Environmental management of the Bagmati River Basin

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ABSTRACT

The Bagmati River is the principal river of the Bagmati Basin (ca. 3640km^2) in central Nepal. The river, fed by springs and monsoon rainfall, originates in the north of Kathmandu Valley (the capital of Nepal) and drains across the Mahabharat Range to the Gangetic plain. The Basin transacts three distinct latitudinal physiographic zones (Mountain, Siwalik and Terai) of the Nepal Himalayas. Hard rock geological formations at the Basin headwaters stand out as a resistant ridge complex compared to the weak and fragile rock formations at the middle stretches of the Basin.

The Bagmati Basin currently faces a number of serious environmental and ecological challenges. Urbanization and industrialization of the Basin headwaters at Kathmandu contributed to water quality deterioration with regional consequences on the aquatic ecosystem and on the health of the downstream sub-basin's user groups. Increasing population pressure on the fragile mountain slopes has also resulted in the rapid degradation of the natural resources. As a consequence, deforestation, soil erosion, landslides, siltation etc. are occurring in the upper and middle sections whereas sedimentation and flooding is frequent in the lower stretches of the watershed. This synergetic effect is of concern for the sustainable use of the resources and infrastructures.

The overall damage caused by the 1993 flood in the Basin has provided impetus to Nepalese planners, engineers, environmentalists, policy makers and stakeholders to think on the Basin-wide environmental perspectives for the overall sustainability of the project. This paper deals with the various facets of environmental management and monitoring of the watershed for its sustainable development.

INTRODUCTION

The Bagmati River originates just below the summit of Shivapuri Hill and is fed by springs and monsoon rainfall and a number of tributaries as it flows down from the Kathmandu valley floor and passes through the valley at Chovar. The river is fed by a number of tributaries originating at Mahabharat and in the Chure Range before it reaches the Terai at Karmaiya. The Bagmati River Basin, based on morphology, land-use etc., can be

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divided into different sub-basins *viz*. Upper Bagmati, Upper Middle Bagmati, Lower Middle (Terai) Bagmati and the Lower Bagmati (Terai) sub-basin. The total area of the Basin within Nepalese territory is about 3638km^2.

In the 1991 census, the total Basin population was given as 1.6 million of which 61.5 per cent inhabit the Upper Bagmati sub-basin, where the capital city of the Kingdom of Nepal, along with other four municipalities including a number of village development committees, are situated. It is also reported that a total of 2174 out of 4271 water polluting industries operating in the country are now in operation in the Upper Bagmati sub-basin.

Increasing degradation of the Bagmati Basin has been evident in recent years due to rapid population growth and expansion of the urban areas within the upper Bagmati sub-basin. Uncontrolled disposal of untreated wastewater (domestic, industrial, solid waste leachate, agricultural runoff etc.) in the rivers has far surpassed the assimilative capacity of the river. Likewise, deforestation, soil erosion and landslides have been causal factors of Basin degradation which is being increasingly threatened by damage to the infrastructure of reservoir, barrage, canals, bridges and roads from debris, tree and logs carried by the river during the monsoon season.

A comprehensive environmental study of the Bagmati River Basin was carried out by the Water and Energy Commission Secretariat using a team of experts to formulate concrete proposals for mitigation measures for:

- pollution abatement and improvement of the river water of the river thereby enhancing its assimilative capacity;
- decreasing suspended solids and siltation in river beds, canals and irrigated fields; and to
- minimizing threats to the stability of infrastructures.

The concept of Basin-wide planning for sustainable development is still new to Nepal. A development programme based on, and implemented by, administrative units could not handle and foresee the environmental impacts in the surrounding vicinity. A basin is a land unit defined by the natural barriers and the natural resources within such boundaries have intricate relationships. Exploitation of one resource has a direct impact on the other. The study was intended to evaluate the environmental conditions of the existing Bagmati River Basin in order to help in the appropriate selection of development projects for the Basin development in a sustainable manner.

NATURE AND SCOPE OF ISSUES

The Bagmati River Basin currently faces a number of serious environmental and ecological challenges. Uncontrolled discharge of untreated wastewater and solid waste into the Bagmati River in the upper sub-basin has degraded the quality of surface water beyond acceptable limits. The impacts of water

quality deterioration have regional consequences on the aquatic eco-system and on the health and cultural, religious and aesthetic values of the downstream sub-basin user groups. Similarly, the increased population pressure on the fragile mountain slopes has resulted in the conversion of marginal land into agricultural land, enhancing the rapid degradation in the quality of the natural resources. Deforestation, soil erosion, landslides, siltation etc., the results of excessive resource exploitation in the head reaches of the Basin, have posed serious threats to the stability and sustainable use of downstream infrastructures – the Bagmati barrage of the Bagmati Irrigation Project and the Kulekhani reservoir of the Kulekhani Hydroelectric Project.

