	Rs. 5,830,000

Source: GBTI, Hattian

The credit disbursement was undertaken to enhance the income level of the individual households and facilitated (i) agricultural input (ii) livestock development and (iii) enterprise development. The 3 type of trainings included (i) management trainings (ii) subject specific training and vocational training. The IRDP schemes benefited 17,327 households in the Attock (Chhachh region), 4,628 households in Ghazi, Haripur (Khari Plain) and 9036 households in Swabi region. The training workshops benefited 1,475 individual members in Chhachh, 1,644 in Ghazi, Haripur (Khari Plain) and 1,176 individual members in the Swabi region.

In addition to the above many beneficial impacts of GBHPP, it has not been less influencing to cause serious adverse impacts on the river-based resources of the active floodplains of river Indus. The waters diversion into the concrete power channel of the project and the subsequent he unfavorable alterations in the active floodplains of the river have invoked various secondary impacts on the local population. Further, the secondary impacts have also caused various tertiary and other high order impacts in the study area. Due to adverse alterations and the eventual ill effects, the beneficial uses of the river-based resources have been directly affected. The local communities, who are deriving livelihood from these resources have suffered their income and thus affected socio-economically.

The directly affected communities have been the professional fishermen, gold panners, the individual households keeping their livestock in the *Belajats* and those associated with the business of running water mills, although their number has been insignificant. The profile of the fishermen, gold panners; the bulk fish-catch per fishing party and the gold recovered per individual before GBHPP is discussed in detail in the previous chapter # 4.

The adverse impacts on the socio-economic condition of the fishermen, gold panners and other households being affected due to impairment of *Belajats* are delineated in the tables # 69 to 73.

Table # 69: Profile of fishermen in the sample villages and their monthly income before and after GBHPP

Sample Villages		Total No. of fishermen in the village	Average household size of fishermen	Average income per month per family in PKR before GBHPP	average income per month per family in PKR after GBHPP
Dist Swabi	Gallah	10	8	9,000	6000
	Bata Kara	97	9	10,000	7,000
	Hund	70	7	7000	6000
Dist Haripur	Khalu	Negligible	NA	NA	NA
	Jammu	Negligible	NA	NA	NA
	Qazi Pur	30	8	7000	5000
	Aldo-Jabbi	Negligible	NA	NA	NA
Dist Attock	Jalalia	Negligible	NA	NA	NA
	Daman	Negligible	NA	NA	NA
	Formali	Negligible	NA	NA	NA

Source: Field Survey, 2007-08

The above table shows that significant decrease in the income of the local fishermen has occurred due to losing fishing opportunities in the river and decrease in the average fish catch as was shown in the table # 62.

The decrease in the fish supply has caused increase in the price of fish and as a result the intake of fish in food has also decreased. The price of fish before and after GBHPP is explained in the table # 70.

Table # 70: Fish price in the local market before and after GBHPP

Sample Villages		Fish price before GBHPP	Fish price after GBHPP
Dist Swabi	Gallah	25	120
	Bata Kara	30	130
	Hund	30	120
Dist Haripur	Jammu	35	140
	Qazi Pur	35	130
	Hasan Pur	25	120
	Aldo-Jabbi	30	130
Dist Attock	Jalalia	40	140
	Daman	45	140
	Formali	35	130

Source: Field Survey, 2007-08

The losing of gold panning opportunity has affected gold recovery and the subsequent addition to the stock of gold but has also affected the income of the gold panning professionals as shown in the table # 71.

Table # 71: Recovery of gold and income of gold panners before and after GBHPP

Sample Villages		Average gold recovery per day per person (before GBHPP)	Average gold recovery per day per person (after GBHPP)	average income per family before GBHPP (in PKR)	Average income per family after GBHPP ((in PKR)
Dist Swabi	Gallah	NA	NA	7,000	4,000
	Bata Kara	0.84 gm	Nil	15,000	10,000
	Hund	0.48 gm	Nil	7,000	5,000
Dist Haripur	Khalu	0.72 gm	0.2 gm	10,000	7,000
	Jammu	NA	NA	NA	NA
	Qazi Pur	NA	NA	NA	NA
	Aldo-Jabbi	0.52 gm	Negligible	8,000	5,000
Dist Attock	Jalalia	NA	NA	NA	NA
	Daman	NA	NA	NA	NA
	Formali	NA	NA	NA	NA

Source: Field Survey, 2007-08 *NA: Not applicable due to non-presence of gold panners

The impacts on river's islands (*Belajats*) due to increased human access following drastic decrease in the surface water quantities in the river have adversely affected the ability of *Belajats* to support livestock and fuel wood supplies for the local population in the study area. As discussed previously in the forest management, few *Belajats* have been re-managed by the local communities and the old practice of livestock rearing has reoccurred in those *Belajats*. This is explained in the table # 72.

Table # 72: Role of *Belajats* (river's bars) in fuel wood supply and livestock rearing

Sample Villages		Public perception about fuel wood supply in % by <i>Belajats</i>		Average No. of livestock per household rearing in <i>Belajats</i>	
		Before GBHPP	After GBHPP	Before GBHPP	After GBHPP
Dist Swabi	Gallah	100	0	7-8	0
	Bata Kara	100	30	6-7	1-2
	Hund	100	30	5-6	2-3
Dist Haripur	Khalu	50	10	Negligible	Negligible
	Jammu	45	5	Negligible	Negligible
	Qazi Pur	60	20	2-3	Negligible
	Aldo-Jabbi	70	10	4-5	Negligible
Dist Attock	Jalalia	55	0	3-4	Negligible
	Daman	60	0	2-3	Negligible
	Formali	65	5	7-8	Negligible

Source: Field Survey, 2007-08

The elders of the local population have revealed that about 90 water mills (*jranda*) existed in Pontia village, which is lying just below the sample village of Gallah. However, most of them were abandoned for being affected by the Tarbela reservoir. However, the remaining 3 water mills in Pontia village, which remained operational before GBHPP, have been lost too due to water diversions into power channel of GBHPP.

5.2.4.2 Nutrition

The nutritional status, especially the protein content of food of the local communities has been affected due to significant decrease in fish-catch in the braided channels of the river during the study area. The reduced supply has caused

sharp rise in price of the fish, which majority of the population cannot afford. Although, there has been some supply of fish from the Tarbela reservoir and barrage of the GBHPP, however, the award of fishing contract to private owners has made the fish resource of Tarbela and barrage more commercial and eventually; has caused significant increase in the price of fish. The rise in the fish price is shown in the previous table # 71. Due to decrease in fish supply from the river and the subsequent increase in the fish price, the frequency of fish intake in food of the local communities has markedly decreased as shown in the table # 73.

