Project no. **INCO-CT-2005-003659**

Project acronym: **ASSESS-HKH**

Project title: **Development of an Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush-Himalayan Region**

Instrument: **Specific targeted research or innovation project**

Thematic Priority: **Specific measures in support of international co-operation; A.2.1 Managing humid and semi-humid ecosystems**

Deliverable No. 15
River quality maps for five representative river sections in the Hindu Kush-Himalayan Region

Due date of deliverable: **Month 31**
Actual submission date: **Month 31**

Start date of project: **April 15th 2005** Duration: **36 months**

Organisation name of lead contractor for this deliverable:
International Centre for Integrated Mountain Development, Lalitpur, Nepal

Revision [Final]

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)		
Dissemination Level		
PU	Public	✓
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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This research work is funded by the European Commission under the 6th Framework Programme contributing to priority "Specific measures in support of international co-operation (INCO); A.2.1. Managing humid and semi-humid ecosystems".

Contract number: INCO-CT-2005-003659
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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
HKH	Hindu Kush-Himalaya
ICIMOD	International Centre for Integrated Mountain Development
masl	meters above sea level
NEPBIOS	Nepalese Biotic Score
PCRWR	Pakistan Council of Research in Water resources
WFD	Water Framework Directive
RQC	River Quality Class

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1 INTRODUCTION

The project "Development of an Assessment System to Evaluate the Ecological Status of Rivers in the Hindu Kush-Himalayan Region (ASSESS-HKH)" aims to develop tools for river assessment and river basin management for the HKH region jointly by Asian and European partners. The project activities are divided into eight work packages. The objective of the Work Package 7: "Sustainable Management Strategies" is to prepare River Quality maps for five representative river sections within the Hindu Kush–Himalayan (HKH) region, review the existing management strategies in the selected river stretches and provide recommendations for sustainable management strategies.

River Quality maps serve as an easily readable tool to identify hot spots and to show where immediate action is required. The River Quality maps could be a tool to attract attention of the decision makers and enable timely measures to be taken for improving the deteriorating River Quality of the rivers. As part of the project River Quality maps of selected representative stretches of rivers of the HKH region have been prepared. A "Screening Methodology" has been developed for the HKH region (WP 5) based on the experiences gained from the extensive field work conducted in the region as well as adapted from the methods of Austrian rivers (Moog et al. 1999). The preparation of the River Quality maps has been done by the individual country partners of the HKH region. These River Quality maps can serve as a valuable visual aid in dissemination activities and form a basis to develop River Quality maps for other regions after the completion of the project.

This report summarizes the results of the application of the "Screening Methodology" for preparing the River Quality maps which was conducted by the partners during the lean flow season from March – May 2007. It also describes the methodology for conducting the sampling for preparing the River Quality maps. The methodology was demonstrated to the partners and applied by partners during a workshop held in Kathmandu in March 2007. The report provides a brief background of the selected representative sites for each country and the River Quality maps.

2 METHODOLOGY FOR RIVER QUALITY MAPPING

A field based capacity building workshop on "Rapid Field Bio-assessment Method" for River Quality Mapping was held jointly by Prof. Dr. Otto Moog (BOKU/Vienna, project coordinator of ASSESS-HKH) and Kathmandu University in Kathmandu from March 4-7 2007. Ten participants from the partner countries of ASSESS-HKH namely, Bhutan, India, Nepal and Pakistan attended the workshop. The objective of the field based workshop was to advice the participants on the application of the Rapid Field Bio-assessment method, re-named as Screening Method as per agreement at the

workshop. Participants applied the method on different river stretches around Kathmandu to be prepared for sampling for the River Quality maps of the selected rivers in their respective countries. The workshop provided a good understanding of the work to be conducted and clarity in terms of methodology and the forms to be used during the sampling process.

The Screening Method provides an overview on the river quality status of the investigation site. This methodology is based on the Austrian state method for screening the ecological quality of rivers and stream developed by Moog et al. (1999) which was adapted for ASSESS-HKH by Moog & Sharma (2005). Basically the assessment procedure is based on sensoric criteria and the biota that can be identified in the field with a special focus on the bio-indicative value of benthic invertebrates. It is also recommended to confirm the field identifications in the lab. More details on the Screening Method are described below.

2.1 Scope

Within the frame of ASSESS-HKH, the Screening Method has been selected to provide data for drawing river quality maps within a reasonable time span. However, the sampling design and methodology described below also allow the calculation of a biotic score. On the other hand, the methodology is not sufficient for applying any multimetric approach.

2.2 Selecting the river stretch

The river section under study needs to be representative for 1) the scope of the study and 2) for river type. Within the HKH research work, the selection of sampling sites was based on the distribution of existing MHS sites from the previous sampling campaigns and on the pollution sources relevant for the area under study. A one hundred meter stretch that is typical for the river has been selected for the study. In case of a new river to be investigated for a researcher, it has been recommended to check the river section of about 500m for selecting representative investigation site.

2.3 Filling the site protocol, starting the Screening Protocol

Sampling was recommended to start from the most downstream point of the investigated section to avoid a self made turbidity which would hamper the sampling. During sampling it was noted that nobody entered the river before sampling or above the sampling team.

2.4 Taking the sample

The sampling followed the multi-habitat approach, in which the distribution of sampling units followed the distribution of habitats. The distribution of habitats in the stretch was estimated, noted it in the Screening Protocol, and used it as a basis for the selection of sampling units. At least ten sampling units would be sufficient for the purpose of river quality mapping (as opposed to 20 units required for Multi-Habitat Sampling). As sampling gear, a standardized hand net with an opening of 25 x 25 cm and a mesh size of 500µm has been used. However, according to the quality of rivers, the number of sample units varied, taking more sample units in case of not missing some targeted organisms or less sample units in case of heavy deteriorated rivers with poor fauna.

2.5 Processing the sample in the field, completing the Screening Protocol

Each sample unit has been regularly emptied into a white tray before taking sample unit from the next habitat. The sample animals gathered from each site were carefully picked out, put a variety of them into a Petri dish (which would help for writing the taxa list and abundance estimates), and poured the rest of the sample units into a bucket. While picking out, only the representatives of all specimens were treated. This was followed for every sample site. A taxa list with relative abundance was obtained for each taxon (estimated on a 1 to 5 scale and filled into back side of the Screening Protocol in the column “Abd”). It was also noted in the protocol if taxa were only abundant in pool section and not in the whole river stretch (e.g. red Chironomids or Tubificidae that occurred in clean rivers only in the pool sections). Allocation of abundance classes with respect to the occurrence of a habitat in the investigated river section was specifically considered when filling the cell “Dominance of benthic organisms” on the first page of the Screening Protocol.

2.6 Packing the remaining sample

Leaves and twigs were thoroughly washed into the bucket and poured through 500µm net size. Once the sample units from all microhabitats were taken, the sediments in the bucket was stirred, and the organic part was poured through a net to reduce the amount of the sampled material. The sample was preserved in formaldehyde in a container that was leak-proof and air proof in the field. This container was labeled with the name of the sampling site, date, etc.

2.7 Further processing of the sample in the lab

After at least one week of fixation, samples taken to the lab were sorted, identified, and additional taxa (each with notification of the respective abundance class) were included in the taxalist prepared in the field. Usually about 20-60% of taxa still remain unidentified when identified in field based on individual skill in identification.

2.8 Application of NEPBIOS

NEPBIOS has also been used in context with River Quality mapping. Some countries have used the NEPBIOS to determine the River Quality class for verification of field results.

2.9 Colour coding of River Quality maps

Based on the field results using the Screening Protocol River Quality maps were prepared using colour banding. For the harmonization of the River Quality classes in the Asian partner countries, the EU Water Framework Directive approach (WFD) with five colour banding of the different River Quality classes was applied:

- Blue for River Quality Class I
- Green for River Quality Class II
- Yellow River Quality Class III
- Orange River Quality Class IV
- Red for River Quality Class V

3 RIVER QUALITY MAPPING

The following river stretches and their locations of the HKH countries have been selected for River Quality mapping.