Issues relating to the physical, biological, socio-economic and cultural environment within the River Basin were reviewed and studied. The specific issues considered during the study were to:

- assess environmental conditions of the Bagmati River Basin;
- conduct a comprehensive environmental analysis of the sub-Basin of the Bagmati River Basin;
- make concrete recommendations for the mitigation of river pollution, solid waste disposal and management, ill effects arising from the extreme use of river water for drinking water and sewerage problems in the Bagmati river Basin; and
- investigate the perceived threat to the Bagmati Barrage at Karmaiya due to accumulation of debris and floating trees by landslides upstream to the barrage and to propose concrete measures to avert the threat.

PROCESS AND PROCEDURAL CONTEXT

Environmental assessment study of development projects has been introduced very recently in Nepal. After the preparation and approval of the National Environmental Impact Assessment Guidelines, 1993, by His Majesty's Government, environmental impact assessment studies of the larger projects have taken place. After the promulgation and enforcement of the Environmental Protection Act, 2053, and Environmental Conservation Regulations, 2054, in 1997 EIA has been mandatory. Since the scope of this study differs from the project specific activities, the study processes did not exactly follow the provisions made in the Act, Regulations and the Guideline. The following study processes were adopted to accomplish the task by the team of experts:

Approval of scope of work

The proponent, using the available information and literature, finalised the scope of the work and prepared draft Terms of Reference. Based on the draft

Terms of Reference the consultants prepared and submitted the technical and financial proposals to the proponent and the agreement was reached between the parties.

Scoping finalisation

The consultants prepared an inception report identifying issues related to the Basin and submitted it to the proponent for finalisation. A scoping seminar was then arranged representing experts and stakeholders. The environmental issues were presented, discussed and then finalised for the study.

Field study

The field study was undertaken by the team of experts in order to collect first hand the information on socioeconomic conditions, existing environmental conditions, present activities in the Basin and collection and analyses of river water samples at different stretches of the Bagmati River and its tributaries. The information collected from secondary sources was also verified during this period. Public hearings and discussions at different locations within the sub-basin were conducted to get people's perceptions about the existing Basin environment and mitigation measures.

Report preparation and submission

Data concerning the sub-basin area was collected from different sources and compiled, analyzed and interpreted. A report was prepared and submitted to the client for review and comment. A seminar was conducted to present the study findings at the central level. Detailed discussions were held on the environmental issues and mitigation measures suggested for Basin-wide planning. Based on the comments and suggestions made during the presentation seminar, the consultants finalized the environmental study report and submitted it to the client.

APPROACH TAKEN

The study approach was initiated through the collection of secondary information. The collected information was reviewed, analyzed, interpreted and evaluated in a meaningful way to meet the study objectives. Most of the secondary information available in the limits of political boundaries was transformed into the Basin context. As the study emphasizes river pollution and the effects of erosion and sedimentation at the Karmaiya barrage site, the field study was mainly focused on these issues. However, other environmental issues were also dealt with, to some extent, with the objective of assessing their effects in terms of the sub-basins. In order to collect baseline data and information about the state of the existing environment in the Basin, separate matrices on baseline conditions and problems concerning natural resources and environment were developed and used for this

purpose. The matrix on baseline conditions and problems definition regarding natural resources was designed to incorporate information about the importance, extent of current use, availability of resources for future economic development, likely future demand, conflicts and availability of alternative resources. Likewise, the matrix to collect data on baseline conditions regarding the environment included the significance, extent and trends of environment degradation, effectiveness of current control measures, extent of environmental degradation with new protection measures and the need for new environmental protection measures. A checklist on the status of data availability on the Basin was also developed and used to facilitate the study objectives.

Study approaches taken in order to accomplish the task were the following:

Physical Resources

Maps collection, analysis and interpretation

Land use, land system, land capability and geological maps of the Basin were collected and analyzed. Based on these maps, different thematic maps on land stability, hazards and soil erosion potentials were prepared and used to qualify the existing environmental conditions of the Basin. Similarly, topographic maps and meteorological maps were collected to prepare drainage and elevation and physiographic maps.

