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Abbreviations and Acronyms

AHEC	Alternate Hydro Energy Centre (IIT, Roorkee)
ASSESS-HKH	Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush Himalayan Region
BOD	Biological Oxygen Demand
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
DOA	Department of Agriculture
DOE	Department of Environment
DOI	Department of Industry
DOPH	Department of Public Health
DOEF	Department of Environment and Forest
EIA	Environmental Impact Assessment
EPC	Environment Protection Council
HKH	Hindu Kush-Himalayan
ICIMOD	International Centre for Integrated Mountain Development
IPM	Integrated Pest Management
IRSA	Indus River System Authority FFC Federal Flood Commission
KU	Kathmandu University Nepal
KWSB	Karachi Water and Sewerage Board
masl	meters above sea level
MOA	Ministry of Agriculture
MoEF	Ministry of Environment and Forest
MOEF	Ministry of Environment and Forests
MOEST	Ministry of Environment, Science and Technology
MOFSC	Ministry of Forest and Soil Conservation
MOLD	Ministry of Local Development
MoUD	Ministry of Urban Development
MOWR	Ministry of Water Resources
MoWHS	Ministry of Works and Human Settlements
MPPW	Ministry of Physical Planning and Works
NEC	National Environment Commission
NECS	National Environment Commission Secretariat
NEPBIOS	Nepalese Biotic Score
NWRDC	National Water Resources Development Council
PCRWR	Pakistan Council of Research in Water Resources
RSMS	River Sustainable Management Strategies
UNEP	United Nations Environment Programme
VDC	Village Development Committee
WAPDA	Water and Power Development Authority
WAS As	Water and Sanitation Agencies
WEC	Water and Energy Commission
WFD	Water Framework Directive
WHO	World Health Organization
WP	Work packages
WQC	Water Quality Class

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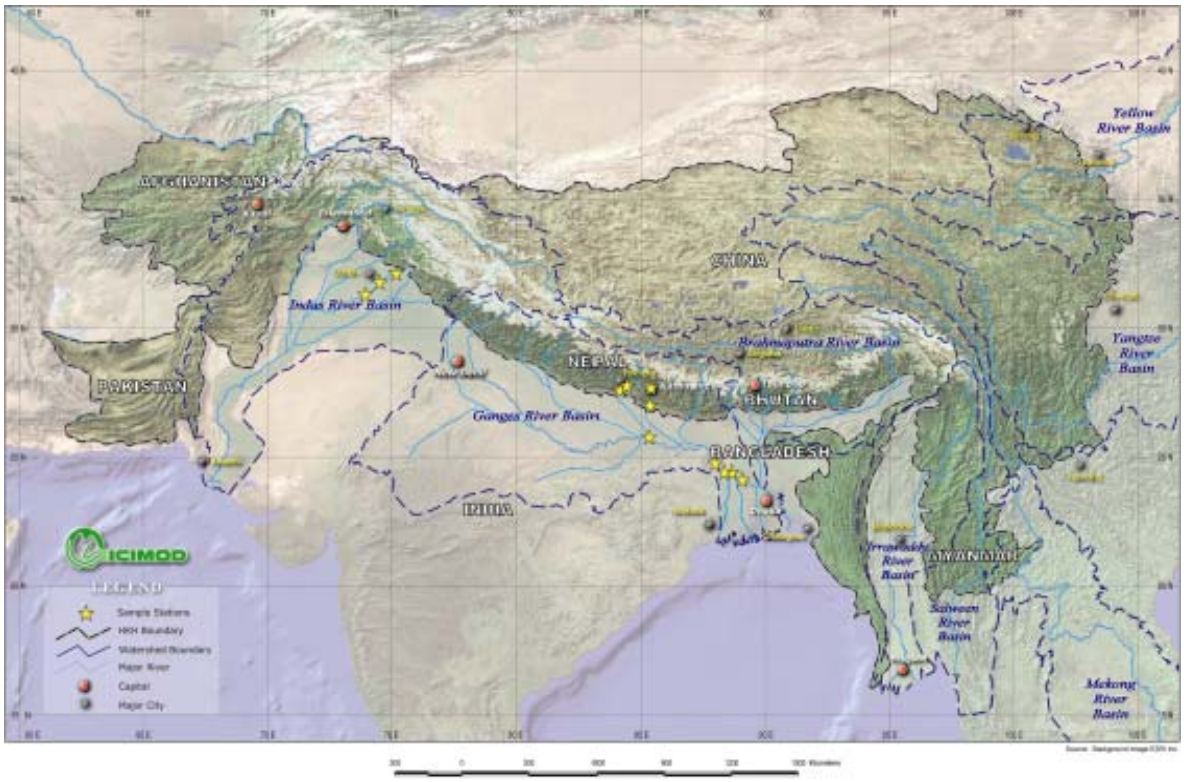
PART I: REGIONAL SYNTHESIS

1 INTRODUCTION

1.1 Background

Three major river systems in the Hindu Kush-Himalayan (HKH) region of South Asia are the Indus, the Ganges, and the Bramhaputra. Five countries that fall within these river systems are Bangladesh, Bhutan, India, Nepal, and Pakistan. Major river basins and their watershed boundaries are shown in Figure 1.

Figure 1: Major River Basins in South Asia



This region is one of the largest storehouses of freshwater in the world supplying the need of about 1,500 million people living in South Asia. These rivers are not only sources meeting the peoples' water needs but are also major foci for both religious and cultural activities. The mountain areas with over 5,000 m under ice and snow are located on the highest elevations of the earth. The Himalayan range contains the world's highest three peaks, including Mt. Everest with an elevation of 8,848 m, the highest peak.

All the rivers of HKH countries are originating from the mountains and they are rain-fed and snow-fed. All HKH's five countries lie in the monsoon climatic regime. Since the monsoon rainfall is erratic and over 80 percent of total precipitation occurs during the four summer months (June through September), the volume of river water fluctuates.

River water is one of the principal natural resources being used in different development activities in the mountains of HKH region. This resource has been used for drinking, sanitation, irrigation, hydro-electricity, fishing, recreation, cremation, etc. Since the last few decades, the

rivers have been degraded environmentally and ecologically, which is however by no means inevitable result of natural processes. It has emerged from the interactive processes between human (development) activities, water resource, and environment.

Though river water is the basis for planning, development, and management of both rural and urban areas, this resource has received considerable stress due to rapid growth of population and urbanisation, coupled with the manner in which it has been used. In most cases, particularly in urban areas, such practice has led to the accelerated deterioration of river environment at local and regional levels such as depletion of water sources and degradation of water quality, destruction of hydrological systems, flash floods and siltation, etc. The most crucial consequence of these environmental trends is the inappropriate and inefficient use of the river water.

Efforts have been made to conserve and develop the river basins in terms of policy measures, programmes, acts, and implementation by the governments of HKH countries in collaboration with international and non-governmental organisations, community based organisations and local people participation. However, they have not been successful for a desired sustainable management of the river basins.

1.2 Background to the ASSESS-HKH Project

The project "Development of an Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush-Himalayan Region (ASSESS-HKH) activities are divided into 8 work packages (WP). The main aim is to develop tools for river assessment and river basin management for the HKH region jointly by Asian and European partners.

In the first year of the ASSESS-HKH project the existing policies and legal instruments pertaining to the sustainable management of water resources in particular to river water quality in the region were reviewed and submitted as Deliverable 6. The analytical process involved the following steps:

Collection of reports, data and information from the five countries
Review of the collected materials
Synthesis of the collected materials
Preparation of the Draft Report
Circulation of the Draft Report to the partners and presentation
Collection of reviews and comments from the partners
Preparation of the Final Report and submission

It is to be noted that the analytical review mentioned above is based entirely on secondary data. The two main sources of information were the country papers presented at the Integrated Workshop on Water Quality in South Asia: Issues and Status, June 29 – July 2, 2004, Kathmandu, Nepal (organized by ICIMOD/CMC) and the State of the Environment Reports prepared by the respective countries with the assistance of UNEP (2001-2005) and status of environment report: South Asia. Partner Organizations in the respective countries have also provided informative documents.

In the first and 2nd year of the project field data were extensively collected and different methodologies to assess the ecological status of rivers were tested. In the third year of the

project the rapid field bio-assessment technique was applied to prepare water quality maps of selected five representative sections of the rivers in each of the partner countries.

One of the objectives under the activity of "Sustainable Management Strategies" among the eight work packages of this Project is to use river quality mapping as a tool to assess the quality of the river stretches for the selected five representative countries of HKH region. The river quality mapping for the sustainable river management strategies is sought for visual aid to all concerned. The river quality maps are considered to serve as an easy readable and understandable tool to identify hot spots along the river stretches, and show locations of sites where immediate action is required. They are used to portray various water quality levels along the river stretches and their stressing factors, so that the decision makers can be able to undertake timely measures for necessary actions. Here, the river quality maps are used as a basis for supplying information to strengthen sustainable management strategies in the selected river stretches. The mapping outputs are also used as a valuable visual aid in dissemination activities. Thus, the mapping methods and outputs can form a basis to develop river quality maps for other rivers of the HKH region.

1.3 Objectives of the Study

In this context, this report has two-fold aims: first, to identify the stressing factors of river water resource and secondly, on the basis of the identified factors to provide sustainable management strategies for the river basins. The major river basins of each of five HKH countries; Bangladesh, Bhutan, India, Nepal, and Pakistan have been considered for case study analysis. The empirical findings of the selected river basins are assumed to provide an example for sustainable river basin management in other regions or countries of the HKH region.

1.4 Contents of the Report

The report is divided into two parts. Part one is divided into four Chapters and presents the regional synthesis. Chapter one provides the background and objectives of the study. Chapter two introduces the methodology and concepts of the study. Chapter three reports on the regional summary of the pressures and identifies the mitigation strategies. Chapter four presents the conclusions and recommendations. Part II of this report presents the individual country reports on mitigation strategies.

2 METHODS AND CONCEPTS

2.1 Methodology for River Quality Mapping

Based on the experiences gained during WP5 (Methodology Development) and WP6 (Eco-data Management Tool) from the extensive field work conducted in the regions, as well as adapted from the methods of the European rivers, the "rapid field assessment screening methodology" (Moog et al. 1999, Moog and Sharma 2005) has been used for the river quality assessment of the HKH region, and the data and information generated by this methodology has been used in the river quality mapping. Each of the individual partner countries of the HKH region has carried out survey in its selected river stretches based on the screening methodology and prepared river quality maps. Prior to this, training on application of the screening methodology was provided to resources persons of all partner countries in order to harmonize the field and evaluation work.

To make comparable and compatible, the river quality mapping has been accomplished by each partner country on common source of Google map. This methodology was demonstrated to the partners during a training held in Kathmandu in March 2007.

The data and information for the preparation of river quality maps have been acquired by using the following procedural steps and activities during the field survey:

- First, reconnaissance survey was carried out along the selected river stretches in each basins to acquaint the field surveyors and researchers themselves with their surrounding conditions. This survey was accompanied by locally available large maps, such as colour topographic maps at the scale of 1:25,000 in case of Nepal. This helped to determine the location of sample sites along the river stretches.

- Secondly, while selecting the sample sites along the selected river stretches, major environmental features such as point of effluent discharge, land use, solid waste disposal, bank condition, substrate composition, and confluence of tributaries were considered. These features have been observed within one hundred metre stretch of each selected site.

- Thirdly, a structured screening protocol sheet was prepared to acquire data and information on various components related to river quality and its stressing activities (Annex 1: Rapid Field Bio-assessment Protocol). Each of the field survey teams completed the sheet by filling in the information and data required by the components for each selected river stretch or corridor. Meanwhile, water samples and benthic macro-invertebrates from each sample site were collected for further laboratory analysis.

  The benthic macro-invertebrates samples were collected with sampling net of 500µm mesh size. Consideration was given to select representative habitats at each sample site (multi-habitat sampling procedure – ASSES-HKH 2006). The collected fauna samples were preserved in labelled bottles containing 4 percent formaldehyde. They were further processed in the lab through sorting and identification based on keys (Nesemann *et* al. 2007; Yule *et* al. 2004; ASSESS HKH Project Keys 2006).

  The data collected through the field protocols were further processed by computer analysis and for each investigated river section a water quality class based on the indicator values of the benthic macro fauna was calculated.

  Five River Quality Classes (RQCs) have been adopted. Each class is described as: RQC I indicating none to very slight organic pollution; RQC II referring to moderate pollution; RQC III signifying critical pollution, RQC IV meaning heavy pollution; and RQC V indicating very heavy to extreme pollution.[1] Description of the saprobic components of river water quality classes for each river stretch is summarised on major features, such as location (upstream and downstream), water use, effluents, stressing factors, settlements, development, conservation, and benthic animals.

- The river quality map for five quality classes was constructed and the quality classes have been depicted by different indicative colours. For complying with the EU Water Framework Directive (WFD), five colour bands of the different water quality classes have been used,

[1] It was decided to add a "VI" River Quality Class to the existing five classes in situation if the observed sites along the river are extremely deteriorated and the environmental conditions, especially oxygen content, do not allow any animals except air breathing. However, there is no this 'Class VI' in the present studies in HKH region.

such as blue for RQC I, green for RQC II, yellow for RQC III, orange for RQC IV, and red for RQC V. RQC VI is indicated by a black banding of the affected river stretch.

2.2 Methods of Analysis of Stressing Factors

As the water of the rivers along their stretches is found to be used for different purposes like drinking, washing, bathing, irrigation, fishing, transportation, hydropower generation, sand and pebble quarrying, industries, cremation and wastes dumping, its quality is also changed, in most cases being deteriorated. So, it is worthwhile to identify stressing factors that pollute quality of the river water.

The observation protocol sheet was also used to record and locate the type of stressing factors along the river stretch. Thus, total stressing factors for each river stretch have been obtained, and then grouped into a maximum of *four* broad general groups such as (i) effluents, (ii) activities and facilities, (iii) hydromorphological degradation and (iv) ecological disturbances, and personal hygiene and sanitation. Sub-sets under each broad group were also identified. The frequency of each type of stressing factors was also computed, and the relative importance of each type has been identified in terms of degree of frequency, i.e. the higher the frequency, the greater is the importance of particular stressing factor to be considered. In addition, other features like settlement density and land uses have also been used in each stressing factor. This analysis has been used later for identifying mitigation options and designing strategies for sustainable river management.

2.3 Methods of River Sustainable Management Strategies (RSMS) Preparation

RSMS is defined as consisting of four major elements, such as stressing factors, mitigating program, responsible agencies, and years of period. The river stressing factors of each of the rivers under study have been obtained from the partner countries' reports. To some extent provided that the information is available, the relative importance of each stressing factor is described. Here, the mitigation strategies are proposed ones, which are defined in terms of three broad periods, such as short-term, medium-term, and long-term. The strategies for each broad class and its individual cases are described in terms of order of relative importance of stressing. The responsible agencies for each strategy are identified and described. In some cases, some particular strategies described against the particular stressing factors are also used for other related stressing factors.

The description of the four elements of RSMS is dependent on the information supplied by the partner countries. The following section deals with the river strategy management of each of the five HKH countries.

3 GENERAL MITIGATION STRATEGIES

3.1 Introduction to River Water

The five countries, Bangladesh, Bhutan, India, Nepal, and Pakistan represent extreme conditions in terms of area expansion and population, and so is the availability of water resources. India is the largest both in terms of area and population, whereas Bhutan is the smallest in both cases (Table 1). Bangladesh has the highest density of population (969/km²), while Bhutan has the largest forest coverage (72.5%), but lowest population density, with only 17 persons/km².