- Bangladesh Dhaka city area
- Bhutan Area around Thimphu, Paro and Haa
- India Upper Gangetic plain around Dehradun and Nainital
- Nepal Seti Basin and Bagmati River Basin
- Pakistan Area around Islamabad and Rawalpindi

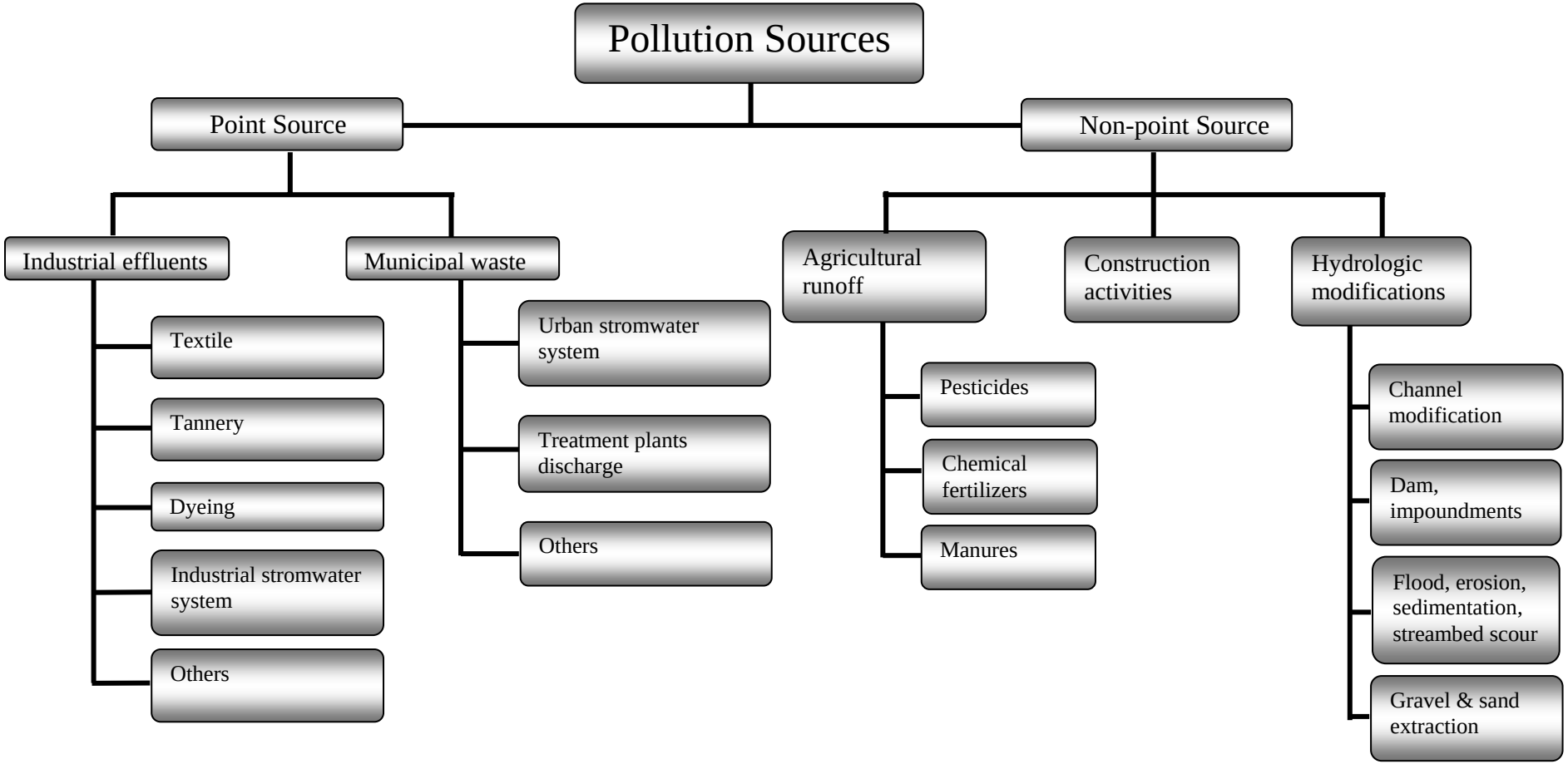
The sampling site selection in each of the country was based on the types of pollution as provided in Figure 1.

(a) Point sources such as industrial effluent, municipal waste, (typically piped discharges) etc.

(b) Non-point sources, such as agricultural run-off, sand and gravel mining, construction and hydro-modification, forestry, timber harvesting, etc

(c) Stressor types – Organic pollution

Figure 1: Types of Pollution Sources



Source: Sharma & Moog (2005); http://dem.ehnr.state.nc.us/basinwide/documents/Chapter6_013.pdf; Bari & Badruzzaman (2007).

3.1 Bangladesh

The rivers around Dhaka city, Bangladesh are found to be polluted by industrial activities, municipal sewage disposal, faecal contamination, agro-chemicals and sediment loading and population pressure (compare Figure 1). Maintaining a sufficient supply of clean water for the growing population is one of the major challenges in the densely populated Dhaka city.

3.1.1 The Sampling Sites

The selected rivers around Dhaka city included

1. Turag
2. Balu
3. Buriganga
4. Shitalakkhya
5. Part of Dhaleshwari
6. Bongshi

The field work was undertaken from April 1 – 8, 2007 during the dry season. Based on reconnaissance survey and discussion with the local people, 20 sites along those 5 rivers were selected for sampling and analysis. These sites covered the following parts of Dhaka city: (a) the part of the Bongshi river and the Turag river from Tongi bridge to its confluence with the Buriganga on the western side, (b) part of the Dhaleshwari river and the Buriganga on the southern side, (c) Tongi khal and part of the Balu river on the northern side, and (d) the Balu river and part of the Shitalakkhya river on the eastern side.

3.1.2 River Quality Classes

Most of the rivers in the selected area were found to have River Quality class III, IV and V. Four sites have River Quality class V, seven have River Quality class IV and the rest Class III. This indicates high pollution in the rivers. Table 1 provides the River Quality classes at each sampling site.

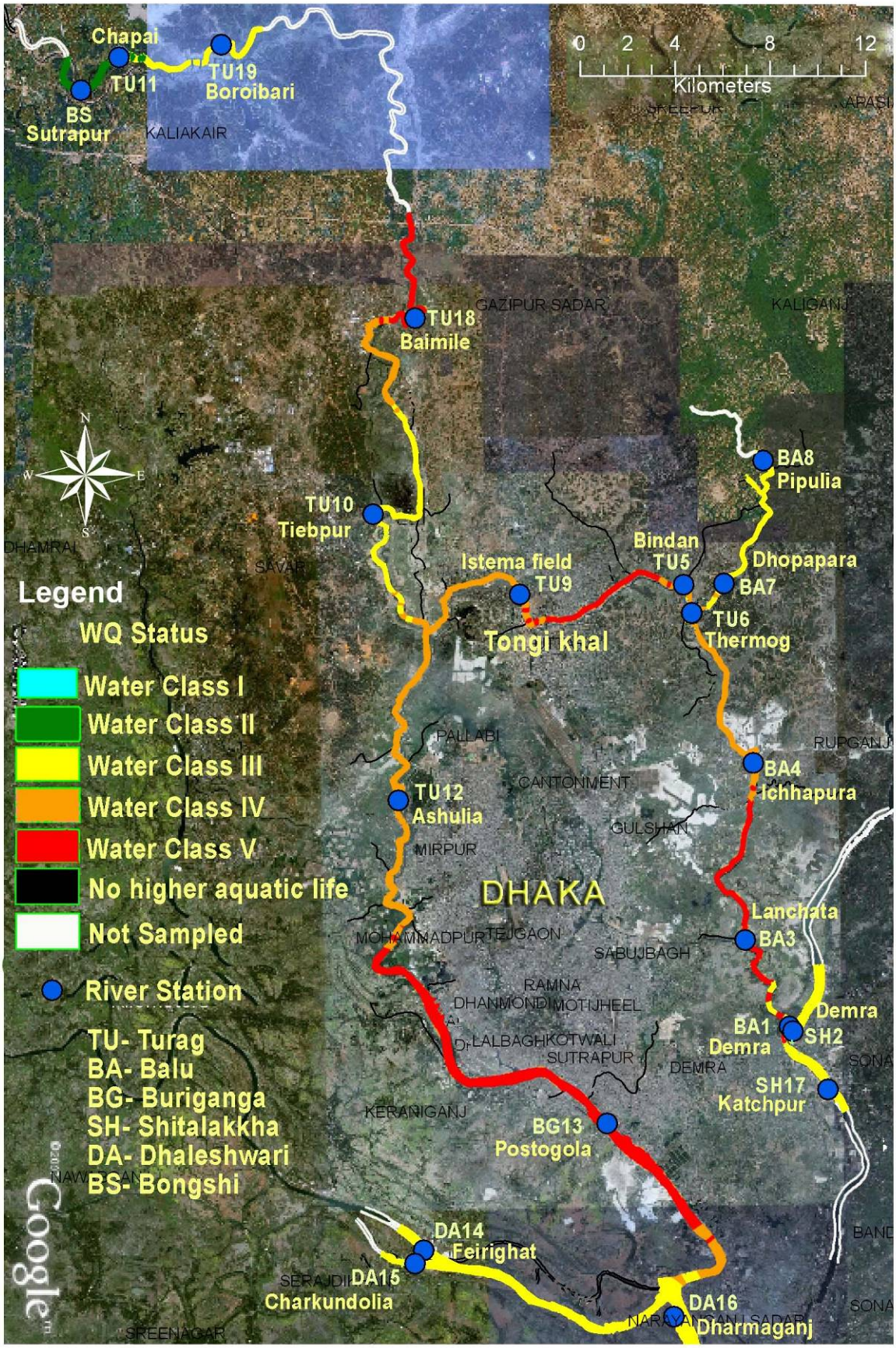
Table 1: List of sampling sites and River Quality classes in the area around Dhaka