Table # 73: Fish intake in food by the local communities in the study area before and after GBHPP

Sample Villages		Average No. of intake of fish in food per month before GBHPP	Average No. of intake of fish in food per month after GBHPP	Decrease in %
Dist Swabi	Gallah	7	2	71.42
	Bata Kara	6	2	66.66
	Hund	5	2	60
Dist Haripur	Jammu	4	1	75
	Qazi Pur	6	2	66.66
	Hasan Pur	5	2	60
	Aldo-Jabbi	6	1	83.33
Dist Attock	Jalalia	2	<1	>90
	Daman	3	<1	>90
	Formali	4	1	75

Source: Field Survey, 2007-08

Decrease in the ground water table due to water diversions of the surface water of the river has adversely affected irrigation in the low discharges seasons (Oct-April). Moreover, the impacts on the river's islands (*Belajats*) and the loss of opportunities of rearing of livestock in theses *Belajats* have caused decrease in the number of livestock per household in the study area. The residents of the study area have attributed the decrease in the number of livestock to decrease in the dairy products.

5.2.4.3 Recreation and Aesthetics

The surface water quantities have been drastically decreased due to diversion of huge waters into the power channel of GBHPP. The decrease in surface water quantities is illustrated in detail in the previous tables in discussion on impacts of GBHPP on "Surface Water Quantities". The fascinating environment that was created by the huge unpolluted, clear crystal and coldest water of the river has been largely impaired in the study area. As a result, the human eyes of the charming scenes and ears of the thrilling music due to striking waters have been deprived. The local poets who once kept praising the charms of the river Indus as "*Abaseen*" (meaning father of the rivers), have now expressed their gloom at the disappearance of the gigantic river, especially during the months of November to April. The dry beds of the deserted braided channels of the river during the low discharges seasons have been elaborately shown in the photographs provided.

As discussed previously, the study area by and large, is devoid of public entertaining facilities / opportunities and or other recreational spots for deriving utility and pleasures. Therefore, the impairment of the magic scenes created by the meandering course of Indus flowing within the lush green river's islands (*Belajats*) has been ranked by the local population as the highest adverse impact of GBHPP.

Due to degeneration of charms of the river and its associated small islands, the river banks, which once would remain densely occupied by the locals, and visitors from the adjoining areas; now awfully present a deserted look, especially during the low discharges seasons.

Moreover, the local business of the surrounding population by running fishing huts commercially has also been affected due to loss of visitors to the riverside. Apart from the friends of the locals, the schools and colleges students have also lost the opportunity of fascinating moments during their short picnic days on the riverside. Due to diversion of waters and the subsequent serious impacts on the luxurious scenic beauty of the vast braided channels, the remarkable potentials of developing ecotourism along the riverside has been lost irreversibly.

5.2.4.4 Archaeological and Historical Resources

The braided channels of the river shrink in breadth and therefore, the narrower course of the river along the western part of the study area; especially at village Hund, offers a relatively convenient crossing point for the general population and adventurers in the past. Hence the area is sufficiently popular amongst the historians and archeologists who portray it as one of the significant corridors between the Central Asian region and subcontinent before the roads and trains communication-means in this region.

In order to consolidate the military establishment in this region, two prominent military forts were constructed by the Mughal Emperor Akbar in past. The strategic construction of these forts was carried out with one each on the left and right bank of river Indus. The history of construction of the two forts is discussed in detail in the previous chapter under the sub heading of "Archeological and Historical Resources" of the study area. The two forts constructed were located at the western strategic part as described below;

- i. Hund Fort on the right bank of river Indus
- ii. Attock Fort on the left bank of river Indus

As the forts were primarily constructed to facilitate military move over and guard against possible adventurism by any neighboring hostile country, the forts have had their strategic association with the river. Without the unique morphology of the river and the physiographic settings of the sites, the fundamental notion of establishing these forts become meaningless. The archaeological and historical significance of these valuable resources are fundamentally linked with the river Indus flowing with full grace of huge water quantities in its channels.

The diversion of huge quantities of water into power channel of GBHPP has caused drastic reduction of surface water quantities into the narrow river channel at the forts sites. The reduction of surface water may diminish the significance of the historical association between the river and these strategic forts that exists since their construction. Thus the loss of association between the river and the forts due to loss of waters in the river is likely to reduce the significance of these forts. Subsequently, the spirit for conservation, at the public as well as government level, to keep these priceless resources well-protected for future shall

be dampened in the long run. On the environment front, any damage done to these cultural heritage would be scaled irreversible and of high significance amongst the long term ill effects associated with GBHPP.

5.3 CONCLUSION

The GBHPP has contributed significantly at the national level to overcome the growing ever gap between the demand and consumption in the energy sector of the country. It generates 1450 MW hydroelectricity, which environmentally, is free of Green House Emissions, and, fairly cheaper economically. The project has returned 31646.19 million KWh up to June 2008 of worth Rs. 126.58 billion at the current market rate, however, with no direct benefits to the affected peoples. The GBHPP has also brought secondary development projects through its Integrated Regional Development Plan (IRDP). However, it has been instrumental to bring unfavorable impacts with respect to local ecology and the communities who were deriving livelihoods from the river based resources in the study area. The post implementation data reveal that waters diversions into power channel of GBHPP have caused drastic reduction in the discharges of waters in the braided channels of river Indus. The reductions of surface water quantities have invoked unfavorable alterations in the natural and human environments all along the braided channels of the river.

The post-project scenario reveal that more than 90 % decrease has arisen in the surface water quantities during the natural low discharges season; and with the net change in water discharges reaching up to -105,930 cusecs during the high discharges season. Although, the percentage of decrease during high discharges season is low, the actual decrease or net change has been the highest during the high discharges season. It may be concluded that the magnitude of water reductions is the highest during the natural high discharges season, while significance of the decrease is the highest during the natural low discharges season. The decrease in the surface water quantities in the river has caused serious ill effects on the recharge mechanism of the groundwater reservoir; with the variation of about 10 feet decline in the underground water table in some locations. Due to significant decline in the groundwater reservoir, some of the dug wells undergo dry during the natural low discharges season. The highest magnitude of reductions of

water discharges in high discharges season have affected deposition of alluvium soils on the river's bars / *Belajats*.