Table 3.1: State of area, population and some resources of HKH five countries

HKH Countries	Area (000 km^2)	Forest coverage (%)	Agricultural land (%)	Population		Soil loss (billion tons/year)
				Growth %	Density/ km^2	
Bangladesh	147.57	11.0	64.2	1.42	969	2.40
Bhutan	40	72.5	7.7	3.1	17	
India	2,973	21.9	47.0	2.0	336	5.30
Nepal	147	29.5	20.0	2.1	156	0.64
Pakistan	803	3	35.0	1.8	187	NA

Source: Bangladesh Bureau of Statistics (2004), SOE: Bhutan (2001), SOE: India (2001), SOE: Nepal (2001), SOE: South Asia (2001); Daniel (2004).

Bangladesh has the largest coverage of agricultural land, but least coverage of forest. There is largest soil loss in India, which is 5.3 billion tons per year (Table 1).

Table 2 indicates that, though the total annual renewable surface water availability is the lowest in Bhutan, its per capita availability is highest, which is due to mountainous country with lowest population size. Two larger countries, India and Pakistan have very low per capita renewable surface water, the amount being ≤ 2,000 and below m^3/year, as compared to other three smaller countries. However, annual per capita renewable water availability is misleading, because 80% of water flows during monsoon season (June - October) which can neither be used nor stored, especially in flat country like Bangladesh. Instead a seasonal per capita water availability would better depict the actual situation. Bhutan has not only the highest per capita withdrawal, but also fairly distributed its use among the three important sectors, such as domestic, industry and agriculture. Nepal has the least withdrawal percent for industry, among the five countries.

Table 3.2: Surface water availability and its use in the five HKH countries

Description	Bangladesh	Bhutan	India	Nepal	Pakistan
Total annual renewable water availability (km^3/y)	1,134	39	1960	224	171
Per capita renewable water (m^3/y)	9,000	58,930	2,000	10,300	1,309
Total annual withdrawal (km^3/y)	34	0.8	350	16.7	186.2
Per capita withdrawal (m^3/y)	275	1200	359	760	NA
Domestic % withdrawal of total	3	36	3	3.4	4.3
Industry	1	10	4	0.3	0.7
Agriculture	96.0	54.0	93.0	96.3	95.0

Source: SOE: Bangladesh (2001), SOE: Bhutan (2001), SOE: India (2001), SOE: Nepal (2001), SOE: South Asia (2001)

3.2 Policies and Acts

The HKH countries are rich in surface water. Most of the large rivers with their tributaries flow from the mountains to ocean flowing through diverse physiographic regions, and therefore they have huge contribution to safeguard of the environment and ecology of the region. On the other hand, the surface water, particularly the rivers have been used for different development sectors and in some cases the water of the rivers has been over-exploited. On the other hand, the HKH countries are facing huge challenge to maintain the quality of the river water and conserve the riverine ecology. In some cases, the pollution loads of the rivers flowing through the large cities have already reached to a maximum.

In this context, the five countries have formulated policies and adopted acts to rationally use of water of the rivers for the benefits of their own people. Here, the policies and acts related directly and indirectly to water resource adopted by them are dealt briefly, because their detail description is already given in Work Package 3.2 (Socio-economic impact) (delivered in October 2005).

- The policy measures, accompanied by acts to conserve water resources in the HKH countries may include uses, protection, management, quality standards, and environmental impact assessment of water resource sector. However, mere formulating policies and acts is not adequate; the most important part is their enforcement and compliance. Moreover, understanding of the policies and acts by majority of the population through effective awareness activities is very essential.

The major policy measures, acts and regulations adopted by each of these HKH countries are as follows (BKH 1994, NWMP 2001, UNDP 2004, UNICEF 2003, WARPO 1999, WSP 1998; RGOB 1998, 2000, 2001, 2002, 2004, NEC 2004; AHEC (2005), CPCB & NATMO (2001), CPCB & NATMO (2001) CPCB 2003 GOI 1999, 2000, 2001, 2002, MOEF (2002), MOEF 1999 MOEF (2002 DWSS 2001, 2002, WAN 2005, WRA 1992, UNEP 2001, WECS 2002, 2004 Ahmed1993; FFC 2000, 2004; GOP 1983, 1997, 2000 ,2005; PCRWR 2002, 2003, 2004; Khan 2004; Kahlown and Majeed 2004):

Bangladesh

- Irrigation Act 1876
- Embankment and Drainage Act 1952
- Bangladesh Water and Power Development Boards Order 1972
- Irrigation Water Rate Ordinance 1983
- Groundwater Management Ordinance 1985
- Water Resources Planning Act 1992
- National Environmental Policy 1992
- EIA Guidelines for use in the water resources sector 1992
- Environment Conservation Act 1995
- National Environment Management Action Plan, 1995 aimed to institutionalize the Policy and implementation
- Water Supply and Sewerage Authority Act 1996
- Environment Conservation Rules 1997
- Bangladesh Environment Conservation Act, 1998 empowering the government to determine the water standards for drinking and industrial effluents
- National Policy for Safe Water Supply and Sanitation, 1998
- National Policy Fisheries Policy, 1998
- Environment Court Act 1999
- National Water Policy of Bangladesh, 1999
- Bangladesh Water Development Board Act 2000
- Urban Water Body Protection Law 2001.
- National Water Management Plan (NWMP), 2001

Bhutan

- Land Acts, 1979
- Forest and Nature Conservation Act, 1995
- Water and Sanitation Rules formed in pursuance of the Municipal Act, 1999

- Environment Assessment Act, 2000
- Bhutan Electricity Act, 2001

India

- River Boards Act 1956
- Water Prevention and Control of Pollution Act 1974; amended in 1988
- Water Prevention and Control of Pollution Cess Act 1977
- Environment Protection Act 1986 and Environment (Protection) Rules 1986
- Hazardous Waste (Management and Handling) Rules 1988
- Policy Pollution 1992
- The Environment Action Programme initiated in 1993 to prepare action plans for the integration of environmental concerns into the development process
- Municipal Waste (Management and Handling) Rules 1999
- National Conservation Strategy and National Water Policy 2002

Nepal

- Aquatic Animals Protection Act 1962
- Solid Waste Management and Resource Mobilization Act 1987
- Solid Waste Management and Resource Mobilization Regulation 1989
- Nepal Water Supply Corporation Act 1989
- Electricity Act 1992
- Electricity Regulation 1993
- Environmental Protection Act 1996; Environmental Protection Regulation 1997
- Drinking Water Regulation 1998
- Local Self Governance Act 1999
- National Water Resources Strategy 2002
- Irrigation Regulation 2003
- National Water Plan 2005

Pakistan

- Environmental Protection Ordinance 1983 and Pakistan Environmental Protection Act 1997
- Created legal structures and enacted rules for the implementation of various international environmental agreements after committed adherence to international declarations, viz., the Declaration of UN Conference on Human Environment at Stockholm 1972 and the Rio Declaration 1992
- Pakistan National Conservation Strategy 1992
- National Environmental Quality Standards (Self-monitoring and Reporting by Industries) Rules 2000
- Pakistan Water Sector Strategy adopted in 2002

Policy Gaps

Despite the efforts have been made by the partner countries to conserve and develop the water resources as described above, there exists fallacy in policy measures and implementation mechanisms, which can be observed from their failure in achieving goals. However, the policy gaps are found to be varied among the partner countries, and in some cases inadequate policy measures are found in the individual partner countries. The major gaps in the existing policy measures are as follows:

- There is a lack of clear definition in the role and responsibilities of different agencies related to water resources in the partner countries and therefore, the activities such as policy formulation, implementation, decision making, and programs are found to be either overlapping or without any coordination between the agencies. As a result, there is poor coordination among the organizations themselves hampers implementation.

- Another common problem among the partner countries is poor performance due to weak enforcement mechanisms. This is due to lack of serious commitment on the part of responsible agencies and absence of effective monitoring mechanism in the fields of enforcement, compliance and outcomes.

- Inconsistencies and conflicting provisions, as well as inadequacies in the existing legislations are found in the partner countries. One example with regard to conflict policy measures is the priority in use of water resources among different sectors such as drinking, irrigation, hydropower, and others. This problem exists within the individual countries, as well as between the partner countries. Nepal is facing conflicting issues in the use of water sources for drinking water and hydro electricity sectors, while at transboundary level the conflict exists in the use, distribution and flood control measures between India and Nepal, and between India and Bangladesh.

- One fundamental problem found in the partner countries is associated with the lack of strategy of integrated river basin development. This requires strong commitment between different sectors within the country, as well as between the neighbouring countries.

- Other problems include uncontrolled municipal waste disposals, lack of skilled manpower, landslides and soil erosion, frequent flash floods, increasing cases of water borne diseases, limited data and research activities, and so on.

3.3 Institutional Structure

The institutional set up of each of the partner countries are as follows:

Bangladesh

- The Ministry of Water Resources is the agency dealing with water resources management (planning and water use and water control infrastructure) through different departments. The Department of Environment (DOE) under the Ministry of Environment and Forest deals with all aspects of pollution and has been monitoring surface water quality parameters (chemical: BOD_5, COD, TSS, conductivity, pH, ammonia, nitrate, phosphate, chloride, etc. and microbial: faecal coliform and total coliform). In addition, the Bangladesh Water Development Board (BWDB) collects data on suspended sediments and surface water salinity along flow data of major and medium size rivers..

The institutional agencies or organizations which have relevant functions in water sector are of four categories:

- government agencies;
- local government institutions;
- other organizations and the private sector; and
- development partners.

The government agencies include 13 ministries and 35 organizations, the most important among which are the Ministry of Water Resources: Bangladesh Water Development Board, Water Resources Planning Organization (WARPO), Joint Rivers Commission, River Research Institute, Surface Water Modeling Centre, Ministry of Agriculture: Bangladesh Agricultural Development Corporation, Department of agricultural Extension, Ministry of Local Government, Rural Development & Cooperatives: Local Government Engineering Department, Department of Public Health Engineering, Dhaka Water Supply and Sanitation Authority, Ministry of Environment & Forest: Department of Environment, Ministry of Shipping: Bangladesh Inland Water Transport Authority, Ministry of Fisheries & Livestock: Department of Fisheries.

The local government institutions are the Paurashava (municipalities) and the upazila Parishads. The category 'Other Organizations & Private Sector' includes community based organizations, non-government organizations (Bangladesh Unnayan Parishad, Bangladesh Centre for Advanced Studies, Save the Environment Movement, etc., mainly deals with awareness and motivational and incidental measurement and analysis) cooperative society, and private sector organizations and institutions. Noted among the development partners are the World Bank, the Asian Development Bank, and the United Nations Development Programme and numerous bilateral development agencies of different countries such as Netherlands, Denmark, Japan, UK, and Canada.

Bhutan

- The National Environment Commission (NEC) is the agency that formulates water policies and acts. It enforces and implements the acts and regulations related to water sector, assesses water development projects, conducts monitoring of the quality of river water, and runs environment awareness activities.

India

- There are several organizations responsible for the conservation and pollution control of water resources and the environment. They are such as the Ministry of Rural Development, the Ministry of Urban Development, the National Water Development Agency, Central Water Commission, and Central Groundwater Board. The Ministry of Agriculture and the Ministry of Power are also responsible for the use of river water. The Water Quality Assessment Authority has been established with the mandate to examine, monitor and coordinate the use and quality of water sources. There are several agencies to look after the environment. For instance, the Ministry of Environment and Forests (MOEF) is a nodal agency of the Central Government responsible for the protection and management of the environment, including water sector issues of the country. The National River Conservation Directorate, Ministry of Environment and Forest (MoEF) looks after the initiatives for conservation of rivers and lakes in the country. The municipalities and towns are looked after by Ministry of Urban Development (MoUD) and accordingly activities like sewerage, sewage treatment plants, solid waste management and a variety of activities eg. Catchment improvement, shoreline protection and improvement of recreational facilities and to ensure public awareness and participation are dealt by the MoUD.

Nepal

- The National Water Resources Development Council (NWRDC), the Water and Energy Commission (WEC), and the Environment Protection Council (EPC) are responsible for developing and conserving of water resources. For coordination and policy formulation, the

Ministry of Water Resources (MOWR), the Ministry of Physical Planning and Works (MPPW), the Ministry of Environment, Science and Technology (MOEST), the Ministry of Forest and Soil Conservation (MOFSC); and the Ministry of Local Development (MOLD) are responsible. These ministries have agencies at district levels too. Though these agencies work for the regulation of water resources, there are no permanent and full time regulatory bodies as such in place. Some of the non-governmental organizations including both local, and district levels facilitate to help the water related activities.

Pakistan

- The Ministry of Water and Power carries out the functions related to water through Water and Power Development Authority (WAPDA), Indus River System Authority (IRSA) and the Federal Flood Commission (FFC). The Pakistan Council of Research in Water Resources (PCRWR) under the Ministry of Science and Technology is responsible for research and training activities related to all aspects of water including water quality. The institutional framework of the water sector includes federal government and its constituent ministries, four provincial governments and their departments, city Water and Sanitation Agencies (WAS As), and the Karachi Water and Sewerage Board (KWSB). Other agencies related indirectly to water resources are the Pakistan Environment Protection Council, the Pakistan Environmental Protection Agency and several provincial departments, which look after the other activities such as irrigation and hydropower, and sanitation.

3.4 Monitoring and Enforcement

The descriptions made above under the policy measures and acts, and institutional set up deals with the agencies that deal with the monitoring and enforcement activities in the partner countries.

However, most agencies are active in the planning and development of water related activities: plans, programs formulation and implementation. But there is virtually no agency that only looks after the regulatory activities of the water sectors in terms of compliance monitoring, implementation monitoring and output monitoring. Even if exist, the agencies appear to be weak in monitoring of river water quality and enforcement of the rules and regulations for maintaining the water quality, environment and ecology.

4 CONCLUSIONS AND RECOMMENDATIONS

The water resource is the most important natural resource in the HKH countries. This resource, particularly the river has multi-facet roles and importance, such as environmental and ecological conservation, developmental use (drinking, hydropower, irrigation, recreation, fishing, and transportation), socio-cultural use (bathing, washing, cremation), and religious (most of the important shrines locating on the bank of river). The great river basins such as the Ganges, the Indus, the Bramhaputra, and some of the mountain river valleys such as Kathmandu, Pokhara, and Thimpu have one of the highest population densities in the world. Most of the large cities are also located on the banks of major rivers for the facilities of drinking water supply, drainage, irrigation, transportation, and dumping sites.

On the other hand, the crucial problems associated with the rivers are their degrading water quality and as a consequence, their loss of ecological functions and services in the partner countries, which are attributed to the wrong policy measures and programs undertaken by these

countries. The watersheds that recharge both surface water and groundwater sources have been degraded due to intensive agricultural cultivation with the increased population pressure. The most conspicuous consequences are the frequent occurrences of landslides and soil erosions in the mountain regions and flash floods in the plain regions. In the context of inadequate and inefficient policy measures undertaken by the partner countries, the recommendations given by each of them are generalized and combined as follows:

- Establish organisation that maintains and generates database on river water resources including water quality, upgrades it regularly through scientific research works, creates information network, makes the information available for policy formulation, planning and designing, and shares it with others.

- Establish regulatory mechanisms for effective monitoring and evaluation of uses and quality control of river water. Agencies looking after river water resource at national, regional, and local level should be given this responsibility. This will also avoid the crucial problem of coordination and implementation that the partner countries are facing.