River	Site	River Quality Class
Balu	Demra	IV
Shitalakkhya	Demra	III
Balu	Lanchata	V
Balu	Ichhapura	IV
Turag	Bindan	V
Turag	Thermog	IV
Balu	Dhopapara	III
Balu	Pipulia	III
Turag	Istema field	IV
Turag	Tiebpur	III
Turag	Chapai	II
Turag	Ashulia	IV
Buriganga	Postogola	V
Dhaleshwari	Ferighat	III
Dhaleshwari	Charkundolia	III
Dhaleshwari	Dharmaganj	IV
Shitalakkhya	Katchpur	IV
Turag	Baimile	V
Turag	Boroibari	III
Bongshi	Sutrapur	III

3.1.3 River Quality Map

The rivers around the Dhaka city were selected to prepare River Quality maps. The main rivers as well as the tributaries in the upper part are found to be of River Quality class III which eventually is deteriorated to class V as it passes through densely populated areas where sewage and industrial effluents are directly discharged into the rivers (see Figure 2).

Figure 2: River Quality Map around Dhaka City



3.2 Bhutan

Major rivers of Bhutan are snow-fed that flow from north to south and discharge into the Brahmaputra river. The rivers generally have steep gradients and narrow steep-sided valleys occasionally opening up to give small areas of flat land for cultivation. The rivers' discharge is high and carry larger amount of sediments during the monsoon season and significant snowmelt at the end of the dry season. Short rain-fed tributaries descend steeply from east or west to join these major rivers.

The climate is dominated by monsoon that causes rain from June-September. Mean annual rainfall varies between 500 mm to 5,000 mm. The mean annual flow for entire country is 2,325 m^3/s. The per capita mean annual flow availability is 109,000 m^3. There is uneven distribution of water over time and space. There are localized and seasonal water shortages for drinking and irrigation. About 78% of the population have access to safe drinking water.

3.2.1 The Sampling sites

Rivers in three catchments with a total of 21 sites have been investigated in the districts of Thimphu, Paro, and Haa. In the Thimphu District, 12 sites along the Thimphu Chhu and its tributaries have been investigated. In the Paro District, seven sites have been investigated with stressing factors of river dam and organic pollution. In the Haa District, two sites with organic pollution as the main stressing factor and two reference sites were investigated. The factors for site selection included the stressors like organic loading, waste dumping, abstraction of water, etc.

3.2.2 River Quality Classes

Most of the rivers of Bhutan are found to be in pristine condition. The main stem of the rivers in the headwater areas are of class I. As the sampling sites were selected to also include organic loading, abstraction of water and waste dumping, some of the sites selected were found to have River Quality class III and IV. In the heart of the Thimphu city where there is high population pressure as well as direct discharge of sewage and waste dumping into the tributaries the River Quality class was found to be V which is still quite rare for Bhutanese rivers. The list of sampling sites and their identified River Quality classes are given in Table 2.

Table 2: List of sampling sites and River Quality classes in Bhutan

River Name	District (Dzongkhag)	RQC
Balakha Chhu	Paro	I
Paro Chhu upstream	Paro	II
Paro Chhu downstream	Paro	II

River Name	District (Dzongkhag)	RQC
Isuna Chhu	Paro	II
Gapjana Chhu	Paro	III
Dopshari Chhu	Paro	II
Paro D/stream	Paro	III
Chanana Chhu	Haa	I
Lukha Chhu	Haa	IV
Haa Chhu upstream	Haa	I
Haa Chhu downstream	Haa	III
Cheri Chhu	Thimphu	I
Drey Chhu upstream	Thimphu	II
Drey Chhu downstream	Thimphu	III
Taba Chhu	Thimphu	II
Thimphu Chhu upstream	Thimphu	III
Thimphu Chhu downstream	Thimphu	III
Chuba Chhu	Thimphu	III
Thimphu centre Channels	Thimphu	V
Changgangkha Channel	Thimphu	V
Swimming Pool Complex Channels	Thimphu	IV
Ola Rong Chhu	Thimphu	II
Tributary to Wang Chhu	Thimphu	III

3.2.3 River Quality Maps

For each of the three districts under investigation, separate River Quality maps were drawn (Figure 3 to 5).