Due to water reductions, the fish-catch, especially of the economically abundant specie the *Mallah* (*Shizothorax sp*) has dropped variably from 200-1000 Kg per day before GBHPP to 8-10 Kg per day after GBHPP in some locations. The deeper cut in fish supplies has caused about 400 times increase in the fish price, and the subsequent 60 to 90 % decrease in the frequency of fish intake in diet of the local residents. The thick forests at the barrage site (1140 ha) have been inundated and lost permanently, while other *Belajats* have suffered 70 - 80 % severe damage due to increased human access and over grazing. The reductions in the surface water quantities and damages to *Belajats* have caused direct impacts on the aquatic and terrestrial wildlife respectively, in the vast channels and river's bars. The impacts on *Belajats* have also affected the 50 to 100 % fuel wood supplies in various locations and livestock grazing, varying from 2-3 to 7-8 domestic animals per household all along the study area. Despite losing the opportunities of watering up to 200 numbers of livestock per day with the river, in various locations; the women folk varying up to 100 in number visiting *Gudders* per day in various locations have suffered the use of these villages' *Gudders* along the river bank for various daily uses. The water mills, which were running in some locations along the channels, have been lost irreversibly due to water diversions into the power channel. The historic profession of gold panning in the sands, deposited by the river has suffered, and, the significant recovery of near 1 gram gold per day per person has been affected due to impairment of sands depositions. The professional local fishermen, gold panners and the individual households who were traditionally using the *Belajats* for livestock grazing and fuel wood supplies before GBHPP have suffered socio-economically.

Nevertheless, the project has contributed positively to providing shortest convenient route between the villages on the left bank area and the right bank. The study area, especially the Ghazi town, which is lying closed to the barrage and Tarbela reservoir has experienced noticeable change in the land use due to effects on irrigated agriculture, arising mainly due to decrease in the ground water reservoir; the increased commercialization; and other strategic / security attractions in Ghazi area.

The local people have been deprived of recreational opportunities in the form of unique morphology of river Indus that was carrying clear and cold waters in huge quantities amidst the beautiful lush green *Belajats*. The historical fort constructed at Hund by the Mughal Emperor Akbar is liable to further damages due to loss of its preservation significance by the locals in wake of the drying up of the river channels. The river Indus and the fort have had their historical association, which may be diminished due to drastic reductions in the water discharges of the river.

CHAPTER # 6

SUMMARY OF FINDINGS, CONCLUSIONS AND SUGGESTIONS

6.1 OVERVIEW

This chapter presents the summary of environmental settings / baseline conditions of the study area existing prior to implementation of Ghazi Barotha Hydro Power Project (GBHPP); and the subsequent post-project alterations in the natural and human environment caused by the project. The study has evaluated the environmental changes of GBHPP on the physical, ecological, human use values and the quality of life values. The research was initiated with an extensive literature review to get adequate acquaintance with the topic of the study, besides exploring global, regional and national status of the water resources projects. Nevertheless, the wide ranging economic, environmental and social impacts associated with water resources projects have also been included in the theoretical and conceptual framework of the thesis.

The research tools included secondary data collection through (i) exploratory search for the literature review (ii) qualitative and quantitative data collection from various sources including government offices, project administration and project NGO; and primary data collection through (i) questionnaire survey (ii) interview method (iii) Focus Group Discussions (FGDs) and (iv) personal observations. As the project is trans-boundary in nature, therefore, the sample frame of the study includes two districts of NWFP (Swabi and Haripur) and one district of the Punjab province (Attock). The Sampling technique comprised of three-stage sampling. The stage I sampling included purposive sampling, whereas the stage II comprised of random sampling for the selection of villages from the affected villages of the three districts. The stage II sampling was based on 17.64 % sample size from Swabi district / cluster, 33.33 % from Haripure district /cluster and 27.27 % sample size from Attock district /cluster. The stage III sampling included random sampling too for the selection of households from the sample villages. The sample size in stage III was 7.08 %, 8.73 % and 7.3 % respectively in Swabi, Haripur and Attock district / cluster. The

sample size was 15 % for the fishermen and 30 % for the gold panners in the three districts.

The study was designed to undertake quantitative and qualitative measurements of the relevant variables, which were systematically operationalized in the field. Through the measurements of these variables, useful research findings have been obtained, which validated the hypothesis of the study. The research was designed with the following research objectives (as in chapter # 1) to draw summary conclusions of the study.

1. To study and review the Environmental Assessment Study / Report of the project and other related documents / reports so as to develop an understanding about the pre-project environmental settings of the area.
2. To evaluate / monitor the post-implementation changes those have arisen in the physical, ecological, human use values and quality of life values of the floodplains in the study area.
3. To evaluate and determine the accuracy of predictions made during the impacts scoping and hence to help fill the gape of knowledge between the predictions and actual impacts.
4. To use the research findings for giving practicable recommendations / suggestions for resolving the ill-effects of Ghazi Barotha Hydropower Project and use the same as a feedback for future Environmental Impact Assessment of water resources projects. This will contribute to strengthening the role of EIA as decision making tool.

6.2 ACCOMPLISHMENTS OF OBJECTIVES

The study is largely proven to have accomplished the research objectives formulated in the research design as reproduced above from the chapter # 1. The chapter # 1 has provided detailed description of GBHPP in 1.9.1 – 1.9.3. Similarly the chapter # 3 has discussed the extent of the Environmental Study of the project in light of the theoretical framework, where as the chapter # 4 has provided the pre-project environmental settings / baseline conditions of the study area with details. Therefore, the objective # 1 of the study has properly been achieved.

The chapter # 5 has evaluated the post-project impacts on the floodplains ecology in the study area. The monthly average discharges below the barrage in the study area have been compared with the pre-project discharges and hence the net changes, measured. Moreover, the impacts of water diversions have been evaluated with regards to aquatic and terrestrial resources and the subsequent ill effects on the human environment in the study area. So the objective # 2 has perfectly been fulfilled in the study.

The chapter # 5 has described the magnitude and significance of the alterations in the natural and human environments caused by GBHPP. Furthermore, the actual impacts of the project on the natural and human are properly characterized quantitatively and or qualitatively. The assumptions in the Environmental Study of GBHPP to offset the adverse impacts on the physical and ecological resources by the current 1000 cusecs compensatory water discharges have proved wrong. The findings of the study, thus, have achieved the objective # 3 of the study.

The present chapter has figured workable suggestions in the end to revive the historic physical and ecological resources, as associated with the river before GBHPP; and to ameliorate the various ill effects caused by the project on the human environment. Hence the study has successfully achieved the objective # 4 of the research.