- Awareness about the conservation of river basins requires to be created continuously among the politicians, policy makers, and government personnel. There should be a common and ever lasting understanding among these nation building agencies that they must conserve water recharge source such as watershed or catchment areas at any cost. Participation of local community system should be adopted as a sustainable policy measure in the conservation of their own water sources.

- The riverine ecology in the city areas requires to be maintained, the degraded quality should be rehabilitated at least into moderate conditions through conservation or strictly prohibiting the dumping of municipal wastes, industrial effluents and hospital wastes, or establishing adequate treatment and recycling plants and maintaining their regulatory functions.

- The concerned agencies should be serious and have committed towards implementing the acts and regulations regarding the conservation and development of rivers, and enforcing effluent standards (industries, municipal wastes, hospital wastes, etc.)

- Strengthening institutional capacity should be made by providing training to the personnel at all levels working in the water resource sector.

- Develop clear and unambiguous regulations and acts so that no conflicting provisions can happen between the sectors related directly to the water resources.

- Periodic sampling and water quality checking should be practiced.

PART II: COUNTRY REPORTS

5 BANGLADESH

5.1 Selection of Rivers for water quality Mapping

Based on reconnaissance visits and discussion with local people, 20 sites on 5 rivers around Dhaka city were selected for sampling and analysis. The selected rivers include: the Balu, the Buriganga, the Dhaleshwari, the Shitalakkhya, and the Turag.

5.2 Results and Discussions

5.2.1 Water Quality Classes

By using the saprobic approach, five water quality classes have been obtained for the five river basins.

Table 5.1 describes the water quality classes in terms of frequency of sampling sites. The Table data shows that 40 percent of the total sample sites lie in WQC III, followed it by WQC IV. There is only one site falling in WQC II and not a single sample site belonging to WQC I. This indicates that the quality of the rivers' water is highly polluted. Among the sampled rivers, the Turag contains all water quality classes, ranging from II to V. It has been observed that the rivers are found to be polluted by industrial activities, municipal sewage disposal and faecal contamination, agro-chemicals, and sediment loading. This means that maintaining sufficient supply of clean water for the growing population is a major challenge in the densely populated Dhaka city.

Table 5.1: Distribution of Sample Sites by River Quality Classes

Sample Rivers	Water Quality Class (WQC)					Total
	I	II	III	IV	V	
1. Balu	0	0	2	2	1	5
2. Buriganga	0	0	0	0	1	1
3. Dhaleshwari	0	0	2	1	0	3
4. Shitalakkhya	0	0	1	1	0	2
5. Turag	0	1	3	3	2	9
Total (*f*)	0	1	8	7	4	20
%	0	5.0	40.0	35.0	20.0	100

The following observations are obtained:

- The water of the rivers all across the stretches is found to be used for multiple purposes like drinking, washing, bathing, waste dumping, etc. River sections of all water quality classes are commonly used for bathing and washing. As the samples of the river stretches contain effluents, such as solid waste, agricultural chemical residues and industrial gutter, they cannot be used directly for domestic purposes, according to the WHO guidelines.

- A total of eight stressing factors of degradation of river water have been identified (Table 5.2). The four major stressing factors found in the basins are waste dumping, bathing and washing, open defecation and sewage discharge.

- The anthropogenic activities are said to be the 'stressing factors' which have disturbed riverine ecology and degraded water quality in the case study rivers of Bangladesh. Because of their steady intensification of the activities, degradation of river water quality at the sample sites along the river stretches has also been observed.

5.2.2 River Stressing Factors

As indicated above, a total of eight stressing factors have been identified along the river stretches, which have been grouped into *four* broad groups (Table 5.2). For the river basins, the stressing factors are indicated by 1 and 0 for the presence and absence. However, the table information does not provide the relative importance of the stressing factors.

Two river basins, including the Balu and Shitalakkhya have shown all types of stressing factors. Among the other three river basins, the Turag does not have environmental and ecological disturbances by animal washing and wallowing; in case of the Buriganga basin, there is absence of agricultural effluents (runoff) whereas the Dhaleshwari basin does not have sewage discharge, solid wastes dumping and sand and gravel extraction. The industrial effluents with the Turag also include tannery.

Table 5.2: Classification of River Stressing Factors, Bangladesh

Groups	Stressing factors	Balu	Buri ganga	Dhale shwari	Shita lakkhya	Turag
a. Effluents	• Sewage discharge	1	1	0	1	1
	• Industrial effluents	1	1	1	1	1
	• Agricultural runoff	1	0	1	1	1
	• Solid wastes	1	1	0	1	1
b. Activities & facilities	• Navigation	1	1	1	1	1
c. Environmental & ecological disturbances	• Sand/gravel extraction	1	1	0	1	1
	• Animal washing and wallowing	1	1	1	1	0
d. Personal hygiene and sanitation	• Bathing and Washing	1	1	1	1	1

Source: Field survey (2007)

5.2.3 River Sustainable Management Strategies (RSMS)

The proposed mitigation strategies are defined in terms of three broad periods, such as short-term, medium-term, and long-term. The strategies for each broad class and its individual cases are described in terms of order of relative importance of stressing. The responsible agencies for each strategy are also provided. In some cases, the particular strategies described against the particular stressing factors can also be used for other related stressing factors.

a Effluents

The effluents (agricultural runoff, industrial effluents, municipal wastes and solid waste, and cremation) are found to be the largest stressing factor. Among these, the occurrence of industrial effluents and then sewage discharge has been the largest.

Existing Mitigation Measures

- There exist efforts such as the National Water Policy, Safe Water Supply and Sanitation, National Environmental Policy, National Fisheries Policy, Industrial Policy, Agricultural Policy, etc. have been formulated by the Government of Bangladesh through different concerned ministries. Yet, these efforts seem to be ineffective, which is evident by the fact that there is still the discharge municipal wastes, sewage and industrial effluents directly into the streams. The municipality effort to stop the direct discharging has been futile.
- Land zoning of industries has been implemented to delimit export processing zone and industrial park to support collective treatment of wastes. Likewise, clean–up and rehabilitation of pollution hot – spots are being made.
- Attempts are also being made for reducing salinity intrusion in surface and ground water, sediment control and reduction in the main rivers and reduction pollution load in water ecosystem
- There exist effluents standards, but they are not effectively implemented.

Proposed Mitigation Measures

Table 5.3 summarises *proposed* strategies for mitigating each of the effluents and its possible responsible agencies. In all cases, however, a well formulated monitoring and evaluation mechanism (system) should be adopted by the respective responsible agencies for enforcement of regulating measures. No short, medium and long-term targets exist yet.

Table 5.3: Strategies for Mitigation Effluents Stressing Factors

Stressing factors	Mitigation Programs	Responsible agencies
• Waste dumping	• Prohibition of dumping • Awareness to locals • Provision of incentives • Development of River banks for prevention of encroachment.	• City corporation • Municipality • Water Supply and Sewage Authority (WASA) • Department of Environment (DoE)
• Sewerage discharge	• Prohibition of direct discharging • Treatment plants & recycling • Awareness to locals • Provision of incentives • Adopt regular monitoring	• City corporation • Municipality • Municipality • Water Supply and Sewage Authority (WASA) • Department of Environment (DoE)
• Agricultural effluent	• Encourage use of manure • Awareness to locals • Provision of incentives • Adopt regular monitoring	• Dept of Agriculture • DOE/NGOs • Dept of Agriculture • DOE/NGOs • Municipality/DOE • Municipality/DOE
• Industrial	• Prohibition of direct discharging	• Municipality/DOE

effluent	• Conduct compliance monitoring • Awareness • Provision of incentives	• Dept of Env/Industry • Municipality/DOE/NGOs/University

Source: Field survey (2007)

The polluting industries and activities are identified as textile industries, dyeing industries, POTW, paper and pulp industries, agricultural runoff, etc.

In the mitigating strategies, generate awareness can be done through adopting seminar, workshop, poster, flyer, newsletter/newspaper, scientific publications, and motivation through providing incentive measures. Regulatory and incentive measures as well as construction of adequate treatment plants and improved recycling should be adopted to reduce pollution load, and compliance monitoring should be adopted for enforcement of regulating measures.

The responsible organisations for adopting and executing the strategies mentioned here include City Corporations, municipalities, Department of Environment, Ministry of Environment and Forest and Water Resources Planning Organization (WARPO). These organizations can execute and regulate them in collaboration with other agencies such as universities, donor agencies, National and International NGOs.

b Activities and Facilities

Group-B includes only navigation as the stressing factor. Operation of boats without proper water treatment facilities are also a major source of river pollution affecting the aquatic life. Oil and lube spillage occurs during normal refueling of ships at river ports. Especially the local fish fauna is severely degraded by the direct toxic effects of the pollutants resulting in an increasing mortality, an increasing in fish fingerling migration, and a lower quality of edible fish.

Existing Mitigation Measures

- Under the National Environmental Policy, efforts are spelt out to maintain the ecological balance and overall development through protection and improvement of the environment, to identify and regulate activities, which pollute and degrade the environment, and to ensure development that is environmentally sound for all sectors, including navigation in the rivers.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 5.4.

Table 5.4: Strategies for Mitigating Navigation Effects on Riverine Ecology

Stressing factors	Mitigation Programs	Responsible agencies
• Littering in the water	• Prohibition of littering in the rivers • Provision of litter containers • Awareness to the passengers	• Ministry of Environment & Forest: Department of Environment • Ministry of Local Government & Cooperatives: Municipalities, City

		Corporations, Water Supply & Sewerage Authority
• Disturbance to river ecology	• Reduce steam boat noise pollution • Prohibition of petro-chemical wastes into the rivers	• Ministry of Shipping: Bangladesh Inland Water Transport Authority • Ministry of Environment &Forest, Department of Environment • Ministry of Livestock and Fisheries: Department of Fishery

Source: Field survey (2007)

c Environmental and Ecological Disturbances

Group-C stressing factors include sand and gravel quarrying and domesticated livestock washing and wallowing. While the first indicates the resources being used for urban development activities, the second factor refers to animal raising by the farmers. Both activities however disturb the riverine ecology.

Existing Mitigation Measures

- The government has formulated the National Water Policy and EIA guidelines for water development projects and increase surface water flow in dry season
- Environment Conservation Act and Regulation for the use of river water has not been effective.
- Polluters pay principle has been adopted
- No policies and programmes have been made by the district government to control against the quarrying and mining of the stones and sand.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 5.5.

Table 5.5: Mitigation Strategies for Rivers Conservation

Stressing factors	Mitigation Programs	Responsible agencies
• Quarrying sand & gravels	• Prohibition of quarrying sand & stone • Construction of embankment • Awareness	• Ministry of shipping: Bangladesh Inland Water Transport Authority; • Ministry of Water Resources: Bangladesh Water Development Board • Department of

		Environment
• Bathing and wallowing of animals	• Control bathing and wallowing of animals in the rivers • Awareness	• Municipalities & Local Community • Municipality/NGOs

Source: Field survey (2007)

d Sanitation (Bathing and washing)

In Group-D, the river stressing factor includes bathing and washing.

Existing Mitigation Measures

- No effective awareness programme about the water pollution and its uses in different activities (bathing, washing, and swimming) at community level has been made by the local government.
- Notice about the prohibition of throwing and dumping wastes in the river is often made by municipality, but has not been effective due mainly to lack of punishment to those who have done it.

Proposed Mitigation Measures

Table 5.6 provides proposed strategies for each stressing facility.

Table 5.6: Strategies for Mitigating Bathing and Washing Activities

Stressing factors	Mitigation Programs	Responsible agencies
• Bathing	• Prohibition of bathing • Provision of adequate community taps • Awareness	• Municipality • Municipality/Dept of Drinking Water Supply • University/NGOs
• Washing clothes	• Prohibition of washing clothes • Provision of adequate community taps • Awareness	• Municipality • Municipality/Dept of Drinking Water Supply • Municipality/NGOs

Source: Field survey (2007)

5.3 Summary and Conclusions

- National and international agencies with operational tasks should be accountable to the public and all stakeholders should have sufficient funding and legislative means, and should work on the basis of the national policy.
- Realistic plans should be drawn based on the best available knowledge, with sufficient political/public support and financial means for implementation.

6 BHUTAN

6.1 Settings of the River Basins

The three rivers of Bhutan that were included in the river quality study are Ha Chhu, Pa Chhu and Thimpu Chhu. These rivers lie in three districts of Haa, Paro, and Thimpu respectively. They are snow-fed rivers, flowing from north to south and ultimately join the Brahmaputra River in India. These rivers generally have steep gradients and narrow steep-sided valleys occasionally opening up to give small areas of terrace land for cultivation. The discharge in the river is high and carry larger amount of sediments during the monsoon season and significant snowmelt at the end of the dry season in the months of March and April. Short rain-fed tributaries descend steeply from east or west to join these rivers.

6.2 Results and Discussions

6.2.1 Water Quality Classes

A total of 21 sample sites along the three river stretches have been investigated. The samples represented all five water quality classes and habitats of the river stretch. The field survey was conducted during the pre-monsoon season. Since national water quality standards for surface water are not available, the findings have been compared with the WHO Drinking Water Quality Guidelines. Table 6.1 shows the distribution of sample sites by water quality classes. Five water quality classes have been obtained for the three river basins by using the saprobic approach.

The rivers in the headwater regions are in pristine condition. On the whole, the quality of water of the rivers is good, as over 57 percent of the total sample sites belong to WQC II and I. However, when they pass through the Thimpu city area, the water quality becomes deteriorated. The sites lying under WQC V and WQC IV are drains, which receive direct discharge of sewage and waste dumping. Yet, the population pressure in the capital city is increasing, which further affects the quality of the rivers.

Table 6.1: Distribution of Sample Sites by Water Quality Class

Water Quality Class (WQC)	Sample Sites	
	Number	Percent
I	3	14.3
II	9	42.9
III	5	23.8
IV	2	9.5
V	2	9.5
Total	21	100.0

Source: Field survey (2007)

The following observations are obtained:

- The water of the rivers all across the stretches is found to be used for multiple purposes like drinking, bathing, irrigation, hydro-power, and wastes dumping. About 78% of the population have access to safe drinking water. The table information shows that the water of

the rivers can be used directly for domestic purposes, according to the WHO guidelines with minimum treatment management.

- The anthropogenic activities including river dams, organic loading, waste dumping, abstraction of water, vehicle washing, automobile workshops (waste oil spill over), and industrial effluents are said to be very critical stressing factors, as they disturb riverine ecology and degrade water quality. In the urban areas of Thimpu & Phuntsholing, the water quality of the tributaries is found to be highly deteriorated as they lie in WQC IV and WQC V where the drains are being polluted due to intensive human activities.

6.2.2 River Stressing Factors

A total of 8 stressing factors of degradation of river water have been identified and is presented in Table 6.2. These 8 stressing factors observed in the three river basins are put into three major groups such as effluents, activities, and environmental disturbances. However, since there is no frequency of the stressing factors or their presence and absence, their relative importance cannot be described.

Table 6.2: Classification of River Stressing Factors, Bhutan

Groups	Stressing factors
a. Effluents	• Domestic sewage • Agricultural effluent • Vehicle oils • Industrial effluents
b. Activities & facilities	• River crossing • Vehicle washing • River dams
c. Environmental & ecological disturbances	• Mining

Source: Field survey (2007)

6.2.3 River Sustainable Management Strategies (RSMS)

Sustainable mitigation strategies are proposed to each of the broad stressing factors of the river stretch. The strategies for each broad class and its individual cases are also described. The responsible agencies for each mitigation strategy are also provided. In some cases, the particular strategies described against the particular stressing factors can also be used for other related stressing factors.

a Effluents

The effluents along the three river stretches include domestic wastes, agricultural runoff, vehicle oils, and industrial wastes. One of the most conspicuous river pollution stressing factors is being the location of automobile workshops on the banks of the rivers. The fundamental problem is also the dearth of data on domestic sewage and industrial effluents, and therefore the range of pollution impacts is yet to be ascertained.