Figure 3: River Quality map of Thimphu District

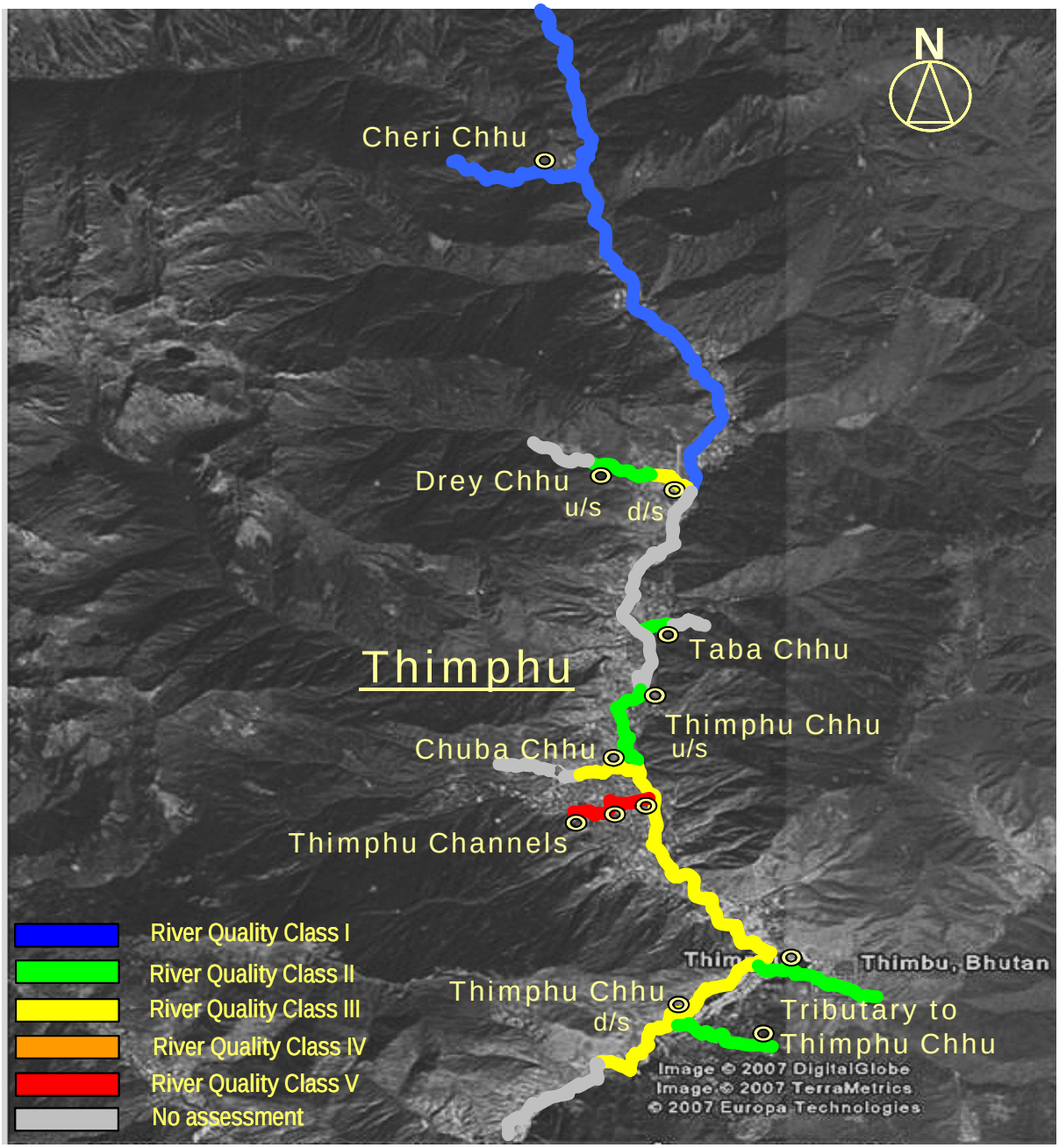


Figure 4: River Quality map of Paro District

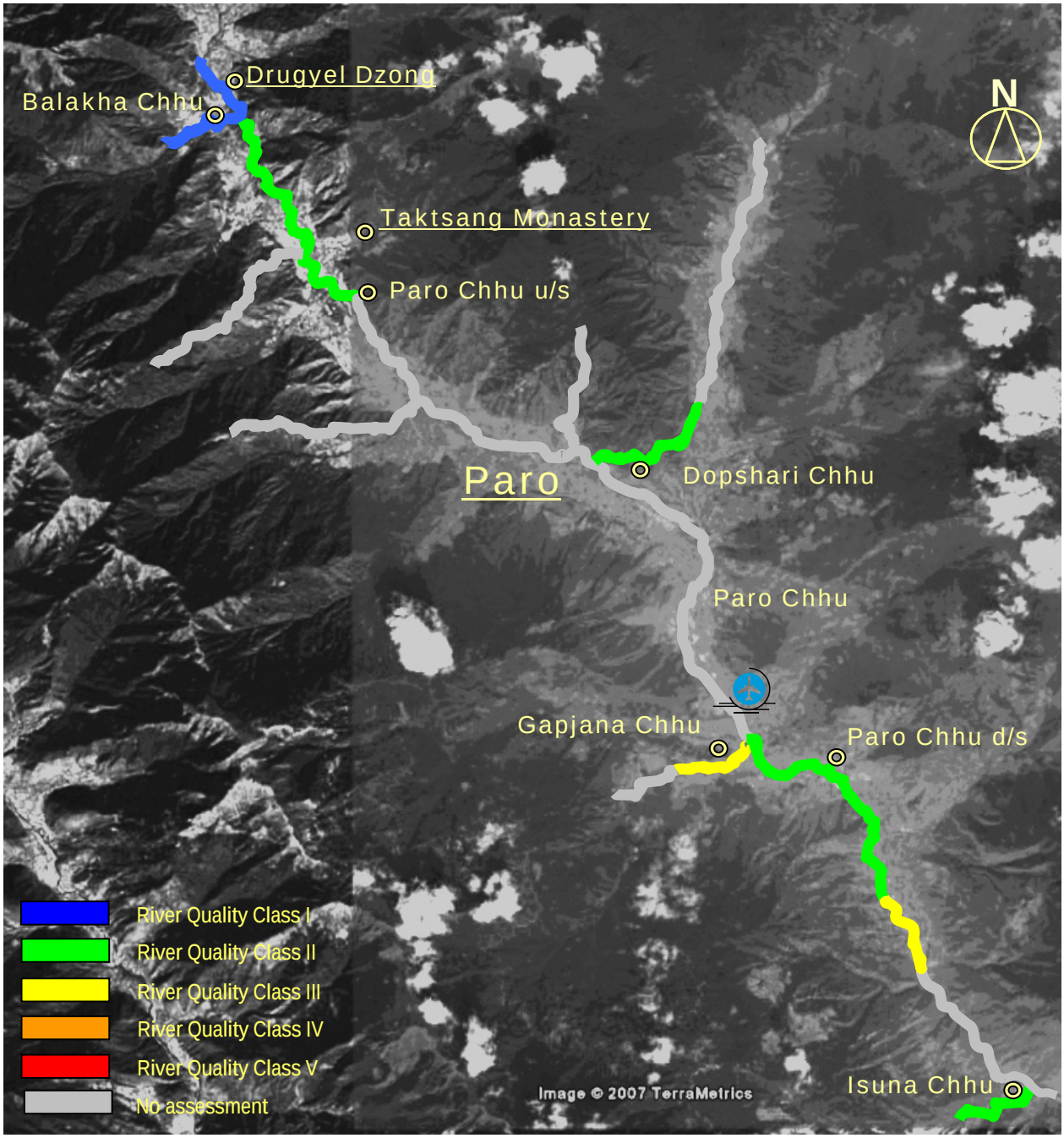
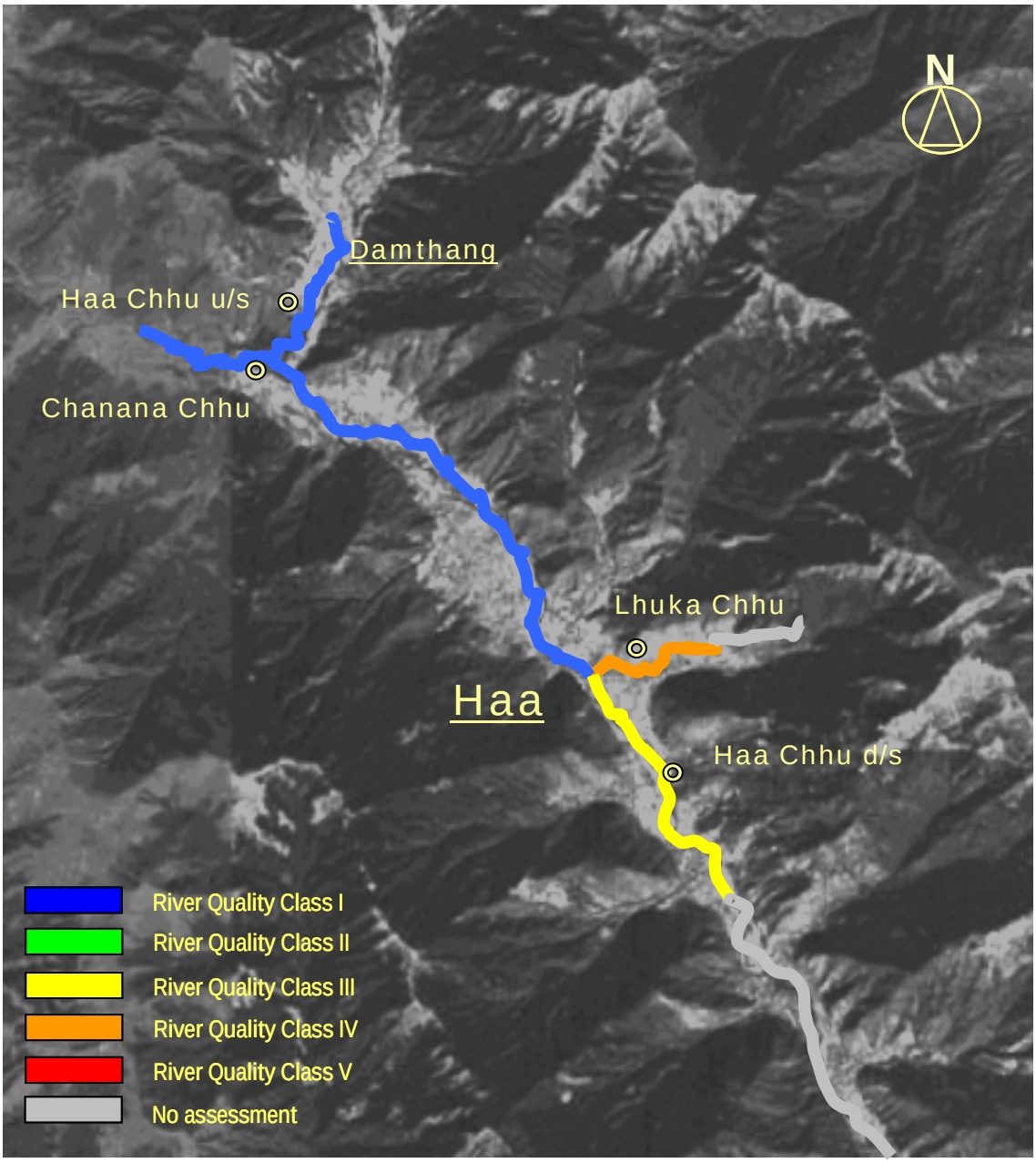