6.3 RESEARCH FINDINGS

The variables were operationalized in the sample villages of the universe and data was collected longitudinally (repeated observations over extended period of time) during the normal, low and high discharges seasons of the river Indus. The analysis of the data provides useful findings about the alterations caused by GBHPP in the natural and human environments of the floodplains in the study area. The summary descriptions of the alterations caused, are underlined as follows:

6.3.1 *Pre-Project Environment*

The river Indus, which has been running in the study area since time immemorial, is regarded as a splendid gift of the Creator of the universe for this area. Its benefits are vastly extended from the upstream northernmost parts to the downstream coastal plains of the country where it disappears on joining the

Arabian Sea. Its significant services for the natural and human environment in the study area are summarized below:

6.3.1.1 Physical Resources

Historically, the river Indus has two natural regimes, the low discharges season and the high discharges season. The low discharges season begins in October and last till the month of April, while the high discharges season from May to September. The 10 year pre-project data showed that the minimum average discharge during the low discharges season was 11,667 cusecs in January, 2002. With this discharge, however, the river was fully capable to extend all its related benefits to local populations in the study area. The maximum discharge recorded during the high discharges season was 293,400 cusecs during the month of July in the year 1998.

The suspended particles get settled in the Tarbela reservoir above the barrage, and the water quality therefore, gets highly improved. The rapid flow in large quantities and the increased surface areas of waters due to spreading in the braided channels contributed towards more dissolution of Oxygen from the air and thus rendered the quality ideal enough for the aquatic life and other uses.

The water-flow of Indus in huge quantities, especially in its braided morphology in the study area is considered to be the main source of ground water recharge in the closed vicinity of the river. Alluvium soil is found in the deltaic terraces and in the *Belajats* (river's bars). The soil is fertile and varies from silt to sandy in composition outside the active floodplains of the river. The Tarbela reservoir has been constructed on earthquake belt due to lack of adequate Environmental Impact Assessment prior to Tarbela dam construction in the past. The study area, especially within the closed proximity to the river, experiences microclimate changes due to evaporation effects from the large water surfaces in the braided channels, and upon the contact of breezing air with the cold water of the Indus.

6.3.1.2 Ecological Resources

The area is popular for the abundance of fisheries in river Indus during this reach. Although, the river due to its excellent water quality, is home to many species of fish, the economically abundant species are *Mallah* (*Shizothorax sp.*),

Mahsheer (*Barbus putitora*) and *Chaina* (*Mystus oar*). This study revealed that as more as 80% of the fish catch is comprised of *Mallah*, which is popular for its delicious taste like the trout fish of the northern coldest water. The fishermen (locally called *Mahimar*) were found to practice fishing in groups. The individual group of fishermen is called "fishing party" locally and its members vary from 3-5 to as many as 15-20. Majority of the fishermen belonged to right bank area of district Swabi, where 97 as the maximum number of fishermen occurred in the sample village of Bata Kara. The highest average fish catch was about 200-1000 Kg per day in Bata Kara (district Swabi) followed by 50-200 Kg in Hund.

The *Belajats* (small islands constituted by the river) were occupied by the productive forests ranging from trees to grasses. *Dalbergia sisso*, *Acacia nilotica* and *Acasia modesta* were the common tree species and *Zizyphus nummularia* amongst the shrub species. The grass species included *Imperata cylindrical*, *Saccharum munia* and *Saccharum spontaneum*. The terrestrial wildlife included variety of species of mammals, reptiles and avian. The common amongst them are wild Boar, Jackals, Rabbits; Herons, Terns, Kingfishers, Wagtails, Larks, House Crow, Common Mynah, Red-vented Bulbul, Collared Dove, Bee-eaters, Woodpeckers, Parakeets, Warblers and Thrushes. According to the locals, the cranes visit this area as temporary stopover during their migration from Siberia on their onward journey to the south of the country.

6.3.1.3 Human Use Values

The local communities, especially the women folk use the river for washing clothes and churning milk at the village's designated points called *Gudders* locally, besides taking river water to their homes for household uses. The study found that there were 3 water mills (out of the total 90 water mills before Tarbela reservoir) in a small village of Pontia below the sample village of Gallah. The women also use the river for watering their domestic livestock. The maximum numbers of livestock being watered with the river were 200 each in the village Gallah and Hund, followed by 150 in the village Bata Kara. The maximum number of village's *Gudders* were 4 each in the village Bata Kara and Qazi Pur, where as the maximum number of women visiting *Gudders* for daily use were 100 per day in the village Gallah.

The study area is famous for an old profession of gold panning in the sands deposited by the river. The maximum numbers of gold panning professionals were found in the village Khalu, which were 150 in number, followed by 25 in Bata Kara. There were no gold panners in the sample villages of district Attock. The study showed that the gold recovered per day in the sand deposited by the river was near 1 gram.

6.3.1.4 Quality of Life Values

The study showed that generally the local communities derived their livelihood directly from the river based resources in the study area. However, the uses of various ecological resources varied amongst the residents of district Swabi, Haripur and Attock. The women direct use of river's surface water was highest in district Swabi and Haripur. The highest average number of livestock rearing in *Belajats* was 7-8 per household in Gallah (district Swabi) and Formali (district Attock), followed by 6-7 livestock per household in Bata Kara (district Swabi). The lowest average number was 2-3 in Daman (district Attock). The highest 100 % supply of fuel wood was recorded in district Swabi, followed by 70 % in Aldo-Jabbi (district Haripur). The lowest supply of 45 % was recorded in Jammu (district Haripur). The study revealed that 80 % of the total gold panners were in district Haripur, while 20 % in the district Swabi. The number of professional fishermen was highest in district Swabi, which was about 85 % of the total fishermen in the study area, while about 14 % belonged to district Haripur. The average fish catch varied between the highest 200-1000 Kg in Bata Kara (district Swabi) to the lowest 50 -100 Kg in Qazi Pur (district Haripur).