Existing Mitigation Measures

Policies and Acts

- The Government of Bhutan has adopted the following efforts such as the Environmental Discharge Standard, Environmental Acts, Industries and Mining Discharge Standards, Pesticides Act, Sewage Management, etc. for the improvement and conservation of environment, including rivers. The population in the major urban areas is increasing rapidly (NEC/RGB 2006).
- There exist interim effluent standards which are being processed for formalization.

Monitoring

- Mechanism of monitoring water quality is weak due to inadequate mechanism for collection and analysis of information

Structural Measures/Infrastructure

- There is a treatment plant in south of the Thimpu City called Babesa which treats sewage discharge 1750 m^3/day and more than 520 buildings are connected to the sewerage line. Plans are afoot to connect the rest of the homes.

Proposed Mitigation Measures

Table 6.3 summarises *proposed* strategies for mitigating each of the effluents and its possible responsible agencies. In all cases, however, a well formulated monitoring and evaluation mechanism (system) should be adopted by the respective responsible agencies for enforcement of regulating measures.

Table 6.3: Strategies for Mitigating Effluents Stressing Factors

Stressing factors	Mitigation Programs	Responsible agencies	Time period
• Domestic wastes	• Prohibition of dumping of wastes • Provision of trash collection • Installation of sewage treatment plants • Installation of wastes recycling processor • Provision of regular cleaning campaign • Finalize Solid Waste Acts • Adopt regular monitoring • Conduct awareness programs to public	• Municipality • Municipality • NEC/ Municipality • NEC/ Municipality • Municipality/NGOs • NEC/ Municipality • NEC/ Municipality • Municipality/ NGOs • NEC/ MoWHS (Ministry of Works & Human Settlement)	• Long term • Long term • Long term • Short term • Short term • Long term • Long term • Long term • Short term • Short term
• Agricultural effluent	• Regulate the use of pesticides • Implement Pesticides Act • Adopt IPM effectively • Manage obsolete	• Min. of Agriculture (MOA) • MOA • MOA • Ministry of Env/ MOA • MOA	• Long term • Long term • Long term • Long term • Long term

	pesticides effectively • Adopt regular monitoring		•
• Vehicle waste oil	• Prohibition of vehicles washing • Prepare and implement Vehicle Emission Standards • Monitoring of oil spill over regularly	Municipality, NEC, MoEA NEC/RSTA NEC, Municipality, MoEA	• Short term • Long term • Long term
• Industrial effluent	• Implement Industrial Discharge & Emission Standards • Enforcement of EA Act & regulations • Monitoring of industrial effluents	• NEC • NEC/ Line Ministries, Authorities as designated under EA Provision • NEC, MoEA	• Long term • Long term • Long term

Source: Field survey (2007)

- In the mitigating strategies, NEC is a lead regulatory agency responsible for regulation and overall coordination, defining policies and plans, legislating standards, enforcing compliance, adopting public awareness, and research and development in the water sector in the country.

b Activities and Facilities

Group-B includes river crossing and vehicle washing as the stressing factors. Washing vehicles in the river and crossing the river by the vehicles are a major source of river pollution affecting the aquatic life.

Existing Mitigation Measures

- NEC has made efforts to maintain the ecological balance and overall development through protection and improvement of the water resources, including rivers, to identify and regulate activities, which pollute and degrade the water resources, and to ensure development that is environmentally sound for all sectors.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 6.4.

Table 6.4: Strategies for Mitigating Navigation Effects on Riverine Ecology

Stressing factors	Mitigation Programs	Responsible agencies	Time period
• River crossing	• Prohibition of vehicles crossing • Construct bridges over rivers • Awareness to local	• Municipality • Dept of Roads • MOE/NEC/NGOs	• Long term • Long term • Long term
• Vehicle washing	• Prohibition of vehicles washing • Awareness to vehicle handlers	• Municipality • NEC/Municipality	• Long term • Long term

Source: Field survey (2007)

c Environmental and Ecological Disturbances

Group C includes river impoundment through dam construction and mining as the stressing factors. These activities however disturb the riverine ecology. These factors belong to human activities.

Existing Mitigation Measures

- The government of Bhutan has formulated the EIA Acts and guidelines for water resources development projects and controlling river pollution
- The Act and Regulation with regard to the river water conservation have not been effective.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 6.5.

Table 6.5: Mitigation Strategies for Rivers Conservation

Stressing factors	Mitigation Programs	Responsible agencies	Time period
• River dams	• Design river dams at feasible river stretches	• MoEA/DoE, NEC/NGOs ,	• Long term
	• Avoid interruption of the longitudinal continuum by creating fish migration facilities	• NEC, Line Ministries	• Long term
	• Implement and enforce environmental impact assessments (EIA)	NEC/RSPN/MoEA/NGOs • NEC, Line Ministries	• Long term
	• Sufficient residual water in the river sections downstream diversion hydropower plants	• NEC, Line Ministries	
	• Awareness		
• Mining	• Enforce implementation of mining acts	MoEA / NEC	• Long term
	• Training for imparting environmental issues	NEC/ NGOs/MoEA	• Long term

Source: Field survey (2007)

6.3 Summary and Conclusions

- Agencies working with the water resources sector should be accountable to conserve the river environment and ecology, and should work on the basis of the national policy.
- The Government bodies should be serious and committed to implement the existing acts and regulations related to river water conservation.
- limnologists and hydro-biologists should be included to addressing ecological impacts during the construction planning of hydropower plants.

7 INDIA

7.1 Settings of the River Basins

In India, the Kosi River has been selected for the water quality analysis and strategy. This river is a major tributary of the Ganga River and the third largest river in the Himalayas. The river flows through the diverse ecological regions, including the Himalayan subtropical pine forest region (IM0301), the Tarai Dwar Savanna region (IM0701), and the upper Gangetic plains (IM0166).

The Kosi River originates from the rain-fed spring source at Rudradhari (Almora district, Uttarakhand) and joins the Ramganga River near village Chamraul (Rampur district). Its total length is 240 km and total catchment area is 3,420 km². It is an important river flowing through the foot hills of the Kumaon region. It drains the central part of the Almora district and the western part of Nainital district of Uttarakhand. It enters into the plain region of the western Uttar Pradesh.

7.2 Results and Discussions

7.2.1 Water Quality Classes

The field work for the water quality of the river was conducted from March 30 to April 8, 2007. A total of 26 sample sites were selected along the Kosi River, stretching from its origin point at Rudradhari to just before the confluence with the Ramganga River near in Rampur village.

By using the saprobic approach, five water quality classes have been adopted for the Kosi river basin. Table 7.1 describes the water quality classes in terms of frequency of sampling sites. The Table data shows that the largest sample sites with nearly 54 percent lie in WQC I, followed by WQC II and WQC III. In the upstream or source area of the Kosi river, most of the sample sites belong to WQC I.

As the Kosi River passes through the urban areas, it is polluted by direct sewage discharge and waste dumping.

Table 7.1: Distribution of Sample Sites by River Water Quality Class, India

Water Quality Class (WQC)	Sample Sites	
	Number	Percent
I	14	53.8
II	5	19.2
III	5	19.2
IV	1	3.9
V	1	3.9
Total	26	100.0

Source: Field survey by AHEC (2007)

The following observations along the Kosi river stretch are obtained:

- The river is found to be used for various purposes, such as drinking, washing and bathing, fishing, wastes dumping (solid waste, domestic wastewater, and industrial wastewater), cremation, irrigation and power generation, industrial uses as raw water and for cooling water. The river water in the upstream areas is found to be used for drinking, and washing and bathing. However, in the downstream the water cannot be used directly for domestic purposes according to the WHO guidelines, since the sample sites are contaminated with the domestic and industrial effluents.
- A total of 8 stressing factors of degradation of river water have been identified (Table 7.2). There are anthropogenic impacts, ranging from minimal to maximum. The four major stressing factors found in the basins are waste dumping, bathing and washing, open defecation and sewerage.

7.2.2 River Stressing Factors

A total of 5 stressing factors of degradation of river water have been identified (Table 7.2). These 5 stressing factors observed in the Kosi river basin are put into two major groups such as effluents, and environmental disturbances. However, since there is no frequency of the stressing factors or their presence and absence, their relative importance cannot be described.

Table 7.2: Classification of River Stressing Factors of the Kosi River

Groups	Stressing factors
a Effluents	• Waste dumping • Household organic waste • Industrial effluents
b Environmental & ecological disturbances	• Deforestation • Minerals quarrying

Source: Field survey by AHEC (2007)

All four stressing factors, except industrial effluent as given in Table 7.2 are observed in all water quality classes ranging from I to IV, whereas in WQC V, the industrial effluents together with all the four stressing factors is observed.

7.2.3 River Sustainable Management Strategies (RSMS)

Sustainable mitigation strategies are proposed to each of the broad stressing factors of the Kosi river stretch. The strategies for each broad class and its individual cases are also described. The responsible agencies for each mitigation strategy are also provided. In some cases, the particular strategies described against the particular stressing factors can also be used for other related stressing factors.

a Effluents

The Kosi River is polluted by the effluents such as solid (organic) waste, waste dumping, and industrial waste.

Existing Mitigation Measures

- The Government efforts, including the Pollution Abatement of the Ganga and the Ganga Action Plan, Management of Water Resources including the conservation of rivers, the Water Prevention & Control of Pollution Acts and Rules, the Water Cess Act and Rules, Environment Protection Act, Hazardous Waste (Management and Handling) Rules, the National Water Policy, the National Environment Policy, Water quality monitoring, etc. are towards improving the quality of the river water. However, these efforts seem to be ineffective and not so encouraging due to poor management and administrative problems.

Proposed Mitigation Measures

Table 7.3 summarises *proposed* strategies for mitigating each of the effluents and its possible responsible agencies. In all cases, however, a well formulated monitoring and evaluation mechanism (system) should be adopted by the respective responsible agencies for enforcement of regulating measures.

Table 7.3: Strategies for Mitigating Effluents Stressing Factors

Stressing factors	Mitigation Programs	Responsible agencies	
• Waste dumping	• Implement the existing environmental regulations: acts & laws • Awareness to locals • Polluters pay	• Municipality/MoEF • Municipality/NGOs • Municipality	• Long Term • Short Term • Short Term
• Sewerage discharge	• Provision of treatment plants & sewer lines • Recycling of sewer water & uses • Awareness to locals through providing training • Participation of local people	• Municipality/ MoUD • Municipality/ MoUD • Municipality/MoUD • Municipality/NGOs	• Short Term • Long Term • Short Term • Long Term
• Industrial effluent	• Install effluent treatment plants • Conduct compliance monitoring • Awareness to stakeholders	• MoUD/Dept of Industry • MoUD/ Dept of Industry • MoUD/NGOs/SPCB	• Long Term • Long Term • Short Term

Source: Field survey by AHEC (2007); MoEF = Ministry of Environment and Forest., MoUD = Ministry of Urban Development, SPCB = State Pollution Control Board

b Environmental and Ecological Disturbances

Environmental and ecological stressing factor along the Kosi river stretch includes deforestation and minerals quarrying.

Existing Mitigation Measures

- The Government of India has enacted a number of environmental laws, policies and regulations to conserve the forest resource. However, there is a need of commitment to

implement these regulations through state pollution control boards, municipalities, public health departments etc.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 7.4.

Table 7.4: Mitigation Strategies for Environmental Conservation

Stressing factors	Mitigation Programs	Responsible agencies	Time period
• Deforestation	• Control deforestation	• MoEF	• Long Term
• Quarrying minerals	• Exploit of minerals rationally • Awareness	• Ministry of Industry • Municipality/NGOs	• Long Term • Long Term

Source: Field survey by AHEC (2007)

7.3 Summary and Conclusions

- National agencies with operational tasks should be accountable to the public and all stakeholders should have sufficient funding and legislative means, and should work on the basis of the national policy.
- Realistic plans should be drawn based on the best available knowledge, with sufficient political/public support and financial means for implementation.
- The Government bodies should be serious and committed to implement the existing acts and regulations related to river water conservation.

8 NEPAL

8.1 Settings of the Two River Basins

The Bagmati and Seti basins lie in Kathmandu and Pokhara Valleys respectively. They are the most important valleys of the midland hills, stretching from east to west in Nepal. On the north lies the Himalayan range that runs parallel to the midland hill and on the south is the Tarai plain. The middle hills range is composed of ridges, *tar* (upland plain), river basins, and valleys. Both Kathmandu and Pokhara are tectonic valleys and present interment character. They are tertiary structural basins covered by fluvial or glaciofluvial sediments, with residual hills and ridges on their valley plains. Each valley is drained by a single most important river – the Bagmati in case of Kathmandu Valley and the Seti in Pokhara Valley. Both rivers have flat terraces on either side.

Kathmandu and Pokhara valleys also present uniqueness in their physical, social, and economic settings. While Kathmandu is an enclosed basin with a centripetal drainage, Pokhara is an open basin in the east and lies on the course of a considerable river, a location that would favour extra-regional deposition. Pokhara basin is filled with gravel, but lacks entirely lacustrine deposits such as lignites, which are so characteristic in various terrace levels of Kathmandu valley (Gurung 1969-70).

Further, Kathmandu valley extends over an area of 590 km^2, which is about five times bigger the size of Pokhara valley (124 km^2). Kathmandu lies at an average elevation of 1,250 metres above sea level (masl), whereas the elevation of Pokhara valley floor averages about 725 masl. As in other parts of the country, rainfall occurs in these valleys during the summer monsoon. However, Pokhara valley receives the largest amount of rainfall in Nepal with an annual average rainfall of about 3,600 millimetres, as compared to 1,900 mm in Kathmandu valley. Furthermore, the Bagmati and all its 9 tributaries (viz. Bishnumati, Dhobi, Manohara, Hanumante, Tukucha, Kodku, Godavari, Nakhu, and Balkhu) are spring- or rain-fed perennial streams. Whereas the Seti and its tributary Mardi are glacier-fed streams on the south slopes of Annapurna Himal and therefore their headwaters lie outside the Pokhara basin (Gurung 1969-70; Sharma 1977). The Seti's other 10 tributaries (viz. Bijayapur, Yamgdi, Marse, Khudi, Dobhan, Kali, Bhurjung, Anpu, Kahun, and Gabadi) are spring- or rain-fed perennial streams. Unlike the Bagmati, the Seti has deep narrow gorges with as deep as 46 metres at some location. There are large-scale slips and cracks along the banks, which sometimes coalesce to make the Seti a subterranean river. However, the major rivers and their tributaries are important for all religious, cultural, social, and economic activities in both basins.

Kathmandu valley with its three districts (Bhaktapur, Kathmandu, and Lalitpur), five municipalities (Bhaktapur, Kathmandu, Kirtipur, Lalitpur, and Madhyapur-Thimi), and a national capital – Kathmandu city has population with over 1.5 million. It has the largest density of population (136 persons/ha). Pokhara valley, on the other hand, lies in Kaski district and has only one municipality – Pokhara city and several villages. The valley has population below 400,000. Both valleys are the most important centres for tourists. They, therefore, attract people from different parts of the world, as well as within the country. Since the last few decades, the growth of urban population in these valleys has been accelerated, and as a consequence, they have witnessed remarkable changes in environmental resources, agriculture systems, and urban infrastructure and facilities.