Figure 5: River Quality map of Haa District



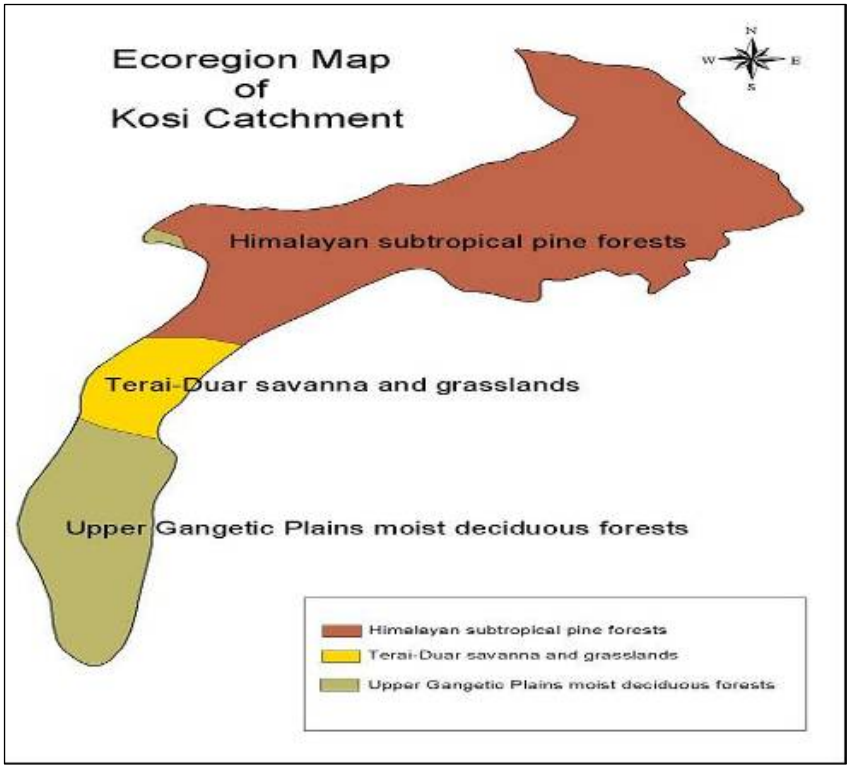
3.3 India

The Kosi River was selected for River Quality mapping in India. This river is a major tributary of the Ganga river and the third largest river in the Himalayas. The river flows through the following eco regions:

- Himalayan subtropical pine forest eco region - IM0301 (core ecoregion)
- Tarai Dwar Savanna eco region - IM0 701
- Upper Gangetic plains eco regions - IM0 166

The Tarai Dwar Savanna eco region (IM0 701) falls between IM0 301 and IM0 166 as shown in Figure 6.

Figure 6: Ecoregions of the Kosi river



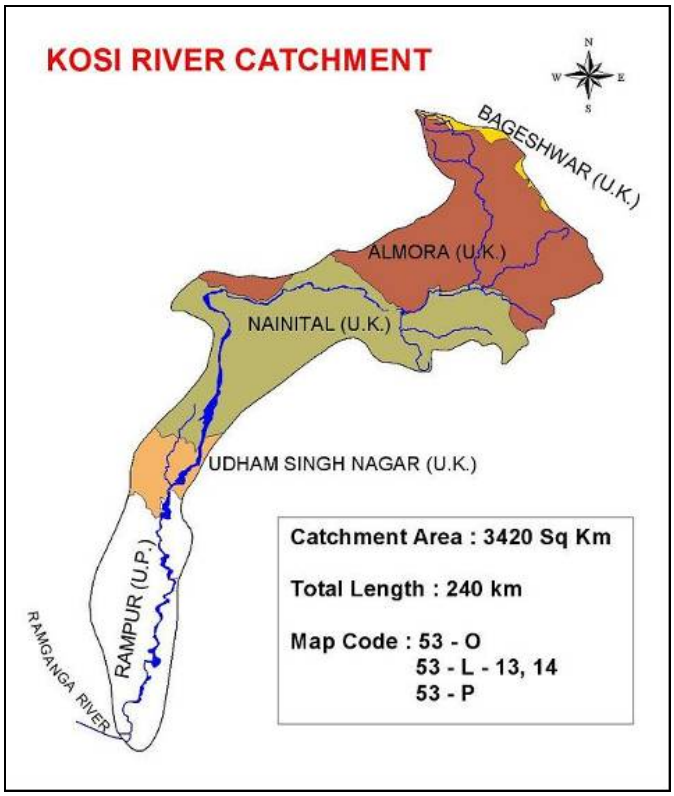
3.3.1 The Sampling sites

The sampling of the whole ecoregion including IM0 701 was carried out to link the River Quality of the two eco regions. The field work was conducted from March 30 to April 8, 2007. A total of 26 samples were collected starting from the origin of the Kosi River at Rudradhari (Kosani) to just before the confluence with the Ramganga River near Patwai (Rampur) village.

The total catchment area of the Kosi river is 3,420 km². Its total length is 240 km which originates from spring source at Rudradhari (District Almora, Uttarakhand (U.K)) and joins the Ramganga river near village Chamraul (Tehsil-Shahabad, Rampur district,

U.P.). It is an important river flowing at 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. Further, it enters the plain of the western Uttar Pradesh (U.P.).
Figure 7 shows the catchment of the Kosi River.

Figure 7: Catchment of the Kosi River



The important tributaries of the Kosi River and its quality and stressing factors are given in Table 3. The common river stressing factors are deforestation, mineral quarry and organic waste.

Table 3: River stressor factors and River Quality

Stream Name	Stressors
Sai	Deforestation, mineral removal, waste dumping and organic pollution from villages
Bitchula	Deforestation, mineral removal and minor organic pollution
Shrota	Deforestation, mineral removal and minor organic pollution
Swal	Deforestation, mineral removal and organic pollution
Uttarvahini (Ramgad)	Deforestation, mineral removal and organic pollution
Pathri	Deforestation, mineral removal and organic pollution
Bahalla	Deforestation, mineral removal, organic pollution, and industrial effluents

The Kosi River is being used for various purposes such as drinking water, washing and bathing, fishing, wastes dumping (solid waste, domestic wastewater, and industrial wastewater), cremation, irrigation and power generation purposes, industrial uses as raw water and for cooling water.

3.3.2 River Quality Classes

Out of 26 sample sites, 14 sites representing more than 50 percent lie in River Quality class I, while both RQC IV and V is only present in one sampling site each. The list of sample sites and their description by River Quality classes is given in Table 4.

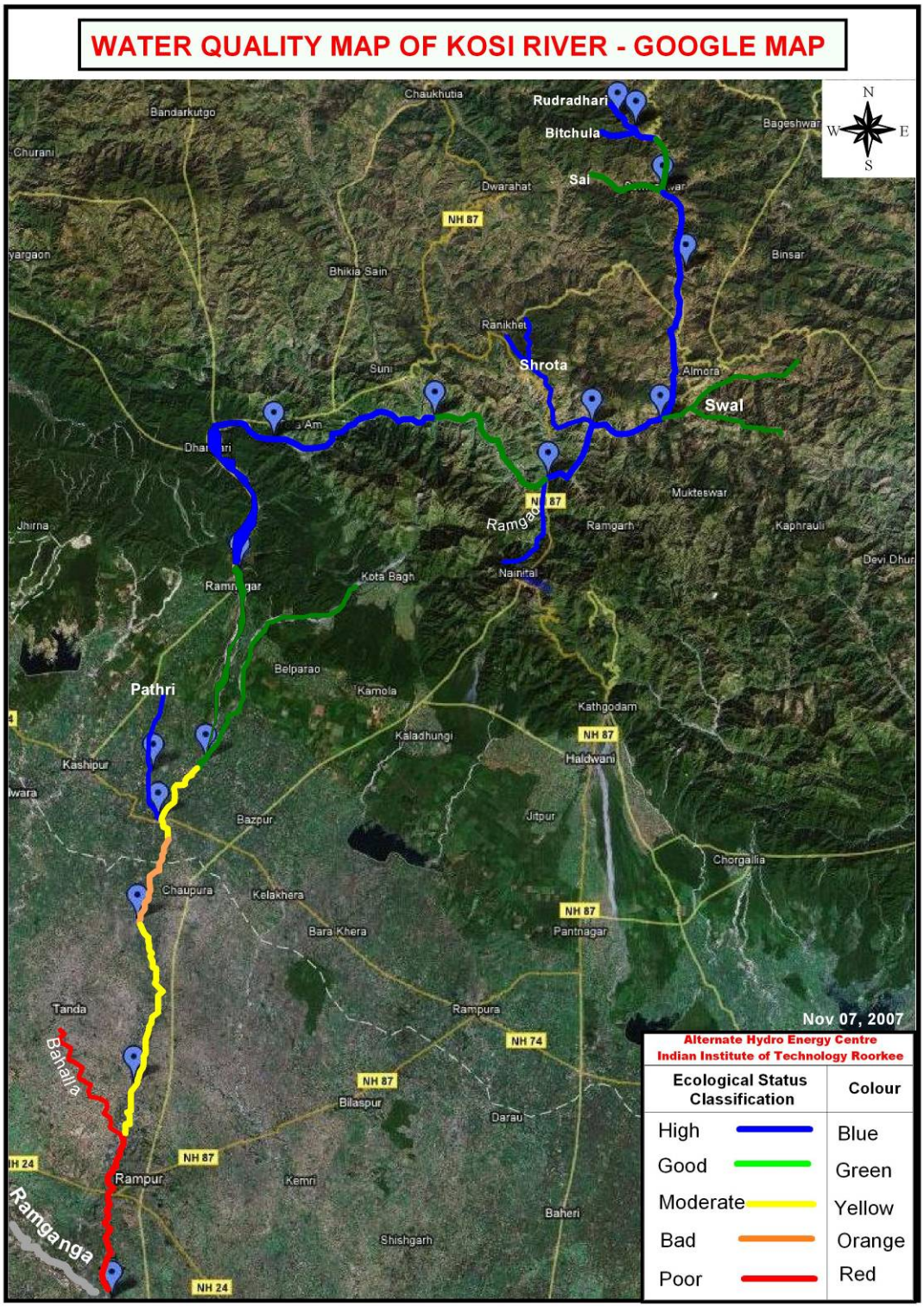
Table 4: List of sampling sites and River Quality classes (RQC)