Water quality

Water quality data available were transformed into the Basin river stretches to qualify the river water quality status in the Basin. For this purpose, river water pollution from both point and non-point sources based on population, livestock, agricultural inputs etc., was evaluated in the Basin in order to assess the river water quality of the Bagmati River system. In addition river water samples at different locations were collected and analyzed to monitor the present status of source pollution indicative parameters.

Hydrology and meteorology

Hydrological assessment of runoff from the Bagmati River Basin was carried out on the basis of the available hydrological data. Frequency analysis was carried out on the annual extreme series on annual extreme flows of streams. Computation of average rainfall over the Basin and rainfall characteristics such as monthly mean and the maximum daily rainfall were also computed. Frequency analysis was carried out on the annual extreme series of daily rainfall. Based on the rainfall data a relationship between monthly precipitation and monthly runoff was established and was used for the purpose.

Sediment transport

Suspended sediment data collected from secondary sources was analyzed and a relationship between sediment load and river discharge was determined using suspended sediment data with river flows and Basin rainfall.

Soil erosion

The Basin conditions with respect to soil erosion were evaluated using available secondary information. Information on soil types, vegetation cover, landslide inventory maps, land utilization maps, settlement patterns, human & livestock activities and soil erosion potential and hazard maps was collected and verified with limited field observations in the Bagmati Basin.

Biological resources

Available information on vegetation, flora and fauna, land-use pattern, maps, and other publications were reviewed to analyze the status of bio-diversity. A limited field survey was conducted to fill the data gaps on aspects of the terrestrial biological. Similarly, a limited field survey using structured and unstructured questionnaire formats for the local fishermen was conducted to analyze the status of aquatic bio-diversity, listing of rare and endangered species, identification of critical river stretches and relationship between water quality and aquatic life.

Socioeconomic resources

Information on population, health and education, water supply, sanitation and solid waste management, economic activities, professional status, agriculture and industries was collected and analyzed. Different techniques and tools were used to verify the information during the field survey period.

Cultural resources

Secondary information on the ethnic composition of the people residing in the Basin was utilized to broadly categories the cultural traditions and their interrelationship with the environment. Places of archeological significance and their state of conservation were discussed, based on secondary information with verification during the field survey.

Major environmental issues were first identified and analyzed for their environmental implications in terms of extent and magnitude in the Basin area.

RESULTS AND IMPLICATIONS

The extent and magnitude of the impacts of the issues concerning the Basin environment and their implications vary greatly in different parts of the Bagmati River Basin. The environmental impacts of the following issues were considered to be the major ones in the Basin.

Water quality of the Bagmati River

Several studies have been carried out over the last decade to assess the Bagmati River water quality. However, these studies are considered within the Upper Bagmati sub-basin (Kathmandu valley river stretch) only. Apart from the study conducted by the Department of Hydrology and Meteorology for a period of four years (1992 -1995), other studies do not provide time series data on the river quality for all seasons of the year. All the studies have reported that the water quality of the Bagmati River in the Kathmandu valley is of very poor quality, chemically and bacteriologically, and unsuitable for any freshwater fauna and flora for most of the dry season. However, in the rainy season (June - September), water quality improves considerably due to the increase in the assimilative capacity of the river. River water quality in the upper Bagmati River stretch is rapidly declining so much that the river is merely a sewer in the dry season. Stanley *et al.*, 1994 have mentioned that the Bagmati River water within the Kathmandu valley is not fit for drinking water, recreation and irrigation purposes.

Paudel *et al.*, 1995 have estimated that the daily BOD_5 generation in the Kathmandu valley from industries and people is about 42 tons. In the dry season the Bagmati drains only 40 per cent of the daily BOD_5 generation and the remaining is retained in the valley itself which is becoming a major source of land and ground water pollution.

S.No	Location	Distance (km) Bagdwar = 0	pH	Con (µmos/cm)	TDS (mg/l)	DO (mg/l)	COD (mg/l)	NH_3 (mg/l)
1	Gokarna		7.6	70	56	6.7	21.6	0.16
2	Gaurighat		6.5	360	288	<0.5	273.6	16.8
3	Shankhamul	26.875	7.1	410	328	<0.5	90	18.6
4	Sundarighat	32.875	7.1	740	592	<0.5	378	42.8
5	Chovar		7.1	720	576	<0.5	367	38.8
6	Khokana	39.375	7.4	600	480	<0.5	108	36.0
7	Kulekhani dovan before		7.9	440	352	6.4	80	19.7
8	Kulekhani dovan after		6.9	600	480	5.6	-	-
9	Khokojar Taldhunge		8.0	220	176	7.3	10.3	ND
10	Banchare, kayan khola	136.625	8.5	180	144	8.0	19	0.04
11	Karmaiya	144.2	8.3	200	160	7.2	6.5	0.02
12	Bramhapuri		8.2	230	184	8.4	66.0	0.21

Source : WECS/NESS, 1997.