8.2 Results and Discussions

8.2.1 Water Quality Classes

A total of 64 sample sites covering the whole river stretch from upstream to downstream for the Bagmati basin and 51 sample sites for the Seti Basin were selected. The field survey was carried out in the month of May, 2007, which falls in the pre-monsoon period.

By using the Saprobic approach five water quality classes have been obtained for the rivers of the Bagmati and Seti basins. Based on the data and information contained in the field protocol sheet, description of major riverine features together with stressing factors is summarised in Table 8.1 for the Bagmati basin and Table 8.2 for the Seti basin. The following observations are obtained:

- The water of the rivers all across the stretches is found to be used for multiple purposes like drinking, washing, bathing, and irrigation. While in all five water quality classes, irrigation, and washing are commonly used, the river water is found to be used for drinking in class I through class III. According to the description of the water quality, Class-II and Class-III cannot be used directly for drinking purpose, as the rivers contain effluents, such as solid waste, agricultural chemical residues and industrial gutter.
- A total of 22 stressing factors of degradation of river water quality have been identified (Table 8.3). A total of 12 sampling sites in case of the Bagmati basin and 7 in case of the Seti basin that come under 'Class-I' have no or minimal anthropogenic impacts. The four major stressing factors found in the basins are waste dumping, bathing and washing, open defecation and sewerage. The number and types of these stressing factors are intensified in Class-II and other ascending classes.
- A relationship between water quality class and density of settlements is observed along the river stretches. The density of settlements is thin in the upstream area where water quality is Class I, and the river water quality is found to be degraded (as indicated in other ascending water quality classes) as is intensified in the density of settlements in downwards along the river stretches. The anthropogenic activities related to development like roads, embankment, reservoir, agricultural intensification, vehicular traffic, sand or stone quarrying, and so on are also increased both in volume and type in downstream areas. These activities are said to be the 'stressing factors' that disturb riverine ecology and degrade water quality. Because of higher intensification, they are responsible to degrade water quality at the sample sites in upstream-downstream and downstream areas. Along with the intensity of activities, conservation of river environment has also been observed. Embankment of the river banks with bamboo and cemented wall, channelization, and buffer corridor are some major conservation activities of the river stretches. However, at the same time, some of these activities like cement embankment and channelization are not river eco-friendly measures.

Table 8.1: Major Stressing Factors by River Quality Class, the Bagmati River Basin, Nepal

Description	Water Quality Classes				
	I	**II**	**III**	**IV**	**V**
No. of sites	12	18	16	10	8
Location	Upstream	Upstream/Downstream	Upstream/ Downstream	Upstream/ Downstream	Downstream
▪ Water use	None, tapped in reservoir, drinking, irrigation, washing	Drinking, irrigation, bathing and washing	Drinking, irrigation, bathing and washing	Irrigation, bathing and washing	Irrigation, bathing and washing
▪ Effluents	None	Domestic, agriculture and industry	Domestic, agriculture and industry	Domestic, agriculture and industry	Domestic, agriculture and industry
▪ Stressing factors	Reference site (minimum anthropogenic impacts)	Stone quarrying and mining , vehicle crossing the river, waste dumping, embankment, open defecation, bathing and washing, agricultural runoff, impoundment, bank erosion and flood	Sand extraction, solid waste dumping, squatter settlements, irrigation, agricultural runoff, vehicle crossing, weir and embankment	Waste dumping, open defecation, bathing and washing, cremation, embankment, sand extraction	Waste dumping, bathing and washing
▪ Settlements	None to sparse	Sparse to medium	Sparse to medium	Dense to medium	Dense
▪ Development	None	None, settlements and roads along the banks	None, agricultural land near to the bank, vehicle crossing the river, well constructed for city water supply	Concrete embankment, road on the banks, settlements	Concrete embankment, road along the banks and waste dumping
▪ Bank fixation	None, natural, embankment	Natural, bamboo embankment, channelization	None, concrete and bamboo embankments, channelization	Concrete embankment in some sections along the rivers	River corridor/ buffer zone of ≈5 m at both banks

Source: *Field Survey and Lab Analysis, 2007*

Table 8.2: Major Stressing Factors by River Quality Class, the Seti River Basin

Description	Water Quality Classes				
	I (7)	**II** (19)	**III** (11)	**IV** (6)	**V** (8)
Water use	None, tapped in reservoir, drinking, irrigation , washing	irrigation, bathing and washing & drinking (animals)	Bathing , washing and Irrigation, fishing, boating , animal wallow	Bathing , washing and Irrigation, fishing, boating , animal wallow	Irrigation and washing
Effluents	None	Domestic, agriculture and industry, leachate from land-filled	Domestic, agriculture and industry	Domestic, agriculture and industry	Domestic, agriculture and industry
Stressing factors	Referenc e site (minimu m anthropo genic impacts)	Stone quarrying and mining , vehicle crossing, waste dumping, embankment, open defecation, agricultural runoff, impoundment, bank erosion and flood, fishing, natural suspended loads	Sand extraction, waste dumping, squatter settlements, irrigation, agricultural runoff, vehicle crossing, weir and embankment; water pools & fish catching	Sand extraction, waste dumping, squatter settlements, irrigation, agricultural runoff, vehicle crossing, weir and embankment; water pools & fish catching	Wastewater effluents, waste disposal; bank encroachment; open defecation
Settlements	None to sparse	Sparse to medium	Sparse to medium,	Sparse to medium	Dense
Developme nt	None	Weir	agricultural fields, vehicle crossing	agricultural fields, vehicle crossing	Concrete embankment, roads on the banks and waste dumping
Bank fixation	None, natural embank ment	Natural, channelization	None, concrete and bamboo embankments, channelization	None, concrete and bamboo embankments, channelization	

Source: *Field Survey, 2007*
Note: *Figures in parenthesis refer to number of sample sites*

8.2.2 River Stressing Factors

As indicated above, a total of 22 stressing factors have been identified along the river stretches, which have been grouped into *four* broad groups (Table 8.3). In both river basins, the relative importance of effluent factors (agricultural, industrial, household, and cremation) is the largest, with above 45 percent. In other three major stressing groups, the pattern of distribution of frequencies or the relative importance is different between these two river basins. While the

relative importance of 'Group-B' (activities and facilities) is the second largest stressing factor (20.4%) in case of the Bagmati basin, it is 'Group-C', i.e. hydro morphological degradation and ecological disturbances (26.1%), is the second largest stressing factor in the Seti basin case. The relative importance of 'Group-B' is the least stressing factor for the Seti basin, while it is 'Sanitation Activity' (Group-D) for the Bagmati basin.

Table 8.3: Classification of the River Quality Stressing Factors

Group	Stressing factors	Basin (*f*)	
		Bagmati	Seti
a. Effluents	• Waste dumping	35	40
	• Sewerage	30	15
	• Cremation site	4	2
	• Industrial effluent	15	3
	• Agricultural effluent	7	3
	Sub-total	91 (45.3%)	63 (47.0%)
b. Activities and facilities	• Squatter settlements	3	2
	• Military camp in upstream	1	
	• Water mills in upstream	1	
	• Picnic spots close to river	3	2
	• Vehicle crossing along river or using rivers as roads	6	2
	• Open defecation	25	5
	• Littering by picnic goers	2	1
	Sub-total	41 (20.4%)	12 (9.0%)
c. Hydro morphological degradation & ecological disturbances	• Channel, embankment & weir	10	12
	• Flood	3	
	• Bank cutting	1	1
	• Reservoir, dam & impoundment	4	7
	• Irrigation	9	3
	• Landfill leachate	2	1
	• Fishing & boating	-	3
	• Stone quarrying & crushing	4	2
	• Sand quarrying	6	6
	Sub-total	39 (19.4%)	35 (26.1%)
d. Personal hygiene and sanitation	• Bathing & washing	30 (14.9%)	24 (19.9%)
	Total	201	134

Source: *Field Survey* 2007.

8.2.3 River Sustainable Management Strategies (RSMS)

Here, the existing and proposed strategies formulated in terms of the order of relative importance are provided. The proposed mitigation strategies are defined in terms of three broad periods, such as short-term, medium-term, and long-term. Complying with the periods defined for the water resource strategy formulated by the Government of Nepal, the years of period for

short-term, medium-term and long-term are 5, 15, and 25 respectively. The strategies for each broad class and its individual cases are described in terms of order of relative importance of stressing. The responsible agencies for each strategy are also provided. In some cases, the particular strategies described against the particular stressing factors can also be used for other related stressing factors.

a *Effluents*

The effluents (agricultural residues, industry, household sewer and solid waste, and cremation) are found to be the largest stressing factor. Among these, the occurrence of household waste dumping and then sewer has been the largest.

Existing Mitigation Measures

- There are efforts being made by the municipalities in collaboration with the Ministry of Local Development for dumping the household garbage on landfill sites and alternatively on the banks of the rivers (in Kathmandu only). Yet the efforts seem to be ineffective and sporadic conflicts have occurred between the government and municipality, and local inhabitants about the dumping sites, as the later is often located outside of municipal boundary. The discharge of household sewer directly into the streams is regulated by the Department of Water Supply and Sewerage, for which every municipal household is paying every month along with water consumption bill. The municipality effort to stop over the direct discharging has been futile.
- The existing treatment plants in the Kathmandu valley are at present not functioning. There is an additional treatment plant being made in the Pashupati-Guheshwari area, which is successful but not adequate. One recently built treatment plant by community at Madhyapur-Thimi municipality is an excellent example for a functioning plant.
- There exist effluents standards, but they are not effectively implemented.
- The cremation of dead human bodies is still practiced in traditional way. The municipalities have been talking about the installation of electric furnace for it since over a decade, but they are not yet materialized.

Proposed Mitigation Measures

Table 8.4 summarises *proposed* strategies for mitigating each of the effluents and its possible responsible agencies. In all cases, however, a well formulated monitoring and evaluation mechanism (system) should be adopted by the respective responsible agencies.

Table 8.4: Strategies for Mitigating Effluents Stressing Factors

Stressing factors	Mitigation Programs	Responsible agencies	Years of period
• Waste dumping	• Prohibition of dumping • Provision of waste collection points • Roads along the river banks & embankment • Awareness to locals	• Municipality/VDC • Municipality/VDC • Municipality/VDC & Dept of Roads • Municipality/VDC/NGO	• Short • Short • Long • Long
• Sewerage	• Prohibition of direct discharging • Treatment plants • Awareness to locals	• Municipality/VDC • Municipality/VDC • Municipality/VDC/NGO	• Short • Mediu m

		s	• Long
• Agricultural effluent	• Reduce amount of chemical fertilizer & pesticides through encouraging manure	• Municipality/VDC/Agricultural Department	• Medium
• Industrial effluent	• Prohibition of direct discharging	• Municipality/VDC/Environmental Department	• Short
• Cremation site	• Electric furnace	• Municipality/VDC	• Long

Source: Field survey (2007)

b Activities and Facilities

The Group-B includes the stressing factors such as open defecation, vehicle crossing along river or direct use of rivers as roads, picnic and littering by picnic goers, and others (squatter settlements, water mills in upstream, picnic spots close to river and military camp in upstream).

Existing Mitigation Measures

- Few public toilets have been made particularly in the core area of the municipalities, particularly in Kathmandu. Recently community toilets with bathing facility are made under Public Partnership Programme in Kathmandu city. There is no information about the public toilets being made in rural areas. No additional effort has been made by the government to construct toilets, and likewise awareness about sanitation on the part of government is limited and not continuous. (ENPHO 2007)
- The government-built bridges are not adequate with respect to the increased number of vehicular traffic and even the government has not made any policies about the restriction of the vehicles plying over the streams.
- No strict monitoring has been made about the prohibition of littering in public parks.
- Till now the Kathmandu city has made only one resettlement programme for the rehabilitation of the squatters, which is also not successful. Further resettlement programmes have not been made on the part of government, nor has upgrading of slums been adequately and efficiently made.
- Conservation of the river sources has been made, but no effective programmes have been made by the government in collaboration with local inhabitants to control over activities hampering the river water quality even in the headwater region.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 8.5.

Table 8.5: Strategies for Mitigating Activities and Facilities Stressing Factor

Stressing factors	Mitigation Programs	Responsible agencies	Years of period
• Open defecation	• Prohibition of open defecation • Provision of community toilets • Awareness to locals	• Municipality/VDC • Municipality/VDC/locals • Municipality/VDC/NGOs	• Short • Medium • Long
• Vehicle crossing	A. Build bridges and/or cause	B. Municipality/VD	C. Mediu

along river	ways	C/Dept of roads/NGOs/Locals	m
• Littering at around picnic spots by picnic goers	• Prohibition of littering • Provision of litter containers • Awareness	• Municipality/VDC • Municipality/VDC/Locals • Municipality/VDC/NGOs	• Short • Short • Long
• Others (squatter settlements, water mills & military camp in upstream, and picnic spots close to river)	• Control of squatting and building of water mills, military camps in upstream • Prohibition of picnic spots close to river & upgrading of slums • Awareness	• Municipality/VDC/Defence ministry • Municipality/VDC • Municipality/VDC/NGOs	• Short • Short+ medium • Long

Source: Field survey (2007)

c Hydro morphological degradation and Ecological Disturbances

Group-C stressing factor includes irrigation, reservoir and impoundment, embankment and weir, flood, bank cutting, quarrying stones and sand, and fishing and boating. These are development activities of river water resource for use, but at the same time disturbing riverine ecology.

Existing Mitigation Measures

- Use of river water has not been effective according to the acts formulated by the Ministry of Water Resources, such as drinking, irrigation, hydro power generation and other activities in order of priority.
- Some of the programmes such as river corridor roads (Bishnumati, Dhobi khola, Bagmati in Kathmandu), and parks have been completed, which are about the protection of river banks and controlling of odour. However, river banks have been the most squatted areas.
- No policies and programmes have been made by the district government to control against the quarrying and mining of the stones and sand, but the local communities in some areas have voiced against such activities.
- Sand quarrying near the bridges is found to be strictly prohibited.
- Use of chemical poisoning and blasting to kill indigenous fish are observed particularly in the Seti basin. There is no strict implementation against the use of any kind of chemicals and blasting for fishing activity.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 8.6.

Table 8.6: Mitigation Strategies for Conservation of River

Stressing factors	Mitigation Programs	Responsible agencies	Years of period
• Water for irrigation	• Building eco-dam for allocation of water for drinking and irrigation	• Municipality/VDC/ Dept. of Drinking Water & Irrigation	• Medium
• Reservoir &	• Prohibition of building	• Municipality/VDC	• Short

impoundment along rivers	impoundments • Regulation of community drinking water as top priority	/Local • Department of Drinking Water	• Short
• Embankment & weir	• Demarcation of river course/ bank • Prohibition of encroaching river banks • Awareness	• Municipality/VDC/ Survey Department • Municipality/VDC/ Locals • Municipality/VDC/ NGOs	• Medium • Short • Long
• Flood	• Protection of watershed by planting trees/grasses • Building of embankment • Awareness	• Municipality/VDC/ Dept. of Forestry/User group • Municipality/VDC/ Local • Municipality/VDC/ NGOs	• Long • Medium • Long
• Bank cutting	• Embankment of river banks	• Municipality/VDC/ Local	• Medium
• Quarrying sand & stone	• Prohibition of quarrying sand & stone • Construction of embankment • Prohibition of stone crushing factories at the river banks • Awareness	• Municipality/VDC • Municipality/VDC/ NGOs/Locals • Municipality/VDC/ NGOs • Municipality/VDC/ NGOs	• Short • Long • Short • Long
• Chemical poisoning & blasting in fishing	• Prohibition of using chemical poisoning & blasting • Awareness	• Municipality, VDC and fishery department	• Short • Long

Source: Field survey (2007)

d. Sanitation (Bathing and washing)

In Group-D stressing factor, sanitation includes bathing and washing of clothes and vegetables.