6.3.2 Post-Project Changes by GBHPP in the Environment

The diversions of huge surface water quantities into the concrete power channel of GBHPP have caused drastic reductions in the discharges of waters in the braided channels in the study area. The reductions of surface water quantities have invoked unfavorable alterations in the natural and human environments leading to adverse secondary, tertiary and other high order impacts. The brief description of the ill effects caused by the project on the floodplains ecology in the study area is as given below:

6.3.2.1 Physical Resources

The post-project data show that more than 90 % decrease has arisen in the water quantities during the natural low discharges season. The month of October has shown 97.92 % decrease during the first operation year of 2004. The lowest decrease during the low discharges season has been in the month of November (2004), which is 81.16 %. The percentage of decrease was known to be lowest during high discharges season. The month of June, 2004 recorded the lowest decrease of 33.69 %. Although, the percentage of decrease during high discharges season is low, the actual decrease or net change in the discharges has been the highest during the high discharges season. Thus the decrease in percentage for the month of July was 52.8 %, however, its actual decrease has been 105,930 cusecs, the highest in the post-project scenario. The net change in the maximum discharges has also been highest during the high discharges season. However, the percentage of decrease is the lowest in high discharges season and highest in the low discharges season. This phenomenon indicates that the magnitude of water reductions is highest during the natural high discharges season than the low discharges season. However, the significance of decrease in surface water quantities in the braided channels is highest during the natural low discharges season than the high discharges season. The decrease in the surface water quantities has caused serious ill effects on the recharge mechanism of the groundwater in the study area. The sample villages lying on the river bank have shown the maximum reductions in ground water table. The maximum reduction in groundwater table of 10 feet was observed in Gallah village, followed by 9 feet in Hund. The lowest decrease was recorded in Jalalia, which is lying about 6 km away from the river. The highest magnitude of the decrease of surface water quantities during the high flood season has affected deposition of alluvium soils on the some of the *Belajats*, which were previously benefiting from the significant depositions.

6.3.2.2 Ecological Resources

The project has inflicted the most noticeable impacts on the fishery resource in the braided channels, both by magnitude and significance. The abundant specie, the *Mallah* (*Shizothorax* sp) is a running water specie, which has recorded remarkable decrease in the daily fish catch. The highest fish catch has

dropped from 200-1000 Kg per day per in Bata Kara to 8-10 Kg per day. Other villages have also shown significant decrease in the fish catch. The valuable forests in the *Belajats* have suffered both the reversible and irreversible impacts due to drastic decrease in the surface water quantities, which were previously supporting life of the flora and naturally guarding against increased human access. The thick forests at the barrage site, covering 1140 hectares of land, have been inundated and lost permanently, while other *Belajats* have suffered 70 - 80 % severe damage due to increased human access and over grazing. The aquatic and terrestrial wildlife has been affected due to decrease in the surface water quantities and the subsequent damages to forest in the *Belajats*. The common species have suffered low, the water related species moderate, while the migratory species have suffered the ill effects, of high magnitude.

6.3.2.3 Human Use Values

The GBHPP is exceptionally significant to overcome the country's growing ever gap in energy between the supply and demand. The generation of 1450 MW is not only emissions free of Green House Gasses and cheaper economically, but high saver of the foreign exchange at a time, when the country is confronting serious foreign reserves crisis. The project has contributed 31646.19 million KWh up to June 2008. However, the project has caused numerous problems on the environmental fronts in the floodplains ecology in the study area. The decrease in the surface water quantities in the braided channels has led to decline in the groundwater reservoir and water table depletion in the dug wells, some of which go dry during the low discharges season of the river. The women folk have suffered the use of *Gudders* (common gathering points on river bank) for washing clothes, churning milk and watering livestock during the months of October to April. The previous water mills have suffered irreversibly due to water diversion into the power channel. The historic profession of gold panning in the sands deposited by the river has suffered, and, the significant recovery of about 1 gram gold per person has been done away with.

Nevertheless, the project has contributed positively to providing shortest route between the villages of the left bank area (Swabi region) and the right bank strategic town of Ghazi. The study area has experienced noticeable change in the land use due to effects on agriculture, arising due to decrease in the ground water

reservoir during the low discharges season; and increased commercialization, especially in the strategic town of Ghazi which is situated very closed to the barrage.

6.3.2.4 Quality of Life Values

The socio-economic impacts associated with GBHPP are mixed and varied greatly in the geographical context. The project contributes a significant proportion of hydro energy that is economically cheaper, environmentally emissions free and an urgent need of the time. It has produced 31,646.19 million KWh up to June 2008 since its experimental operation in 2003, and an economic return of Rs. 126.58 billion at the current market rate, instead of the proposed Rs. 23.42 billion at per the PC1 of the project. In addition, the project has undertaken numerous community infrastructure and human resource development schemes worth billions under the Integrated Regional Development Plan (IRDP) for the affected areas. However, the project has caused serious ill effects with respect to local ecology and the communities who were deriving livelihoods from the river based resources.

The professional local fishermen, gold panners, the individual households who traditionally were using the river's *Belajats* for livestock' grazing, forage and wood supply, have suffered their income and consequently their socio-economic conditions. Due to drastic decrease in the surface water quantities, the previous fish-catch in heaps has reduced to almost negligible all along the river in the study area. As a result the fish price has increased about 400 times in average, and subsequently, the intake of fish in food has decreased from 60 to 90 % in frequency in various locations.

The area has been deprived of recreational opportunities that existed due to unique morphology of river Indus, carrying clear and cold waters within the lush green river's islands (*Belajats*). The historical fort constructed at Hund (sample village) by the Mughal Emperor Akbar, as the military post, for guarding river crossings has had its historical association with the river. Therefore, the fort is likely to lose its preservation significance owing to drying up of the river channels, especially during the low discharges season, when more than 90 % of the water is diverted into power channel of GBHPP.

6.3.3 *Testing of Research Hypothesis*

The research findings revealed that GBHPP has caused both the beneficial and adverse impacts on the floodplains ecology in the study area. The benefit of generating 1450 MW emissions free cheaper electricity for the country is rated highly significant at the national level. Moreover, the project has also brought various secondary development schemes for socioeconomic uplift of the local communities. Nevertheless, the diversion of huge quantities of water of the river into the power channel of GBHPP has resulted into adverse alterations of the natural and human environment and the subsequent various ill-effects of high magnitude and significance locally. The various variables, thus, measured quantitatively and or qualitatively; and interpreted into tables and figures validate the larger research hypothesis of the study.

6.4 CONCLUSIONS

The GBHPP generates 1450 MW electricity, which is a significant contribution at the national level, to bridge the growing gap between the energy demands and consumptions. The project is also reflection of the government policy to utilize the country's renewable hydro potentials, which are cheaper and environmentally free of emissions of Green House Gases. The reliance on renewable sources of energy has increased tremendously in wake of the global economic recession and climatic changes. The project has produced 31646.19 million KWh of worth Rs. 126.58 billion up to June 2008. Like any huge project funded by the international donor agencies, the GBHPP has launched numerous secondary development projects to ameliorate the resulting unfavorable changes in the floodplains ecology; and ultimately help offset the ill effects on the human environment in the study area. The study has described the main components of the Integrated Regional Development Plan (IRDP), training programs and credit disbursements carried out for the socio-economic uplift of the local communities. However, the water resources projects being environmentally one of the most sensitive development projects, the GBHPP has also been no exception to cause many adverse impacts of varied magnitude and significance in the geographical context.