Table 1: Water quality along the Bagmati River

From water quality analyses results, it is found that the water quality of tributaries of the Bagmati River outside the valley is found to be good and can be used for a variety of purposes. River water quality at different sections of the Bagmati River is presented in Table 1 above and Figures 2-4.

River water quality analysis data shows that the river water within the valley is bad but as the River passes through the valley the quality of water improves slowly. After mixing with Kulekhani River water, Bagmati River water quality improves considerably. This situation continues after mixing with other tributaries originating in the hills and Chure as well. Water quality along the Bagmati River outside the valley seems to be improved till it passes through Karmaiya. However, the river water quality seems to deteriorate at Bramhapuri due to the disposal of partially treated industrial effluent from a Sugar Mill. WECS/NESS 1997 has mentioned that the sugar mill has already started the construction of an effluent treatment plant and by the time this is completed the main pollution source will be controlled in the region.

The deterioration of water quality in the upper Bagmati sub-basin has far reaching implications for the entire Bagmati river stretches because of the location of the sub-basin at the Bagmati headwaters.

It is reported that the decline in the river water quality has a direct detrimental impact on the health of the water user groups downstream of the Bagmati Basin. Incidents of diarrhoea, typhoid, jaundice, cholera and skin diseases are of common occurrence among the user groups. However, there are no specific surveys with regard to this. The riverside inhabitants complain of the occurrence of such diseases in the dry season when they have no option other than using the river water to meet daily demand. Livestock toll is even higher in the dry months due to water related diseases.

The polluted river water has seriously impaired the aquatic ecology and bio-diversity along the Bagmati River. Fresh water fish have been completely wiped out from their habitats in the upper sub-basin and are declining in the river stretches of the upper middle and lower middle sub-basins.

The river is losing its religious and spiritual significance. The sacred river water for Hindu devotees has now become filthy and unsuitable for use on religious and cultural grounds.

Sedimentation and flooding

Sedimentation and flooding in the Bagmati Barrage and Kulekhani Reservoir have been identified as one of the major environmental issues in the Basin posing serious threats to the sustainability and the effective use of the infrastructures. Excessive erosion in the upland mountains and flooding and sedimentation in the plains and valleys are envisaged to be the common features in years to come. In other words the Bagmati Barrage & Kulekhani Reservoir will be under a constant threat of floods with a high concentration

of sediment load. The environmental implications for such structures, in the event of floods, are well exemplified by the flood of July 1993. Sediment deposits in front of the barrage at Karmaiya caused wide-spread floods in the Sarlahi and Rautahat districts. The damage to human lives and property was immense. Similarly, it has been estimated that over 7.71 million m^3 of sediments were deposited in the Kulekhani reservoir in three days of rainfall in July 1993, which is very high compared to 1.18 million m^3 of sediment deposited per year during the last 15 years.