Existing Mitigation Measures

- No effective awareness programme about the water pollution and its uses in different activities (bathing, washing, drinking, and swimming) at community level has been made by the local government.
- Notice about the prohibition of throwing and dumping wastes in the river is often made by municipality, but has not been effective due mainly to lack of punishment to those who have done it.
- Even the public organisations are not fully aware about the interpretation and use of water quality class maps of the Bagmati River being prepared and published.

Proposed Mitigation Measures

Table 8.7 provides proposed strategies for each stressing facility.

Table 8.7: Strategies for Mitigating River Water Stressing Activities

Stressing factors	Mitigation Programs	Responsible Agencies	Years of period
• Bathing	• Prohibition of bathing in terms of sanitation viewpoint • Provision of adequate community taps • Awareness	• Municipality/VDC • Municipality/VDC/Dept of Drinking Water Supply • Municipality/VDC/NGOs	• Short • Medium • Long
• Washing clothes, vegetables	• Prohibition of washing clothes and vegetables • Provision of adequate community taps • Awareness	• Municipality/VDC • Municipality/VDC/Dept of Drinking Water Supply • Municipality/VDC/NGOs	• Short • Short • Long

Source: Field survey (2007)

8.3 Summary and Conclusions

It is asserted that the efforts being made towards conserving riverine environment, particularly in large urban areas in Nepal have been inadequate and ineffective, as it is evidenced by the types of stressing factors and their intensity they are found in two important river basins of the Bagmati and the Seti. It is found that the river water has been used for different purposes, ranging from household (bathing, swimming and washing) to livelihood means (fishing and boating), to irrigation, to industries, to traffics and to wastes dumping. The findings also show that the major stressing environment factors are waste dumping, bathing and washing, open defecation and sewerage. There exists a relationship between the number and types of the stressing factors and water quality classes, which is indicated by an increase in intensification of anthropogenic impacts along with the ascending order of poor water quality classes. It is important however to establish relationship between these two indicators by in-depth study.

In both river basins, the relative importance of effluent factors, such as agricultural, industrial, household, and cremation is the largest. In case of other three major stressing groups, the relative importance is not the same between the two river basins. The results of differential impacts of the stressing factors in the two river basins however provide valuable information to the river environmentalists for conserving river stretches. If detailed programmes and strategies are made for each of the stressing factors as prescribed in this study, sustainable management of riverine environment and ecology can be achieved. The methodology adopted in this study can be a model for conservation planning of other river basins in the developing world.

9 PAKISTAN

9.1 Settings of the River Basins

The Soan river of Pakistan is the main river that flows through its diverse ecoregions of alpine to broad leaf forests. The river begins from the altitude of approximately 590 masl and flows through the urban areas of Islamabad and Rawalpindi. It drains out the urban wastes.

9.2 Results and Discussions

9.2.1 Water Quality Classes

There were altogether 42 sample sites along the Soan river stretch, covering the watersheds of Islamabad and Rawalpindi. The samples represented all five water quality classes and habitats of the river stretch. The field survey was conducted during the pre-monsoon season. Since the national water quality standards for surface water are not available in Pakistan, the findings have been compared with the WHO Drinking Water Quality Guidelines. Table 1 shows the distribution of sample sites by water quality classes. Five water quality classes have been obtained for the five river basins by using the saprobic approach.

Table 9.1 shows that the largest number of sample sites, constituting 31 percent of the total lie in WQC II, followed it by WQC V and WQC III. WQC I contains a considerable number of sample sites. The sample sites of WQC V and WQC IV represent the largest proportion, indicating the highly polluted quality of the river water. It has been observed that the Soan River is found to be polluted by a wide range of anthropogenic activities such as industries, household wastes, poultry waste, and hospital wastes.

Table 9.1: Distribution of Sample Sites by River Quality Class, Pakistan

Water Quality Class (WQC)	Sample Sites	
	Number	Percent
I	6	14.3
II	13	31.0
III	9	21.4
IV	4	9.5
V	10	23.8
Total	42	100.0

Source: Field survey (2007)

The following observations are obtained:

- The water of the rivers all across the stretches is found to be used for multiple purposes like vehicles washing, and different types of wastes dumping, etc. The water of the river cannot be used directly for domestic purposes, according to the WHO guidelines, since the samples of the river stretches contain effluents, such as municipal wastes, industrial effluents, etc.
- A total of 10 stressing factors of degradation of river water have been identified (Table 9.2). There are anthropogenic impacts, ranging from minimal to maximum. These 10 stressing factors observed in the Soan basin are put into three major groups such as effluents, activities, and environmental disturbances.
- The anthropogenic activities including river impoundments, dumping of construction and household wastes are said to be very critical stressing factors, as they disturb riverine ecology and degrade water quality. Because of higher intensification, they are responsible to degrade water quality at the sample sites along the river stretch. In the urban areas, the water

quality is found to be highly deteriorated as they lie in WQC IV and WQC V where the river literally becomes a sewer outfall.

9.2.2 River Stressing Factors

As indicated above, a total of 10 stressing factors have been identified along the Soan river stretch, which have been grouped into *three* broad groups (Table 9.2). Since there is no frequency of the stressing factors or their presence and absence, their relative importance cannot be achieved.

The waster quality of the Soan River is found to be affected by a range of stressing factors (Table 9.2).

Table 9.2: Classification of River Stressing Factors

Groups	Stressing factors
a Effluents	• Solid wastes • Waste water • Poultry waste • Hospital waste • Industrial effluents
b Activities & facilities	• River crossing • Vehicle washing
c Environmental & ecological disturbances	• River impoundment • Construction • Landslides

Source: Field survey (2007)

9.2.3 River Sustainable Management Strategies (RSMS)

Sustainable mitigation strategies are proposed to each of the broad stressing factors of the river stretch. The strategies for each broad class and its individual cases are also described. The responsible agencies for each mitigation strategy are also provided. In some cases, the particular strategies described against the particular stressing factors can also be used for other related stressing factors.

a. Effluents

The effluents along the Soan River include solid waste, waste water, poultry waste, hospital waste, and industrial waste.

Existing Mitigation Measures

- There exist efforts such as the National Water Quality Monitoring Programme, Water Quality Monitoring in Rural Areas, Demarcation of Groundwater Quality Zones, Development of low Cost Arsenic Removal Technologies, Development of Low Cost Water Testing Kit, National Water Quality Monitoring Programme, Drinking Water Quality Standards (Draft), National Conservation Strategy, Water Sector Strategy, National Environmental Policy, Environmental Protection Act, Water User Association Ordinance, etc being made by the Government of Pakistan. Yet, these efforts seem to be ineffective, and

there is lack of harmony and integration between various regulations, which is evidenced by the fact that there is still the discharge of household sewer directly into the streams. The municipality effort to stop the direct discharging has been futile.

- There exist effluents standards, but they are not effectively implemented.
- Mechanism of monitoring water quality is weak due to inadequate mechanism for collection and analysis of information

Proposed Mitigation Measures

Table 9.3 summarises *proposed* strategies for mitigating each of the effluents and its possible responsible agencies. In all cases, however, a well formulated monitoring and evaluation mechanism (system) should be adopted by the respective responsible agencies for enforcement of regulating measures.

Table 9.3: Strategies for Mitigating Effluents Stressing Factors

Stressing factors	Mitigation Programs	Responsible Agencies
• Solid waste	• Provision of proper disposals • Fixing of recycling plants • Use of organic wastes • Training for solid waste handling and river training • Awareness through electronic & print media	• Water & Sewerage Board • Municipalities • Dept of Agriculture • Dept of Public Health (DOPH) • Dept of Communication
• Waste water	• Build of wastewater treatment plants • Improvement in existing treatment facilities • Capacity building of operators and engineers • Develop & implement waste water quality standards • Establishment of wastewater quality monitoring network	• Municipalities • Municipalities/DOPH • Municipalities/NGOs/ • Ministry of Environment (MOE) • Ministry of Environment/ Dept of Industry (DOI)
• Poultry waste	• Establishment of treatment facilities • Encourage the use of waste as manure • Manage ammonia gas emitted by poultry farm • Capacity building of poultry farmers • Legislation enforcement & monitoring	• Dept of Agriculture (DOA) • DOA • Municipality/DOA • Municipality/DOA • DOA

• Hospital waste	• Recording of the types of hospital wastes • Segregation and collection of hospital waste • Installation of incinerators in hospitals • Legislation enforcement & monitoring • Adopt better management system	• Municipality/DOPH • Dept of Env/DOPH • Hospitals/DOPH • Hospitals/DOPH • Hospitals/DOPH
• Industrial waste	• Installation of waste water treatment plants • Enforcement of regulations • Establishment of information cell for awareness and better management	• Municipality/MOE/DOI • Municipality/MOE/DOI • Municipality/MOE/DOI

Source: Field survey (2007)

In the mitigating strategies, awareness and provision of proper wastes managing systems means to disposing of plastic, disposable materials, kitchen garbage and paper products separately in the containers, and establishment of recycling plants for the management of solid waste. Encourage farmers to use of household organic wastes such as sewerage, animal dung etc. as a manure to be added in crop fields.

Educational program should be adopted for solid waste handling through syllabus and involvement of NGOs and for the protection of river bodies.

b. Activities and Facilities

Group-B includes river crossing and vehicle washing as the stressing factors. Washing vehicles in the river and crossing the river by the vehicles are a major source of river pollution affecting the aquatic life.

Existing Mitigation Measures

- Under the National Environmental Policy, efforts are spelt out to maintain the ecological balance and overall development through protection and improvement of the environment, to identify and regulate activities, which pollute and degrade the environment, and to ensure development that is environmentally sound for all sectors, including navigation in the rivers.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 9.4.

Table 9.4: Strategies for Mitigating Navigation Effects on Riverine Ecology

Stressing factors	Mitigation Programs	Responsible Agencies
• River crossing	• Enforcement of legislation • Construct bridges over river • Reconstruct streambeds • Awareness to local communities	• Ministry of Environment (MOE) & Transport

		• MOE & Transport • MOE
• Vehicle washing	• Provision of vehicle washing stations • Adopt legislation for avoiding vehicle washing • Awareness to vehicle handlers	• Ministry of Environment & Transport • MOE

Source: Field survey (2007)

c. Environmental and Ecological Disturbances

Group-C includes the stressing factors such as dumping of construction materials, river impoundments, and landslides. These activities however disturb the riverine ecology. The first two factors belong to human activities, whereas the latter relates to natural cause.

Existing Mitigation Measures

- The government has formulated the National Water Policy and EIA guidelines for water development projects
- Environment Conservation Act and Regulation for the use of river water has not been effective.

Proposed Mitigation Measures

The proposed strategies for each stressing facility are provided in Table 9.5.

Table 9.5: Mitigation Strategies for Rivers Conservation

Stressing factors	Mitigation Programs	Responsible Agencies
• River impoundments	• Prohibition of building of river impoundments • Design river impoundments at selected places based on EIA • Awareness	• Municipality/MOE • Municipality/MOE • MOE/NGOs
• Dumping of construction materials	• Prohibition of dumping in the river • Develop and enforce the regulations • Training for imparting environmental issues	• Municipality/MOE/Locals • MOE/NGOs
• Landslides	• Dissemination of information about earthquake-induced landslides • Avoid human activities on critical hill slopes • Implement standards for activities to slope susceptibility	• MOE/NGOs • MOE • MOE

Source: Field survey (2007)

9.3 Summary and Conclusions

- National agencies with operational tasks should be accountable to the public and all stakeholders should have sufficient funding and legislative means, and should work on the basis of the national policy.
- Realistic plans should be drawn based on the best available knowledge, with sufficient political/public support and financial means for implementation.
- The Government bodies should be serious and commitment to implement the existing acts and regulations related to river water conservation.

10. Summary of the HKH Region

The tables 10.1 and 10.2 show summary description of river stressing factor of all HKH partner countries. Table 10.1 shows that there are 21 stressing factors in Nepal, followed it by Pakistan with 9 and Bhutan with 8. Two stressing factors such as sewage discharge and industrial effluents are common in all five HKH countries. The presence and absence of stressing factors by country are indicated by logical expression such as 1 and 0 respectively.

Table 10.1: Overview of Classification of River Stressing Factors in HKH-countries

Stressor Groups	Stressing factors	**Bangladesh**	**Bhutan**	**India**	**Nepal**	**Pakistan**
a. Effluents	• Sewage discharge	1	1	1	1	1
	• Industrial effluents	1	1	1	1	1
	• Agricultural runoff	1	1	0	1	0
	• Solid wastes	1	0	1	1	1
	• Cremation	0	0	0	1	0
	• Poultry waste	0	0	0	0	1
	• Hospital waste	0	0	0	0	1
b. Activities & facilities	• Navigation	1	0	0	0	0
	• River crossing	0	1	0	1	0
	• Vehicle washing	0	1	0	0	1
	• Squatter settlements	0	0	0	1	0
	• Military camp in upstream	0	0	0	1	0
	• Water mills in upstream	0	0	0	1	0
	• Picnic spots close to river	0	0	0	1	0
	• Littering by picnic goers	0	0	0	1	0
	• Open defecation	0	0	0	1	0
c. Environmental & ecological disturbances	• River dams	0	1	0	1	1
	• Mining	0	1	1	0	0
	• Deforestation	0	0	1	0	0
	• Sand/gravel extraction	1	0	0	1	0
	• Channel, embankment & weir	0	0	0	1	0
	• Flood	0	0	0	1	0
	• Bank cutting	0	0	0	1	0
	• Irrigation	0	0	0	1	0
	• Landfill leachate	0	0	0	1	0

	• Fishing & boating	0	0	0	1	0
	• Construction	0	0	0	0	1
	• Landslides	0	0	0	0	1
	• Animal washing & wallowing	1	0	0	0	0
d. Personal hygiene and sanitation	• Bathing and Washing	1	0	0	1	0

0 = absence; and 1 = presence

Table 10.2 shows that there are policies and instruments in all HKH partner countries with varying level. All five countries do have national water development plan. Likewise, the common problems to all are ineffective implementation mechanism and enforcement. Water quality standards exist in all countries but Bhutan and Pakistan have not yet finalized. There is only one organization involved in water policy issues in Bhutan, whereas several organization are found to be involved in this policy issues in other four countries. Coordination and integration in water policy is strong only in Bhutan, while it is weak in other four countries.