River	Site	RQC
Kosi	Ramnagar upstream Barrage	II
Kosi	Totaciling downstream Kosani	II
Kosi	source Rudradhari	I
Kosi	100m downstream source Rudradhari	I
Kosi	downstream confluence Bitchula	I
Bitchula (tributary)	upstream confluence to Kosi	I
Kosi	upstream confluence river Sai at Someshwar	I
Kosi	downstream Sai river at Someshwar	I
Sai	upstream confluence Kosi at Someshwar	II
Kosi	Kosi river at Dadymkhola 200m downstream weir	I
Swal	upstream confluence Kosi near Khwarab bridge	II
Kosi	upstream confluence Swal river near Khwarab bridge	I
Kosi	upstream confluence Shrota river (near Kakadighat)	I
Shrota	upstream confluence Kosi river near Kakadighat	I
Ramgad (Uttarwalini)	upstream conf. Kosi river	I
Kosi	upstream confluence river near Kherna	II
Kosi	Betalghat 1 km upstream Bridge	I
Kosi	35 km upstream Ramnagar (downstream Betalghat)	I
Pathri	(near Shive Temple downstream bridge)	I
Kosi	downstream Ramnagar (near Ratanpura village)	III
Kosi	upstream confluence River Pathri near Kashipur	III
Pathri	upstream confluence river Kosi near	III
Kosi	downstream confluence river	IV
Kosi	upstream Dariyal village downstream Kashipur	III
Kosi	500m downstream Lalpur dam upstream Rampur city	III
Kosi	downstream Rampur upstream confluence Ramganga	V

3.3.3 River Quality Map

As the Kosi river passes through urban area due to direct sewage discharge and waste dumping the River Quality class deteriorates to class III and even IV for a short stretch. The River Quality map of the Kosi Basin is given in Figure 8.

Figure 8: River Quality Map of the Kosi River Basin



3.4 Nepal

In Nepal the Bagmati and the Seti rivers have been selected for preparing the River Quality maps. The Bagmati basin lies in Kathmandu valley while the Seti basin lies in the Pokhara valley. They are the most important valleys of the midland hills, stretching from east to west. 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, 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 in lacustrine deposits such as lignites, which are so characteristic in various terrace levels of Kathmandu valley.

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, 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 its all 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. 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 the capital 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.

3.4.1 The Sampling Sites

Prior to determination of sample sites along the river stretches, reconnaissance survey was carried out in both river basins. This was accompanied by colour topo-sheets at the scale of 1:25,000 to determine the sample sites. The criteria used for selecting the sites included: (a) point source and non-point source, (b) accessibility and settlements, and (c) already existing sampling sites. A total of 77 sample sites covering the whole river stretch from upstream to downstream for the Bagmati basin and 54 sample sites for the Seti Basin were selected considering the points of effluent discharge, land use, solid waste disposal, bank condition, substrate composition, and meeting of tributaries. The field survey was carried out in April and May, 2007 (pre-monsoon period). The water of all classes is found to be commonly used for irrigation; while River Quality classes I, II and III is found to be used for drinking purpose. The use of the water of various classes is presented in Table 5. Three major stressing factors in all classes but RQC I include agriculture, domestic wastes and industrial effluents.

Table 5: River Quality Classes (RQC) & Uses: Bagmati River Basin (BRB) and Seti River Basins (SRB)

RQC	Sample Sites		Water uses	Effluents
	BRB	SRB		
I	12	5	Reservoir, drinking, washing, irrigation	None
II	18	23	Drinking, washing, irrigation	Agriculture, domestic & industry effluents
III	16	15	Drinking, washing, irrigation	Agriculture, domestic & industry effluents
IV	13	7	Agriculture, domestic & industry effluents,	Agriculture, domestic & industry effluents
V	18	4	Washing and irrigation	Agriculture, domestic & industry effluents

3.4.2 River Quality Classes

River Quality classes I to V was obtained in both the Bagmati and Seti Basins. In the Bagmati the stretches of class I reference sites were very short compared to Seti where the river was found to be in a more pristine condition. The distribution of sample sites along the two river stretches by quality class is shown in Table 6. The distribution

pattern between the two river basins is more or less the same, with larger number of sites in RQC II and RQC III.

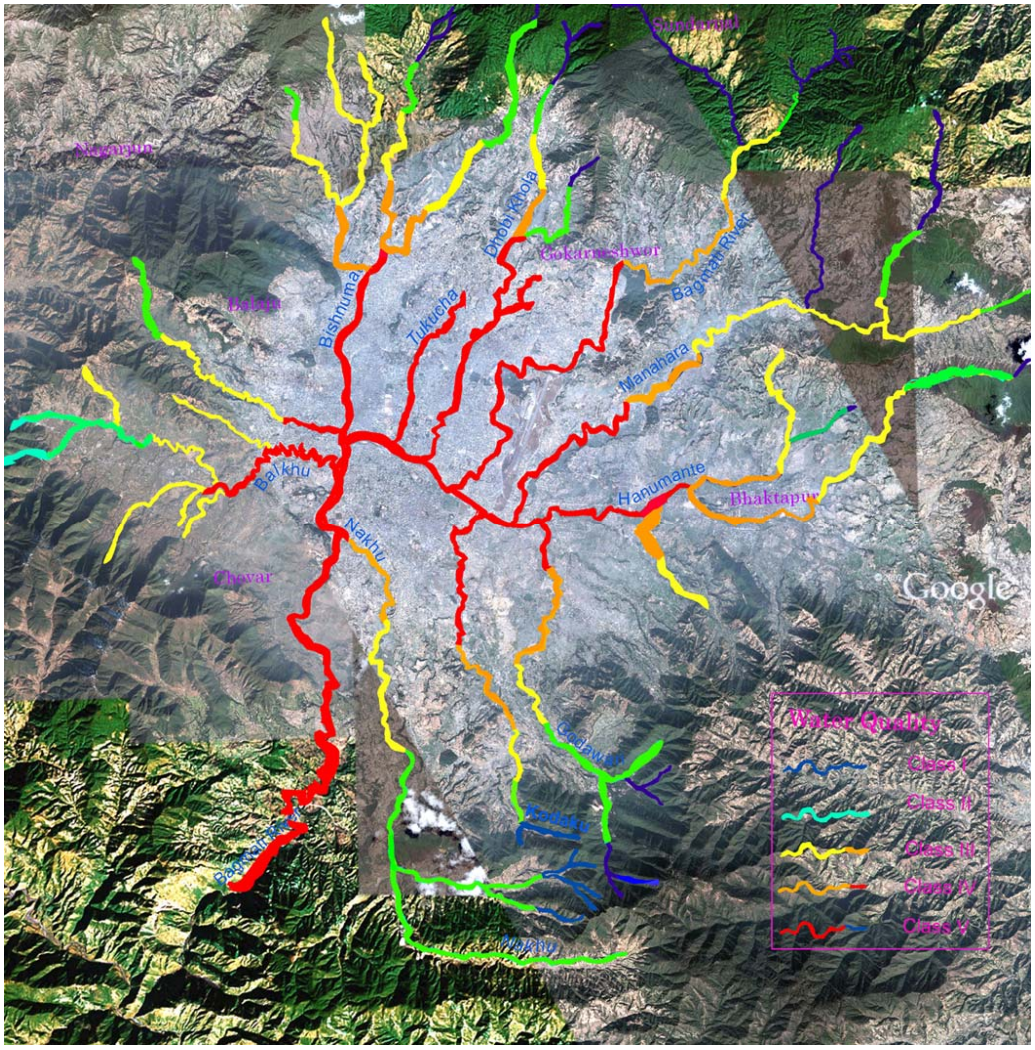
Table 6: Distribution of sampling sites by River Quality classes