The summary findings of the study suggest that the project has proved unprofitable for the large local populations living on the right bank area of district Swabi and left bank areas of district Haripur and Attock. The impacts on the local populations have arisen due to some of the unpredicted adverse changes in the vast floodplains ecology of river Indus. The study has found that the physical and ecological resources of the floodplains ecology have deteriorated due to significant changes in the hydrological regimes of the river. The drastic reductions in the hydrological regimes in the braided channels of the river have happened, basically, due to diversion of huge quantities of surface waters of the river into power channel of GBHPP.

The analysis has revealed that the drastic reductions in the discharges of the river, especially up to more than 90 % during the natural low flow season (October-April); and the subsequent changes in the physical environment have, in turn, invoked further impacts on the ecological resources. The aquatic resources in the vast braided channels such as fisheries and aquatic wildlife; and the terrestrial resources such as forests, livestock' forage and terrestrial wildlife in the river's bar or *Belajats* have suffered directly due to significant reductions in the river's discharges and increased human access. The fish catch has remarkably been reduced after GBHPP in various locations along the river. The decrease in fish catch has caused about 400 times increase in fish price and 60 to 90 % decrease in the frequency of fish intake in the local diets. The study has also shown that the compensatory water discharges designed in the project plan are extremely insufficient to support fishery and other ecological resources, mainly due to the widened, braided and highly meandering course of the river in the study area.

The analysis show that the local populations associated with earning livelihoods from the fishing industry, the gold panning profession and grazing livestock in the *Belajats*, have suffered economically. The findings also revealed that due to serious impacts on recharge mechanism of the groundwater reservoirs, decline in the underground water table reaching up to 10 feet in various villages has happened. Decline in the underground water has affected water supply for drinking / household uses and irrigated agriculture. The impairments of *Belajats* due to drastic reductions in the discharges of the river and increased human access, the utility of fuel wood supplies by the *Belajats*, which varied from 50 to 100 % in

various locations, has been lost altogether; besides loss of natural habitats for the various wildlife species all along the river. The impacts have also happened on other social services, which were extended by the river before GBHPP. The women users of the river have lost the significant uses of the river for washing clothes, milk churning and watering livestock. The opportunity of using the river channels for running water mills has been lost irreversibly in the area. The impairment of the scenic views of the unique morphology of the river; and the huge quantities of clean and cold waters passing through the charming lush green *Belajats* have caused huge adverse impacts on the recreational / aesthetic utility of the river in the study area. The historical fort constructed at the village Hund by the Mughal Emperor Akbar may suffer further neglect due to loss of its preservation significance in wake of the drying up of the river channels due to water diversions.

6.5 SUGGESTIONS

During post-audit of the impacts of GBHPP, it was found that the project has caused significant beneficial as well as numerous harmful effects on the natural and human environment of the study area. The study underlines the following suggestions to offset the adverse impacts of GBHPP and help diversify its benefits on equity basis amongst the local and non local stakeholders:

1. Monitoring the Study Area as an Ecosystem

Keeping in view the huge contribution of GBHPP to the under stressed energy capacity of the country, and, the subsequent detrimental effects of the project on the floodplains ecology, a systematic monitoring program for the study area is required on regular basis throughout the project life. The monitoring should be executed by the Federal and Provincial Environmental Protection Agencies in collaboration with the academia. This will help identify the actual effects and evaluate the effectiveness of the mitigating measures adopted. The approach must be based on investigating the entire study area as an independent larger ecosystem of the environment, comprising the entire floodplains included in the study area. The monitoring should cover the following components of the environment and help suggest timely interventions to resolve the problems.

A. Monitoring of Water Resources

The surface water quality and quantities should be regularly monitored in the river down the barrage. As the surface waters of the river have been found to influencing the recharge of the ground water reservoirs, the possible effects of the changed hydrological regimes on ground water reservoir should closely be monitored.

B. Monitoring of Ecological Resources

The aquatic resources including the valuable fishery resource, terrestrial flora and fauna in the river's islands / *Belajats*, including the wild Boars causing damages to agricultural crops, should be monitored regularly throughout the project life to assess the potential impacts of the project on these resources.

C. Monitoring of the Human Environment

The study has discovered significant impacts of the project on the physical and ecological resources of the river. As a result, the human environment of the floodplains has been influenced adversely in terms of various economic and social services by the natural environment. The socio-economic indicators of the local communities should be monitored to assess the social effects of the water diversion, and, of the various community uplift programs, which were launched by the project to mitigate the adverse impacts, especially on the most vulnerable groups.

2. Enhancement of the Compensatory Water Releases

As one of the significant research discoveries in the study, it has been found that the compensatory water releases of 1000 cusecs during the low discharges season as designed in the project, is extremely insufficient to support the biological resources in the vast braided channels of the river. In view of the drastic reductions exceeding 90 % in the low discharges season, the compensatory water releases must be enhanced to at least 3,000 cusecs for the natural low discharges season. Research for the re-adjustment mechanism of the compensatory water releases is discussed in detail in the next chapter of "Future Research".

3. Change in the Mechanism of Discharge of Compensatory Water Releases

The study has found that the compensatory waters are released during the low discharges season in bulk quantities at pulses, rather at the steady rate, and, through the under sluices of the project. The bulk releases have been found to cause the reported losses of human lives downstream. The bulk releases are also without any worth for the aquatic resources, especially the fisheries. Therefore, it is suggested that the compensatory water releases must be released at the steady rate, and, through the gates of standard bays to extend waters to the largest braided channels of the river. The change thus, in the discharge mechanism, is believed to ensure optimum utilization of the compensatory water releases for mitigating adverse impacts on the fisheries and other aquatic life.

4. Multi-Sector Multi-Year Integrated Development Program for the Affected Communities

The GBHPP has contributed an economic return of Rs 126.58 billion up to June 2008 since its experimental operation in 2003. The ecological justice demands that the economic benefits of the project should be distributed equally without any socio-economic miseries and environmental deteriorations for the local communities. For this purpose, a Community Development Program (CDP) must be established on permanent basis throughout the project life for welfare of the affected communities.