Table 10.2: Summary of Water Policies in HKH-countries

Description		**Bangladesh**	**Bhutan**	**India**	**Nepal**	**Pakistan**
Policy and Instruments						
National Water Policy	National water development plan	x	x	x	x	x
	Water management plan	x	-	x	-	x
Protection	Environmental /Water Law		-	x	x	x
	Water quality standards	x	(x)[1]	x	x	X[2]
	EIA	(x)	x	?	x	?
	Water Quality Monitoring Programs	(x)	(x)	x	(x)	x
Implementation		ineffective	ineffective	ineffective	ineffective	ineffective
Institutional framework						
No. of governmental organization involved in water policy issues		several	1	several	several	several
No. of executive institutions		1	1	>2	several	1
No. of monitoring institutions		1	1	>2	>2	1
Involvement of NGOs		no	yes	yes	yes	yes
Community participation in water conservation		weak	weak	weak	mediocre	weak
Enforcement		weak	weak	weak	weak	weak

Coordination & integration of water policy	weak	strong	weak	weak	weak

1 = on preparation by NEC
2 = drafted by PCRWR

References:

AHEC (2005) *Study of Pressures and Impacts on Rivers Water Quality – Review of Existing Policies and Socio-Impacts (Draft Report).* Roorkee: Alternate Hydro Energy Centre, Indian Institute of Technology

Ahmed, N. (1993), *Water* Resources *of Pakistan*. Lahore

BKH (1994) *Industrial Pollution Control Management, Interim Report*. Manila: Asian Development Bank, BKH Consulting Engineers, (ADB TA 1769-BAN)

CPCB & NATMO (2001) *Environmental Atlas of India*

CPCB & NATMO (2001), *Water Cess Act.* New Delhi: Government of India, Central Pollution Control Board

CPCB (1999a) *Water Quality Status and Statistics (1996 &* 1997). New Delhi: Central Pollution Control Board

CPCB 2003 *Water Quality in India: Status and Trends (1999 – 2000)*. MINARS/20/2002-2002

DWSS (2001) *Establishing National Drinking Water Standards and Programs for Water Quality Monitoring and Surveillance.* Kathmandu: His Majesty's Government of Nepal (under WHO Country Program NEP PHE 001, 2001/01)

DWSS (2002) *DWSS National Drinking Water Quality Standards*. Kathmandu: His Majesty's Government of Nepal, National Task Force on Drinking Water Quality Standards.

Engleman, R..; Roy, P. (1993) *Sustaining Water – Population and the Future of Renewable Water Supplies.* Population and Environment Programme, Population Action International

ENPHO (2007), *ENPHO Monthly E-Bulletin*, Number 03-02, March.

FFC (2000) *Pakistan Water Sector Strategy*. Islamabad: Federal Flood Commission, Ministry of Water and Power

FFC (2004) *Promoting Private Investment in Drainage - Final Report.* Islamabad: Office of the Chief Engineering Advisor/Chairman, Federal Flood Commission (FFC), Ministry of Water and Power

GOI (1974) *Water (Prevention & Control of Pollution) Act*. New Delhi: Government of India

GOI (1986) *Environment (Protection) Act.* New Delhi: Ministry of Environment and Forests

GOI (1989) *Hazardous Wastes (Management and Handling) Rules (as amended)*. New Delhi: Government of India

GOI (1989) *Manufacture, Storage, Import of Hazardous Chemical Rules (as amended)*. New Delhi: Government of India

GOI (1992) *National Conservation Strategy and Policy Statement on Environment and Development.* New Delhi: Ministry of Environment and Forests

GOI (1992) *Policy Statement for Abatement of Pollution 1992*. New Delhi: Government of India

GOI (1998) *Bio-medical Waste (Management and Handling) Rules*. New Delhi: Government of India

GOI (1999) *Municipal Wastes (Management and Handling) Rules*. New Delhi: Government of India

GOI (2000) *Municipal Solid Wastes (Management and Handling) Rules*. New Delhi: Government of India

GON (1999) *Local Self Governance* Regulations 1999. Kathmandu: Government of Nepal

GON (2000) *Irrigation Regulations 2000.* Kathmandu: Government of Nepal

GON (2001) *Nepal Demographic and Health Survey*. Kathmandu: Ministry of Population & Health/Family Health Division

GON UNDP (2002) *Progress Report 2002 - Millennium Development Goals*. Kathmandu: Government of Nepal and United Nations Development Program

GON (1990) *Constitution of the Kingdom of Nepal*. Kathmandu: Government of Nepal

GON (1992) *Electricity Act (1992).* Kathmandu: His Majesty's Government of Nepal

GON (1993) *Electricity Regulation (1993).* Kathmandu: Government of Nepal

GON (1996) *Environment Protection Act 1996.* Kathmandu: Government of Nepal

GON (1997) *Drinking Water Regulations.* Kathmandu: Government of Nepal

GON (1997) *Environment Protection Regulations 1997.* Kathmandu: Government of Nepal

GON 1999) *Local Self Governance Act 1999*. Kathmandu: Government of Nepal

GOP (1983) *Environment Protection Ordinance 1983.* Islamabad: Government of Pakistan

GOP (1997) *Pakistan Environmental Protection Act 1997*. Islamabad: Government of Pakistan

GOP (2000) *National Environmental Quality Standards Rules 2000*. Islamabad: Government of Pakistan

GOP (2005) *State of Environment - Pakistan (Draft).* Islamabad: (Posted in the website www.environment.gov.pk)

Gurung, Harka (1969-70), Geomorphology of Pokhara Valley, *the Himalayan Review*, Vol. II-III, pp 29-49.

Kahlown, M.A.; Azam , M. (2004) *Water Quality Issues and Status in Pakistan*. Islamabad: Pakistan Council of Research in Water Resources (PCRWR)

Kahlown, M.A.; Majeed, A. (2004) *Water Resources of Pakistan*. Islamabad: Pakistan Council of Research in Water Resources, Ministry of Science and Technology

Khan, H.N. (2004) *Pakistan Water Quality Issues*. Paper presented at the Regional Integrated Workshop on Water Quality in South Asia – Issues and Status, June 29 – July 2, 2004, Kathmandu, Nepal

MOEF (2002) *Report of the Expert Group on Water Quality Monitoring System for Protecting the National Water Resources*. New Delhi: Government of India, WQAA

MOEF 1999 *Annual Report (1999 – 2000).* New Delhi: Government of India, Ministry of Environment and Forests

Moog, O., A. Chovanec, H. Hinteregger & A. Römer (1999): Richtlinie für die saprobiologische Gewässergütebeurteilung von Fließgewässern.- Wasserwirtschaftskataster, Bundesministerium für Land- und Forstwirtschaft, Wien: 144p.

Moog, O. & S. Sharma (2005): Guidance for pre-classifying the ecological status of HKH rivers,- to be downloaded from the ASSESS-HKH homepoge (www.assess-hkh.at) under "preclass_guidance_manual_Nov05.pdf"

MOWR (2000) *National Water Policy 2000.* New Delhi: Government of India, Ministry of Water Resources

NDWQS (2005) *A Brief Introduction on the Final Version of NDWQS in Nepal*. Kathmandu: Task Force for National Drinking Water Quality Standards

NEC (2004) *Brief Report on State of the Environment.* Thimpu: National Environment Commission (NEC)

NEC/RGB (2006), *National Biosafety Framework of the Kingdom of Bhutan*, Thimpu: National Environment Commission/Royal Government of Bhutan.

NWMP (2001) *National Water Management Plan Volume No.2 Main Report,* Dhaka: National Water Management Plan

NWP 2004, 2005, NDWQS (2005) NWRS (2002) UNDP (2004)

NWP (2004) *National Water Plan – Background Papers on Irrigation, Hydropower, Water Supply and Sanitation, Other Economic Uses of Water, Watersheds and Aquatic Ecosystems, and Policy and Legal Framework.* Kathmandu: MWR/WECS

NWP (2005) *National Water Plan, Water Resources Strategy Formulation Phase III.* Kathmandu: MWR/WECS

NWRS (2002) *Nepal Water Resources Strategy 2002.* Kathmandu: MWR/WECS

PCRWR (2002) *Water Quality Status in Pakistan.* Islamabad: Pakistan Council of Research in Water Resources, Ministry of Science and Technology

PCRWR (2003) *Water Quality Status in Pakistan.* Islamabad: Pakistan Council of Research in Water Resources, Ministry of Science and Technology

PCRWR (2004) *Water Quality Status in Pakistan.* Islamabad: Pakistan Council of Research in Water Resources, Ministry of Science and Technology

PCRWR 2002, 2003, 2004; Khan 2004; Kahlown and Majeed 2004

RGOB (1998) *The Middle path, National Environment Strategy for Bhutan*. Thimpu: National Environment Commission, Royal Govt. of Bhutan

RGOB (2000) *Environment Assessment Act 2000.* Thimpu: National Environment Commission, Royal Govt. of Bhutan

RGOB (2000) *First Greenhouse Gas Inventory*. Thimpu: National Environment Commission, Royal Govt. of Bhutan,

RGOB (2000) *Initial National Commission*. Thimpu: National Environment Commission, Royal Govt. of Bhutan,

RGOB (2001) *State of the Environment Bhutan 2001.* SACEP, NORAD, UNEP, NEC, RGOB

RGOB (2002) *Regulation for the Environmental Clearance of Projects and Regulation on Strategic Environmental Assessment, 2002.* Thimpu: National Environment Commission, Royal Govt. of Bhutan

RGOB (2004) *Environment Discharge Standard*. Thimpu: National Environment Commission, Royal Govt. of Bhutan

Sharma, Chandra K. (1977), *River Systems of Nepal*, Kathmandu: Sangeeta Sharma.

SOE (2001) *State of Environmental*. Bangladesh: UNEP & DOE/Government of Bangladesh

UNDP (2004) *Human Development Report - 2004*. UNDP (Oxford University Press, New Delhi)

UNDP (2004) *Human Development Report 2004 – Empowerment of Women.* Kathmandu: United Nations Development Programme

UNEP (2001) *Environmental Issues – State*

UNEP (2001) *State of the Environment Nepal 2001*. Kathmandu: MOPE, ICIMOD, SACEP, NORAD

UNICEF (2003) *Bangladesh – Statistics*. UNICEF

WAN (2005) *Water Laws in Nepal – Laws Relating to Drinking Water, Sanitation, Irrigation, Hydropower and Water Pollution*. Kathmandu: WaterAid Nepal

WAN (2005a) *Draft Country Strategy: 2005/06 – 2009/10. Kathmandu: WaterAid Nepal*

WAPRO (1999) *The Environmental Setting, Technical Paper No. 4*. National Water Management Plan Project, WAPRO

WRA (1992) *Water Resources Act 1992*. Kathmandu: HMGN/MWR

WSP (1998) *Dhaka Water Resources Management Programme, Final Report*. Dhaka: Fourth Dhaka Water Supply Project, WSP International Ltd., Dhaka Water supply and Sewerage Authority (DWASA)

ANNEX

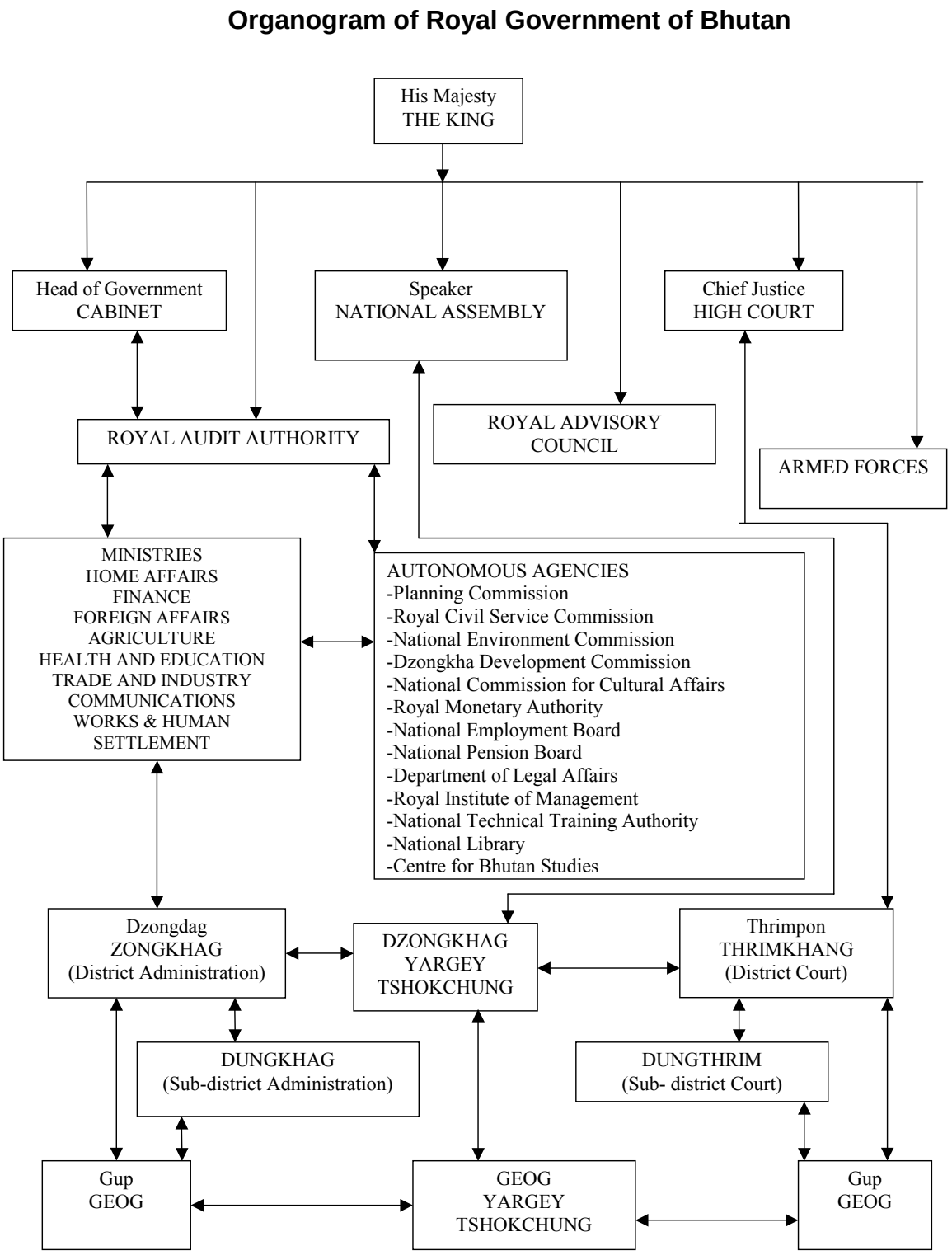
1. Screening protocol
2. Institutional framework of water sector- Bangladesh
3. Institutional framework of water sector- Bhutan
4. Institutional framework of water sector- India
5. Institutional framework of water sector -Nepal
6. Institutional framework of water sector- Pakistan