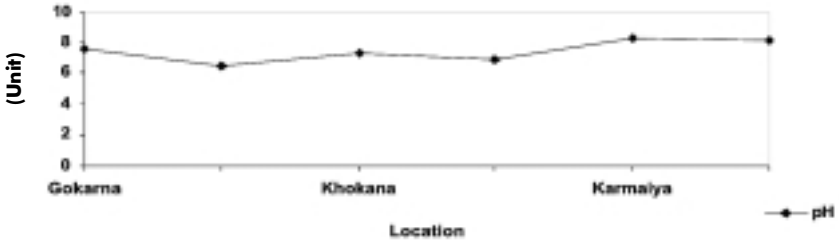

Figure 2: pH variation along the Bagmati River

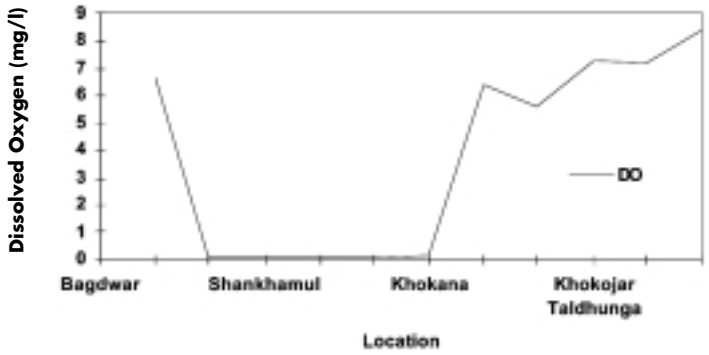

Figure 3: DO variation along the Bagmati River

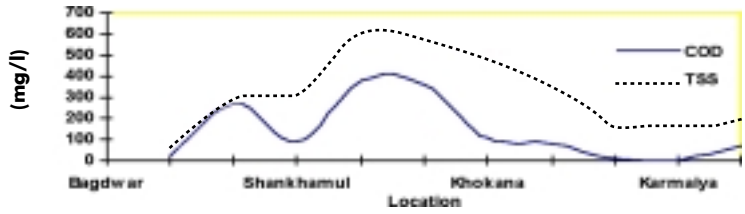

Figure 4: COD and TES variation along the Bagmati River

Mitigation measures

Mitigation measures were formulated with the objective of minimizing the negative impacts on river water and erosion and sedimentation in the Basin.

The mitigation measures for river pollution include:

- setting of effluent standards;
- setting of ambient river quality standard;
- construction of wastewater treatment plants in the Kathmandu Valley;
- on-site sanitation;
- effective solid waste management;
- ban on river bed sand mining in the upper Bagmati sub-basin; and
- increase assimilative capacity of the river in the upper Bagmati sub-basin.

The mitigation measures for erosion control and sediment transport at the Bagmati Barrage and Kulekhani Hydroelectric Power Reservoir include:

Short term measure

- physical intervention

Long term measures

- land stabilization and erosion control;
- conservation of forest resources;
- reforestation of degraded forest;
- discouraging conversion of forest into agricultural land; and
- discouraging traditional agriculture practice on sloping or unleveled surfaces.

In view of the present institutional arrangements, availability of information and management, establishment of a National Water Resources Research and Information Centre has been suggested.

LESSONS LEARNED

The concept of Basin-wide planning for sustainable development is still new to Nepal. The present practice of planning and implementation programmes, based on administration boundaries i.e. districts and village development committees irrespective of the Basin, has serious environmental implications in the balanced natural environment in Nepal. The environmental constraints posed by the natural boundaries of the ecosystems are very important in sharing the fruits of development on an equitable and sustainable basis. Exploitation of one resource has a direct impact on the other. But this factor was never considered in most of the earlier development initiatives in Nepal vis-à-vis the development effort which could not achieve the goal of poverty alleviation of the Nepalese people. Development activities thus implemented have resulted in serious

negative impacts on adjacent areas due to the creation of imbalances in the existing environment.

Uncontrolled disposal of raw sewage and industrial effluents in the Bagmati River system has created serious health concerns for the downstream water user groups. Likewise deforestation, agricultural malpractice in the uplands and excessive exploitation of natural resources has increased the rate of erosion, and mass wasting and sedimentation in downstream areas has posed serious and constant threats to the overall stability of infrastructures.

In view of the experiences and the lessons learnt from the past, the concept of Basin-wide planning has been felt necessary for sustainable development in Nepal. Mitigation measures have been formulated, based on the present environmental conditions and study recommendations, with regard to river water pollution and short term and long term measures to curb the present rate of erosion and sedimentation are envisaged to be effective for the Basin environmental management.

LIST OF RELEVANT PUBLISHED PAPERS OR OTHER SOURCE MATERIAL

Nepal Environmental and Scientific Services (P) Ltd. (1997*): Environmental Study of Bagmati Watershed and Mitigation of River Pollution,* Final Report, Water and Energy Commission Secretariat, Ministry of Water Resources, Kathmandu, Nepal.

Paudel A. (1998*):* Bagmati River Water Quality Management: problems and constraints, paper presented in a seminar organized by the Department of Water Supply and Sewerage, Society of Public Health Engineers Nepal, UNICEF-Nepal and World Health Organization held on 22 - 23 March, 1998 in Kathmandu, Nepal.

Stanley International Ltd., Mott MacDonald Ltd. and East Consult (P) Ltd., (1994): *Bagmati Basin Water Management Strategy and Investment Program, Final Report*, His Majesty's Government, Ministry of Housing and Physical Planning/JICA/The World Bank.

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