A small fraction of less than 1 % of the annual income of GBHPP would suffice to create sufficient fund for their welfare programme focussing on poverty reduction with special reference to health, education and employment schemes or skills development in the area. The fund should be spent in the priority areas on participatory approach of the public of the area. Moreover, the fishing licenses for fishing in the project's barrage and Tarbela reservoir must be granted to the affected local fishermen on priority basis. This will provide them alternative fishing opportunity, and also to overcome the losses of fish supply to the local communities.

CHAPTER # 7

FUTURE RESEARCH

This chapter is aimed to provide proposal for future research to undertake scientific monitoring studies of the floodplains ecology of river Indus in the study area, in wake of the implementation of GBHPP in May, 2004. The useful findings obtained at the end would help identify the ill effects that have arisen over the longer course of time due to water diversions into power channel and the subsequent water reductions in the vast braided Indus river channel in the study area. The long term adverse impacts identified thus can be compared with the predictions made during the project feasibility study. The careful comparison between the actual and predicted impacts will identify the gap in knowledge about the potential changes associated with water resources projects in general and water diversions projects in particular. The knowledge obtained from the experience of GBHPP will contribute to strengthening the role of Environmental Impact Assessment (EIA) as decision making tool in project planning and policy formulation in future.

The monitoring study to be undertaken on regular basis through out the project life, will lead to timely interventions by the project proponent in collaboration with and the local communities. Thus innovative solutions may be sought to problems emerged in the physical and human environment. The solutions / mitigating measures to be adopted should be efficient, less expensive and largely relevant to the needs of the local communities. Ultimately, the project will become more sustainable on environmental grounds while the welfare of the local communities and vulnerable groups remain uncompromised at the larger national economic development achieved with the GBHPP. The future research is proposed to encompass the following dimensions in the study:

7.1 METHODOLOGICAL

The study should be designed to use the GIS tool to detect changes in the land use in the study area, and, analyze the surface water quality and quantities in the braided channels of the river below the barrage of GBHPP. The source of data for the GIS should be the satellite imageries taken by the Quick Bird or SPOT

satellites using Multispectral Sensors (MSS) for analysis of vegetation cover in the river's islands (*Belajats*). For getting the most highest resolution of images of these satellites, the Panchromatic sensed images should also be obtained for use in the system. The satellite images in the near Infra Red (IR) bands will be useful for determination of changes in the vegetation cover over the course of time. The vegetation cover can be properly related with the changes in the surface water hydrology in the braided zone of the river as well as the other interventions initiated for the management of natural vegetation in the *Belajats* by the project / government or local communities in the area.

The methodology should be based on using the hybrid GIS to utilize the Raster data of satellite images as well as the vector data obtained through field surveys and other sources. The GIS based methodology can also be used to make predictions about the changes in the vegetation cover / land use and or hydrology in the braided zone for future with and without human interventions with aim of sustainable management of biological resources.

7.2 OPTIMIZATION OF THE COMPENSATORY WATER RELEASES

The Environmental Management Plan (EMP) is the scheme of actions devised in development projects, which are likely to cause unfavorable alterations in the natural and or human environment. The EMP is usually comprised of mitigating measures that are launched during the construction as well as operation phase in order to eliminate the adverse impacts altogether or minimize their intensity to the affordable level. The GBHPP is basically a water diversion project involving power generation through the diverted surface waters of the Indus river. The diversions of huge surface waters cause water reductions / losses to the critical level in the vast braided zone of Indus in the study area. The loss of waters in the braided zone has affected the aquatic and terrestrial resources, and other significant services related with the surface water quantities of the river.

The environmental study that was carried out as part of the feasibility study of the project predicted adverse impacts on the biological resources of the river, especially the significant stock of fish resources in the river in the study area below barrage up to its confluence with river Kabul at Attock bridge. The project was designed to release 1,000 cusecs water as compensatory water to offset the adverse

impacts on fishery and other aquatic and terrestrial resources in the braided zone of the river. However, the study has found that the 1,000 cusecs compensatory water is extremely insufficient to support the vast ecosystem and its resources in the braided zone. As the river attains meandering shape with repeated divisions in small to large sub channels, the compensatory water that has been released so far during the low discharges season of the river does not reach most of the significant channels and natural creeks. The fish stock in the channels in this reach is mainly dependent on migration from the downstream areas for which the presence of sufficient water in the river's channels is essentially a well established prerequisite.

On the basis of information in interview with the local fishermen and expert opinion of the fishery department, the compensatory water releases should be enhanced during the low discharges season to facilitate fish migration and the eventual return of fish to the affected channels.

As the power generation undertaken in the project is of prime importance and direly needed nationally in wake of the serious energy shortfall, it is proposed that further research should be carried out systematically to arrive at an optimum level of compensatory water releases during the low discharges season for the support of fishery and other biological resources. The research should involve enhancing the compensatory water releases in steps beginning with addition of 500 cusecs to the existing 1,000 cusecs ($1000 + 500 = 1500$) and comparison with the results obtained. It is believed that the optimum level may be obtained at about $3,000 \pm$ cusecs as the compensatory water for the biological resources of the vast ecosystem in the study area. The research will avoid unnecessary water releases at the expense of any reduction in the power generation of the project.

7.3 ANALYSIS OF SURFACE AND GROUND WATER RESOURCES

The research has established an important linkage between the surface water of the river and the groundwater reservoirs in the sample villages. The natural recharge mechanism of groundwater reservoirs by surface water of the river in the floodplains was elaborated in detail in chapter 5. The recharge, thus, signifies the preservation of surface water quality for the direct use of river by the women folk, aquatic resources and the associated food chain; recreational utility as well as for the protection of groundwater quality in the study area. The impairment

of surface water quality, especially during the low discharges season may pose the potential threat to quality deterioration of the groundwater reservoirs and the impending health problems.

The study therefore, underscores the significance of undertaking research for analysis of the surface water and groundwater quality on regular basis to avoid the potential health disaster in the human environment. Besides other parameters, water quality assessment of river and groundwater should be conducted for determination of Temp, pH, Turbidity, Electrical Conductivity (EC), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD); and Ecloi test as indicator of pathogenic contamination from the household sources. On the basis of results of the above tests, further investigative analysis can be carried out for quality evaluation.

7.4 ANALYSIS OF WASTE WATER VIS A VIS POPULATION EXPANSION IN THE STUDY AREA

The floodplains of river Indus in the study area provide an important physiographic layout for effective drainage system of the surrounding villages, especially along the right bank of the river. A number of small and large streams join the river Indus on the right bank below the barrage up to its confluence with the river Kabul. The most significant of them are the two streams named locally as Topi Khwar and Badri Nala, which receive the untreated household sewage and storm waters in huge quantities from a number of collecting small streams and big drains of the upstream villages. Moreover, the sewage of the Tarbela dam colonies and GIK Engineering Institute is also disposed off without treatment in the river. The left bank receive sewage from the Ghazi cantonment area as well as other surrounding settlements.