Appendix 1

Screening Protocol (Mountains) for assessing the river quality of streams in the ASSESS-HKH region						
Decision support table	river quality classes					
Multiple choices possible	I	II	III	IV	V	VI
Sensory features	To be ticked/counted if not in accordance with natural river type					
Non natural turbidity, Suspended solids			+	+	++	
Non natural colour		+	+	+	++	
Foam		+	+	+	+	
Odour (water)		+	++	++	++	
Waste dumping		+	+	+	+	
Ferro-sulphide reduction – (water velocity< 0,25 m/s)	-					
Mud reduced but with aerobic surface		+	+++	++		
Mud reduced but with anaerobic surface				++	+++	+++
Lower surface of stones (% cover black dots)		< 25 %	25-75 %	75-100 %	100%	100%
Upper & lower surfaces of stones				+	++	++
Ferro-sulphide reduction – (water vel.) 0,25-0,75 m/s)	-	-				
Mud reduced but with aerobic surface			+	+++	+	+
Mud reduced but with anaerobic surface				+	++	++
Lower surface of stones (% cover black dots)			< 50 %	50-100 %	100%	100%
Upper & lower surfaces of stones					+++	+++
Ferro-sulphide reduction – (water velocity > 0,75 m/s)						
Lower surface of stones (% cover black dots)			< 25 %	25-50 %	50-100 %	50-100 %
Upper & lower surfaces of stones					+++	+++
Bacteria, fungi, periphyton						
Sewage fungi & bacteria (visible to the naked eyes)	(-)	(-)	few	medium	many +++	many +++
Sulphur bacteria (visible to the naked eyes)	(-)	(-)	(-)	+	+++	+++
Stones with algal vegetation (periphyton) in thin layers	++	++				
% of thick, significant layers of algae	< 25 %	25-75 %	75-100 %	75-100 %	few	
Filamentous green algae	none to few	filaments, tufts	large tufts	(large) tufts	+	
Benthic macro-invertebrates						
Species richness	medium/high	(very) high	medium	few	very few	+++none**
Dominance of very sensitive organisms (8 to 10)*)	+++					
Dominance of sensitive organisms (6 to 8)*)	+	+++	+			
Dominance of medium tolerant organisms (4 to 6)*)			+++	+		
Dominance of tolerant organisms (3 to 4)*)			+	+++	+	
Dominance of extremely tolerant organisms (1 to 2)*)					+++	
Rhithrogena spp.	+++	++				
Perlidae	++	+				
Plecoptera	++	+				
Euphaeidae	++	+				
Stenopsyche spp.	++	+	+			
Rhyacophilidae	+++	++	+			
Caenis spp.	+	++	++			
Heptageniidae	++	++	+			
Psephenidae	++	+++	+			
Glossosomatidae	++	+++	+			
Sphaeriidae	+	+	++			
Simuliidae	+	++	++			
Psychomyiidae	+	+++	++			
Tabanidae	+	++	+++			
Potamidae	+	++	++	+		
Libellulidae / Corduliidae		+	+++	++		
Hydropsychidae (medium to many)		+	+++	+		
Planorbidae		++	+++	+		
Lymnaeidae		+	+++	++		
Physa spp.			+	++		
Leeches (more than naturally occurring)	-	-	+	+++	+	
Chironomids with red colour		very few	few	medium	+++many	none
Bezzia-Group				+	++	
Psychodidae white				+	+++	
Air-breathing animals, e. g. rat-tail maggots					+++	+++
Oligochaeta / Tubificidae (mud-worms)	0 to very few	few	few/ medium	medium/ many	many	none
Sum of columns						
*) check scores in the HKHbios list on the back page **) if only airbreathing organisms						

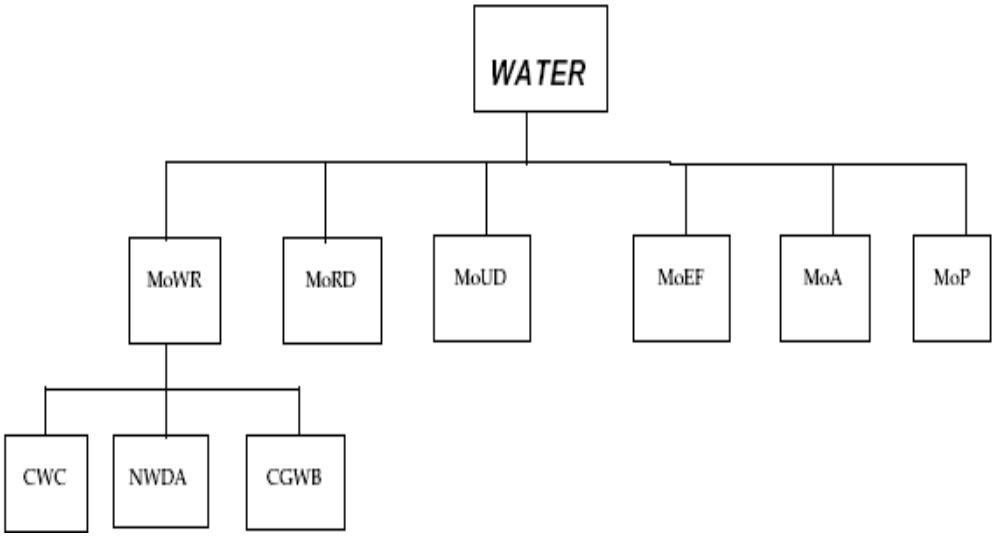
TAXON / NEPBIOS		Abd	TAXON / NEPBIOS		Abd	HABITAT	%
Aeshnidae	6		Limnocentropodidae	9		**Mineral**	
Aphelocheiridae	7		Limoniidae	8		Hygropetric	
Athericidae	10		Lymnaeidae	6		Boulders	
Baetidae	7		Micronecta	4		Cobbles	
Bezzia-Group	2		Muscidae	3		Stones	
Bithyniidae	5		Naucoridae	4		Pebbles	
Blephariceridae	10		Nemouridae	9		Gravel	
Brachycentridae	7		Neoephemeridae	9		Sand	
Caenidae	6		Nepidae	4		Sandy mud	
Calopterygidae	4		Noteridae	4		Mud	
Chironomidae *red*	1		Notonectidae	3		Clay	
Chironomidae *not red*	5		Odontoceridae	5			
Chlorocyphidae	9		Palaemonidae	4		**Biotic**	
Chloroperlidae	5		Peltoperlidae	10		Micro algae	
Coenagrionidae	4		Perlidae	8		Macro algae	
Corbiculidae	5		Perlodidae	9		Submerged macroph.	
Corduliidae	4		Philopotamidae	7		Emerged makrophyte	
Corixidae	6		Physidae	3		Living terrest. plants	
Corydalidae	2		Planariidae			Wood	
Culicidae	5		Planorbidae	4		CPOM	
Dryopidae	4		Pleuroceridae	4		FPOM	
Dytiscidae	6		Polycentropodidae	7		Debris	
Ecnomidae	8		Potamidae	7		Sewage bacteria	
Elmidae	7		Protoneuridae	5			
Ephemerellidae	6		Psephenidae	7			
Ephemerellidae (*Drunel.* sp.)	7		Psychodidae (white)	2			
Ephemeridae	10		Psychomyiidae	6			
Epiophlebiidae	8		Ranatridae	4			
Euphaeidae	7		Rhyacophilidae	8			
Gammaridae	4		Salifidae	3			
Gerridae	4		Scirtidae	8			
Glossiphoniidae	7		Simuliidae	7			
Glossosomatidae	9		Siphlonuridae	10			
Goeridae	4		Sphaeriidae	5			
Gomphidae	6		Stenopsychidae	6			
Gyrinidae	10		Stratiomyidae				
Helicopsychidae	10		Taeniopterygidae	10			
Heptageniidae	10		Tabanidae	2			
Heptageniidae (*Epeorus* sp.)	9		Thiaridae	4			
Heptageniidae (*Iron* sp.)	9		Tipulidae	8			
Hept. (*Rhithrogena* sp.)	8		Tubificidae	1			
Hydraenidae	6		Veliidae	4			
Hydraenidae (*Ochthebius* sp.)	10						
Hydrobiosidae	10		**Other Taxa ⇩**				
Hydrometridae	6						
Hydrophilidae	6						
Hydropsychidae	6						
Hydroptilidae	10						
Lepidostomatidae	5						
Leptoceridae	7						
Leptophlebiidae	10						
Leuctridae / Capniidae	6						
Libellulidae	6						
Limnephilidae	9						

Appendix 2: Institutional framework of water sector- Bhutan



Source: ICIMOD (2005), Development of an Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush-Himalayan Region :*Review of River Water Quality Policies, Pressures and Impacts, and Socio-Economic Relevance.* Kathmandu: ICIMOD

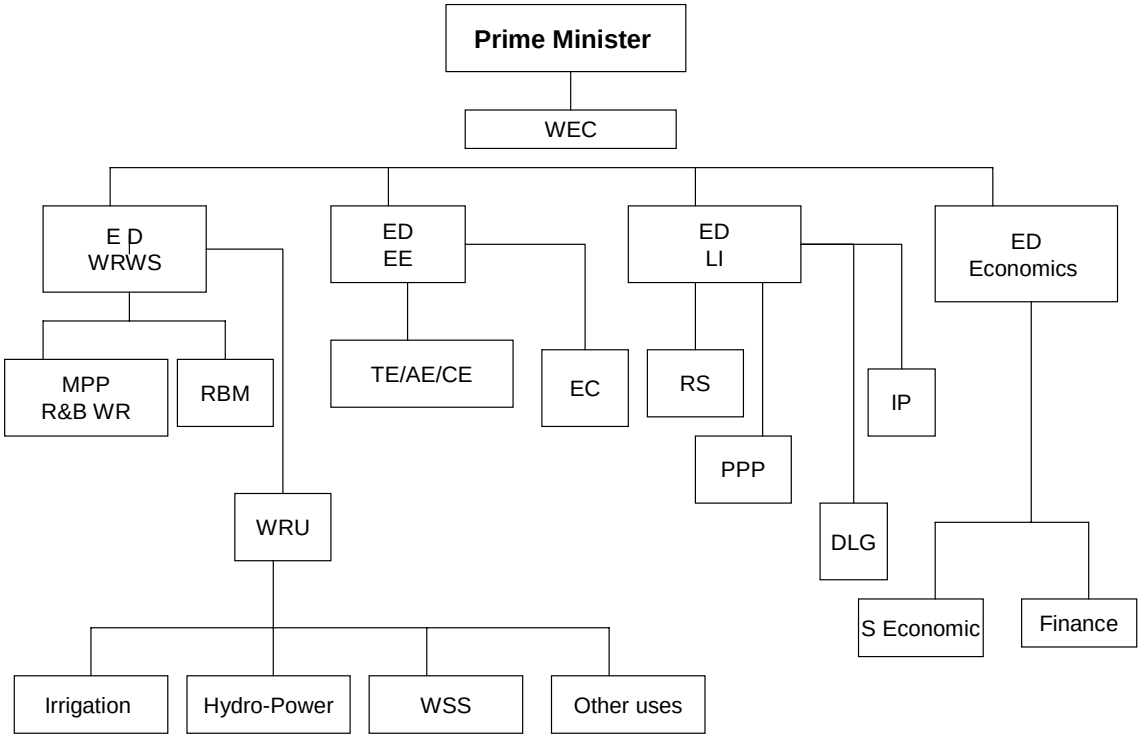
Appendix 3: Institutional Setup for Water Management in India



MoWR	-	Ministry of Water Resources
MoRD	-	Ministry of Rural Development
MoUD	-	Ministry of Urban Development
MoEF	-	Ministry of Environment & Forests
MoA	-	Ministry of Agriculture
MoP	-	Ministry of Power
CWC	-	Central Water Commission
NWDA	-	National Water Development Agency
CGWB	-	Central Ground Water Board

Source: ICIMOD (2005), Development of an Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush-Himalayan Region :*Review of River Water Quality Policies, Pressures and Impacts, and Socio-Economic Relevance.* Kathmandu: ICIMOD

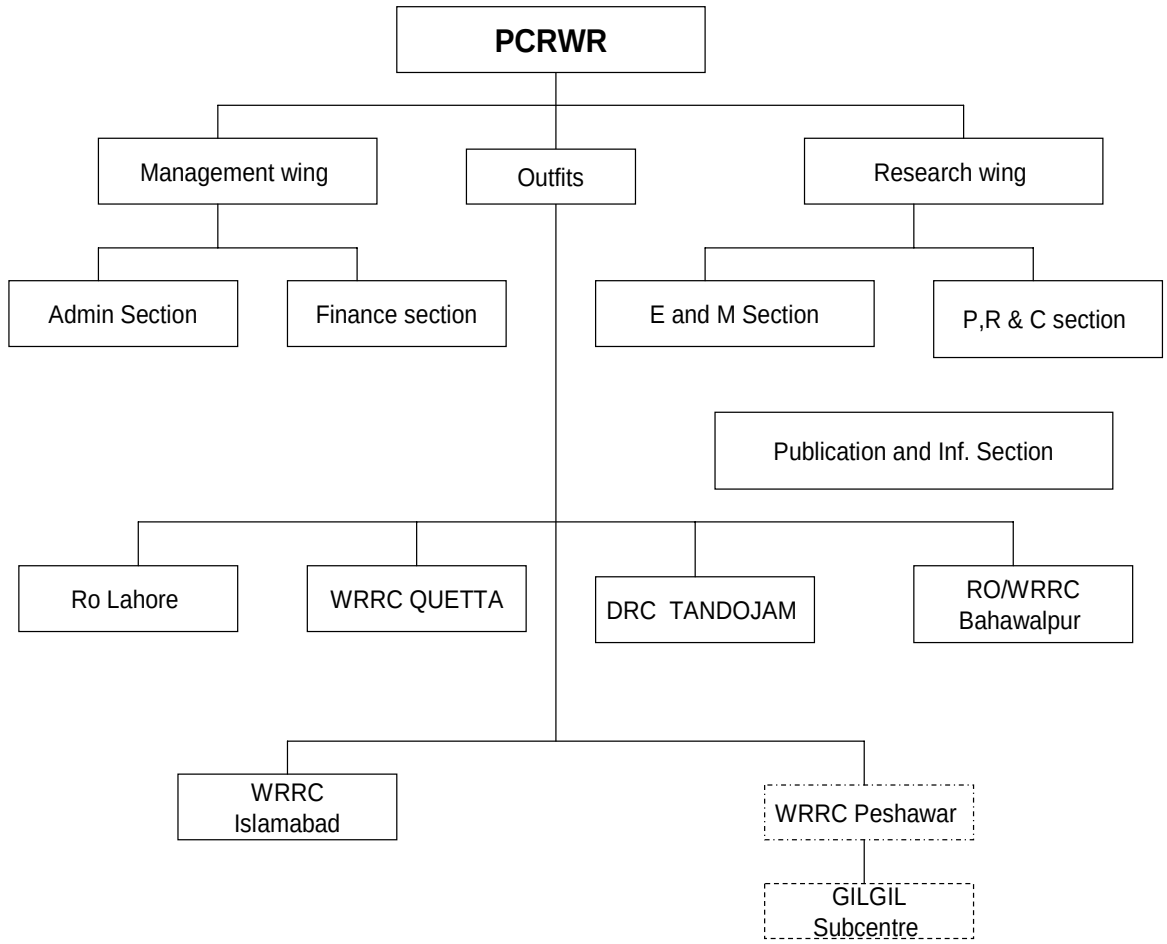
Appendix 4: Proposed Organizational Chart of Water Energy Commission (WEC), Nepal



Source: WECS (2005), National Water Plan Nepal, Kathmandu, Water Energy Commission Secretariat, ppH-1 (Annex 8).

WEC =Water Energy Commission, ED = Executive Director, WRWS = Water resource and Watershed, EE = Energy and Environment, LI =Legal and Institutional, MPP =Multipurpose Project, R&BWS= Regional and Bilateral Water Resources, RBM = River Basin Management, WRU = Water Resources Uses, WSS = Water Supply and Sanitation, TE/AE/CE = Traditional Energy/Alternate Energy/ Commercial Energy, EC = Environment and Conservation, RS = Resettlement, PPP = Policies for broader Participation including Private Sector, DLG = Decentralization Local Governance, IP =International Practices, S Economic = Socio-economic,

Appendix 5: Strategic Plan of the Pakistan Council of Research in Water Resources (PCRWR). Pakistan



Source: PWPD (1992), Strategic Plan of the Pakistan Council of Research in Water Resources. Ishlamabad: pp136, Pakistan Water Policy Document.

PCRWR = Pakistan Council of Research in Water Resources, WRRC = Water Resources and Research Centre, E& M = Evaluation and Monitoring, P, R&C = Planning, Research and Coordination, DRC = Drainage Research Centre.