RQC	Bagmati Basin	Seti Basin
I	12	5
II	18	23
III	16	15
IV	13	7
V	18	4
Total	77	54

3.4.3 River Quality Maps

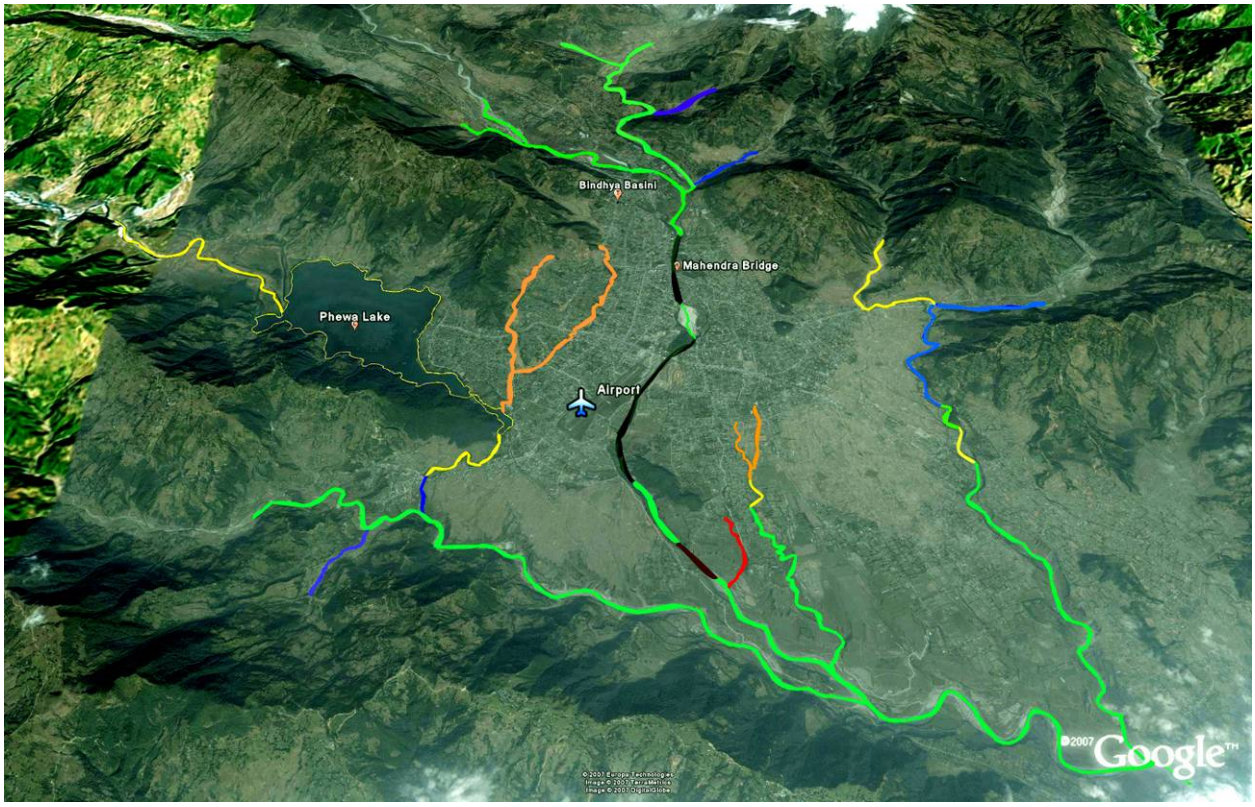
Figure 9 shows the River Quality classes of the Bagmati basin. While the rivers pass through the city area, the quality has become poorer with RQCs III, IV and V. After leaving the city area, the quality of the river still persists to be class V till further downstream after it discharges through the gorge.

Figure 9: River Quality Classes of the Bagmati River Basin



The River Quality of the Seti River Basin is fairly good in quality in comparison to Bagmati. Figure 10 shows the River Quality map of the Seti basin.

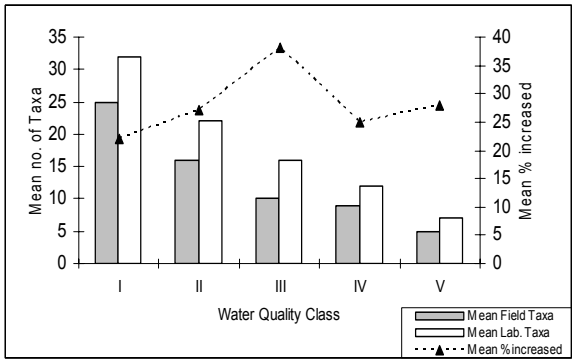
Figure 10: River Quality Classes of the Seti River Basin



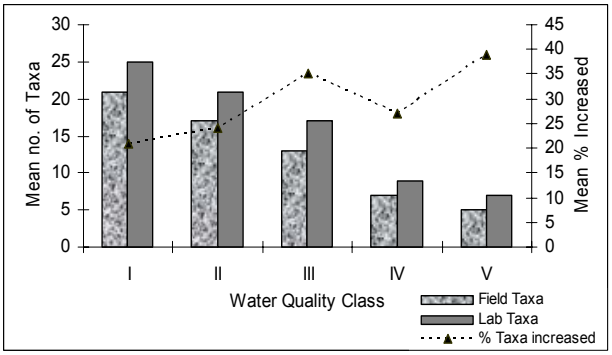
3.4.4 Comparison of taxa from field and lab identification

Figure 11 shows the comparison of the taxa identified in the field with those at the lab. It has been found that the number of taxa per site has increased by 35 to 45% after lab identification.

Figure 11: Comparison of taxa identified in the field and the laboratory



11 a. Bagmati river basin



11 b. Seti river basin

3.5 Pakistan

In Pakistan, the Soan river flowing through Rawalpindi has been selected for the River Quality mapping. The Soan is the main river flowing through the diverse ecoregions. Its brief description is given in Table 7. Multi-habitat sample strategy has been considered to represent all habitats of the river stretch.

Table 7: General description of the Soan River, Rawalpindi

Components	Features
Altitude	Upland - 300-600 (masl)
Size	Medium: approximately 7,723 km^2
Geology	Mainly Limestone (Meso- and Micro-lithal) and sandy river bottom
Forest	Broad leaf forests
Eco-region	IMO 301: Western Himalayan Sub-alpine Conifer forests
Stream behaviour	Starts from an altitude of approx. 590 masl; extends from alpine to broad leaf forest; enters into urban area of Islamabad and Rawalpindi; drains out the urban waste/sewage

3.5.1 The Sampling sites

There were altogether 42 samples selected for the River Quality mapping covering the watershed of Rawalpindi and Islamabad. The samples represented all River Quality classes and the habitats of the river stretches. The sampling was conducted during the pre-monsoon season. The findings have been compared with WHO Drinking River Quality Guidelines as River Quality standards for surface water are not available in Pakistan. Table 8 shows the distribution of sample sites by River Quality classes.

Table 8: Distribution of Sampling Sites along the Soan River

River	No. of Samples	River Quality Class
Soan	5	I
Soan	14	II
Soan	9	III
Soan	4	IV
Soan	10	V
Total	42	

3.5.2 River Quality classes

Table 9 summarises the sample features with chemical quality and River Quality class (RQC). The percentages of samples exceeding parameters permissible limits were 9 for pH and 26 for BOD.

Table 9: Description of Sampling Sites along the Soan River

Location	pH	Conductivity µS/cm	BOD (mg/l)	O_2 saturation (%)	O_2 (ppm)	RQC
Soan Bridge	7.7	1371	99	54.3	4.35	V
Lahi Nalla	7.7	1413	84	25	1.65	V
Soan Camp	8.3	509	70	81	5.5	IV
Jandala	8.5	607	27	50	3.6	III
Shahdra	7.6	625	11	87	5.5	II
Kuri	7.7	753	117	50	3.5	III
Sambli	7.8	412	17	114	7.8	II
Gulehra Gali	7.9	411	7	119	8.7	II
Kassa	8.0	413	9	108	7.3	II
Salgran Nalla US	7.01	448	1	104	8.62	I
Hatchu Bagla US	7.09	440	2	109	9.45	I
Torimna US	7.06	410	5	100	9.10	II
Shahdara DS	7.19	440	6	92	7.20	II
Chakoor DS	6.60	427	4	85	6.98	II
Rawal Dam US	7.01	430	14	86	7.54	II
Barakau DS	6.68	446	6	86	8.23	II
Bari Imam US	7.46	415	7	85	6.9	II
Quaid-i-Azam University US	6.19	588	3	110	9.64	I
Yasmin Gardon DS	7.14	534	4	92	4.01	III
Rawal Dam DS	7.01	422	3	94	4.02	III
Kuri Nalla US	6.72	491	4	104	8.62	II
Mira Bagwal US	6.10	581	4	98	7.86	II
PAF US	7.38	502	5	72	6.76	II
Navy Nalla DS	6.04	747	300	11	0.99	V
Zera Point DS	7.42	661	250	7	0.54	V
H-9 Nalla DS	7.67	508	240	8	2.88	V
Adhi Home DS	7.70	371	210	7	0.54	V
G-10 Markz UP	7.53	462	200	4	0.26	IV
G-10 Markz DS	7.79	533	250	6	0.37	V
Golra Sharif US	8.12	575	5	73	3.28	III
Rupprain US	8.01	444	4	90	7.51	III
Jamie-a- Fridia US	7.03	960	7	52	2.75	III
Saidpour US	7.52	629	9	42	3.00	IV
Terlai DS	7.55	504	14	63	3.80	IV

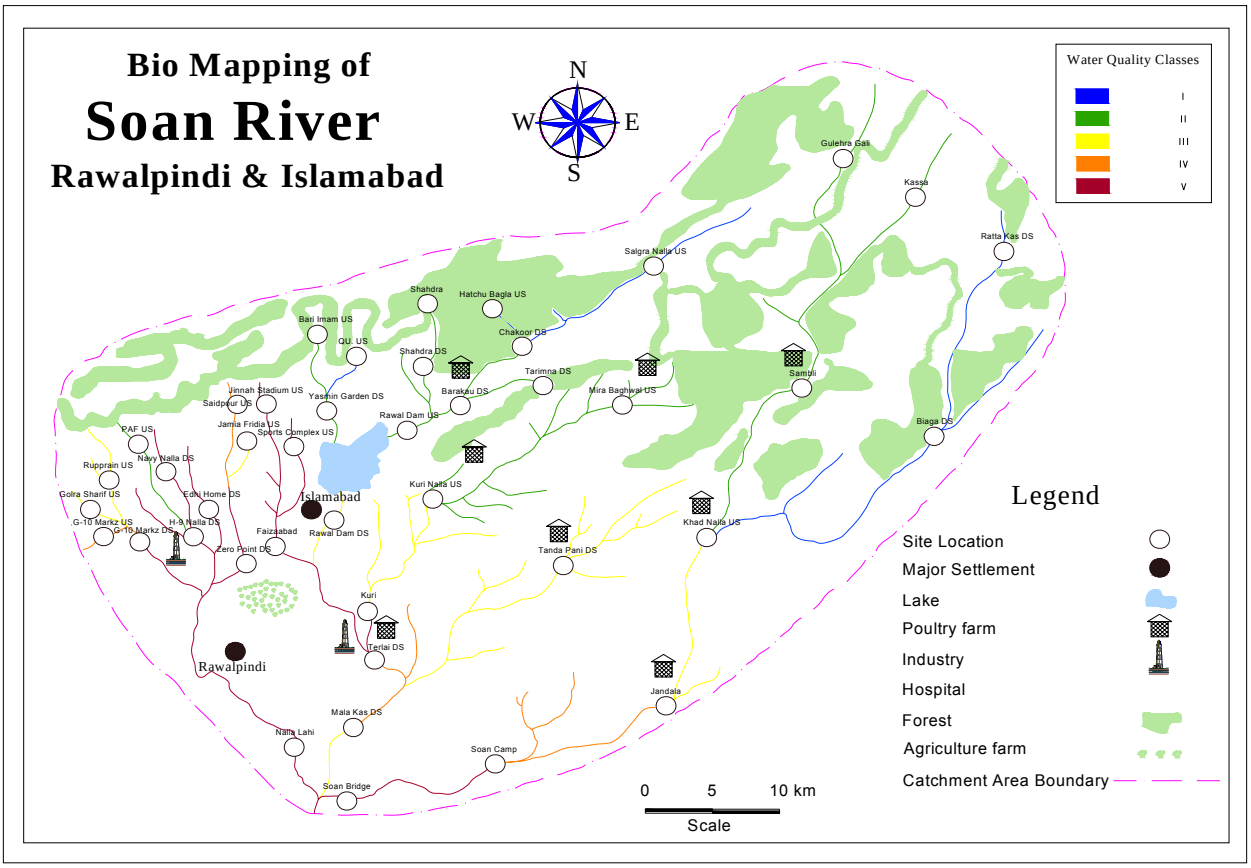
Location	pH	Conductivity µS/cm	BOD (mg/l)	O_2 saturation (%)	O_2 (ppm)	RQC
Malakas DS	8.03	431	10	82	3.32	III
Tanda Pani DS	8.20	562	8	101	8.23	III
Khad Nalla US	8.31	362	4	81	7.06	II
Ratta Kass US	8.10	455	2	102	11	I
Biaga US	8.25	354	2	96	8.03	I
Faizaabad DS	6.9	747	160	11	0.25	V
Sports Complex US	6.4	588	280	200	0.56	V
Jinnah Stadium US	6.1	400	130	210	0.89	V

Note: US = Upstream, DS = Downstream

3.5.3 River Quality Map

The River Quality map of the Soan river passing through Islamabad and Rawalpindi is given in Figure 12. In the urban areas the River Quality is found to have deteriorated to class IV and V where the river literally becomes a sewer outfall.

Figure 12: River Quality map of Soan River



4 CONCLUSIONS AND RECOMMENDATIONS

This study on the River Quality of selected areas included the major city regions of five HKH countries, such as Dhaka in *Bangladesh*, Thimpu and Paro in *Bhutan*, Rampur and Kashipur in *India*, Kathmandu and Pokhara in *Nepal,* and Islamabad and Rawalpindi in *Pakistan*.

The number of rivers studied and their sample sites for the river quality assessment varied among the partner countries: They were five rivers - the Turag, the Balu, the Buriganga, the Shitalakkhya, and the Dhaleshwari and 20 sample sites for Bangladesh, three main rivers – Thimphu Chhu, Paro Chhu and Haa Chhu and a total of 23 sampling sites for Bhutan, the Kosi river with some tributaries and 26 samples sites for India, two river basins - the Bagmati and the Seti and 115 sample sites for Nepal, and one river basin - the Soan with tributaries and 42 sample sites for Pakistan.

The water quality all along the stretches of the rivers flowing through the major cities regions of all five HKH countries exhibits more or less similar results. The pollution level is found to be higher in the rivers while they pass through the core parts of the cities and lie mostly in the river quality classes of III, IV and V. The river stressing factors for these different river stretches were as following:

Countries	River Stressing Factors
Bangladesh	industrial activities, municipal sewage disposal, faecal contamination, agro-chemicals and sediment loading
Bhutan	organic loading, waste dumping, and abstraction of water
India	deforestation, minerals quarrying, waste dumping, and organic wastes from the villages
Nepal	agriculture, domestic wastes and industrial effluents
Pakistan	urban waste and sewage

In all five countries, the rivers are commonly used for waste dumping, direct sewage and industrial effluent discharge. The water from the rivers has also been abstracted for drinking and irrigation, hydropower generation; washing and bathing, fishing, navigation, and cremation.

In the extent of methodology used, there is some variation among the HKH countries. For instance, in Nepal the taxa identified in the field were compared with those at the lab and the number of taxa per site was found to be increased by 35 to 45%. In Pakistan, the samples were analysed at permissible limit of chemical parameters such as pH and BOD, which were exceeded by 9 % and 26% respectively. The abundance

and diversity of animals along the stretches of the rivers were analysed at family and genus levels and some at species level.

To conclude, the river quality classification method through screening field protocol tool is found to be a useful tool for sustainable development of river resource including river assessment and river basin management for the HKH countries. The tool is also found effectively useful for recording features (both natural and anthropogenic activities) seen along the rivers.

The screening field protocol tool is also useful for monitoring of the quality of rivers in terms of temporal (seasonal) and spatial variations caused by natural phenomena and manmade interventions.

The river quality map indicated by different colours is found to be a very effective tool for visual interpretation and impression to all concerns from village layman to executive personnel.

For making wider use for similar type of study in other countries, the screening field protocol needs to be updated on the regular basis in terms of bio-indicators. In such way new families of macroinvertebrates can be incorporated in the protocol, based on the state of the art of scientific know how. Dissemination of all methodology used in this study needs to be imparted among the interested persons on regular basis through workshops, conferences and publications.

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