Besides the storm and household sewage, the Topi Khwar also receives the industrial effluents from the nearby Gadoon Amazai Industrial Estate (GAIE). Although, most of the industries are closed presently due to inappropriate policies of the government, however, their operation in future is likely to generate huge quantity of effluents, which are bound to join the Topi Khwar; and onwards the river Indus. It may be worthwhile to restate here that the GAIE was established to provide alternative employment opportunities to opium growers in this area. The

estate was designed properly with the entire necessary infrastructure, however, without any treatment facility for the industrial effluents.

The study area in general, and the Topi town on right bank and Ghazi town on the left bank on particular, are prone to rapid commercialization and the subsequent population expansion. The huge quantities of untreated sewage and the industrial effluents from GAIE in future, pose serious challenge to surface water quality of the river, especially during the low discharges season. There is every possibility that the situation may worsen further with the expansion of population in the surrounding villages of the floodplains of river Indus.

The waste water should be assessed carefully vis a vis population expansion and the projected growth in the surrounding villages. The eventual water quality deterioration of the river is likely to render the already reduced surface waters of the river and the insufficient compensatory water releases largely incapable to extend any utility to biological resources and or the human environment of the floodplains ecology of river Indus.

7.5 MULTI-SECTOR MULTI YEAR DEVELOPMENT PLAN

In order to develop the area, evidence based multi sector multi year development plan, with the participation of the local communities, should be prepared. This area needs more in-depth research, through the project life, to evaluate the ongoing impacts of GBHPP on the human environment in the study area and help suggest practicable and effective interventions, which are relevant to the needs of the affected peoples.

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ANNEXURE - I

(Questionnaire for Local Residents)

1. Name of Village: _____ 2. Name of Respondent: _____
 3. Number of Family Members _____ 4. Gender (H.H): _____ m, _____ f
 5. Number of literate per H. H: _____
 6. Educational Level: 1. Head _____ 2 (other family members). _____
 3. _____ 4. _____ 5. _____ 6. _____ 7. _____
 7. Source of income: _____
 8. Income of the H.H per month: _____
 9. Source of Fuel: _____
 10. Contribution of Fuel Wood by *Belajats* (river's islands):
 - (a) Before GBHPP: All _____ Half _____ Quarter _____ None _____
 - (b) After GBHPP: All _____ Half _____ Quarter _____ None: _____
 11. Number of Animals Rearing in *Belajats*:
 - (a) Before GBHPP: _____ (b) After GBHPP: _____
 12. Effects of GBHPP on Animals Rearing in *Belajats* (% Reduction / Increase):

 13. Effects of GBHPP on Wildlife and Forests in *Belajats*:
 - (a) Wild life _____ (b) Forests: _____
 14. Effects of GBHPP on Fishery: Supply (%) _____ On Fish Price (%) _____
 15. Changes in Land Use by GBHPP: _____
 16. River-Use Before GBHPP: (a) For Water Supply: _____
 - (b) Watering Animals: _____ (c) as *Guddurs* (for washing clothes and churning milk): _____ Number of *Gudders* in this Village?

- How many women visited *Gudders* per day? _____ Alternative(s) to *Gudders*:

(d) Use of river water for Water Mill (Y / N): _____ if yes, number of water mills in this village? _____ (e) Use of Riverside for Recreation:

(i) Used by Locals: _____ (ii) By Non Locals: _____

(iii) Specify month (s) of visits: _____

17. Effects of GBHPP on Ground Water Yes: _____ or No: _____

If yes, (a) Its impacts on domestic use in terms of water depletion in well (feet):

(b) Distance of well from the river (meters / Km): _____

(c) On Agriculture Yes: _____ or No: _____

(d) Specify month(s): _____

18. Contribution of GBHPP to providing / improving Infrastructure:

19. Employment by GBHPP: (a) During Construction _____

(b) During Operation _____

20. Compensation for any Effect: _____

21. Consultation by GBHPP Authorities before Commencement of the Project (Y/N): _____

22. Expectations of any from GBHPP: _____

23. Any other Observation / Comment by the Respondent about GBHPP:

ANNEXURE -II

(QUESTIONNAIRE FOR LOCAL FISHERMEN)

1. Name of Village: _____
 2. Name of Respondent: _____
 3. Number of Family Members _____
 4. Gender (H.H): _____ m, _____ f
 5. Number of literate per H. H: _____
 6. Educational Level: 1. Head _____ 2 (others). _____ 3. _____
4. _____ 5. _____ 6. _____ 7. _____
 7. Source of income before GBHPP: _____
 8. Total income of the H.H per month before GBHPP? _____
 9. Do you have had a fishing license Y / N: _____
 10. Method of fishing (netting / electrification etc: _____
 11. Abundant fish specie in the river in the project area: _____
 12. Total Fish Catch per day before GBHPP: _____
 13. Name of main fish markets / areas where fish was supplied: _____
 14. Fish catch after GBHPP: _____
 15. Main source of income after GBHPP: _____
 16. Total income of the H.H per month after GBHPP? _____
 17. Compensation by the GBHPP (Y / N): _____
 18. If yes, how? (Monetary / Employment in GBHPP): _____
 19. Suggestion for revival of fishery in the project area: _____
-

ANNEXURE -III

(QUESTIONNAIRE FOR GOLD PANNERS)

1. Name of Village: _____
2. Name of Respondent: _____
3. Number of Family Members _____
4. Gender (H.H): _____ m, _____ f
5. Number of literate per H. H: _____
6. Educational Level: 1. Head _____ 2 (others). _____ 3. _____
4. _____ 5. _____ 6. _____ 7 _____
7. Source of income before GBHPP: _____
8. Gold panned out per month before GBHPP: _____
9. Total income of the H.H from gold panning per month before GBHPP?

10. Source of income after GBHPP: _____ 11. Total
income of the H.H per month after GBHPP: _____
12. Employment by GBHPP: (a) During Construction _____
(b) During Operation _____
13. Compensation for any Effect: _____

14. Consultation by GBHPP Authorities before Commencement of the Project
(Y/N): _____
15. Expectations of any from GBHPP: _____

16. Any other Observation / Comment by the Respondent about GBHPP:
