Environmental Impact Assessment (DRAFT)

Project 43448
June 2013

NEP: Bagmati River Basin Improvement Project

Prepared by DHI Group for the Asian Development Bank.

CURRENCY EQUIVALENTS
(As of 17 May 2013)

Currency Unit	–	Nepalese Rupee (NRe/NRs)
NRe 1.00	=	$0. 011410
$1.00	=	NRs 87.64

Abbreviations

ADB	–	Asian Development Bank
AEP	–	Annual Exceedence Probability
BRBIP	–	Bagmati River Basin Improvement Project
BOD	–	Biodegradable Oxygen Demand
BREMP	–	Bagmati River Environment Management Plan
CBO	–	Civil Based Organisation
CEMP	–	Construction Environmental Management Plan
COD	–	Chemical Oxygen Demand
DHM	–	Department of Hydrology and Meteorology
DNPWC	–	Department of National Park and Wildlife Conservation
DO	–	Dissolved Oxygen
DOI	–	Department of Irrigation
DSCWM	–	Department of Soil Conservation and Watershed Management
DSS	–	Decision Support System
D&BC	–	Design and Build Contractors
EA	–	Executing Agency
EARF	–	Environmental Assessment and Review Framework
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
EPA	–	Environment Protection Act
EPR	–	Environment Protection Rules
GoN	–	Government of Nepal
GAF	–	Grievance Action Form
GFP	–	Grievance Focal Points
GRC	–	Grievance Redress Commission
GRM	–	Grievance Redress Mechanism
HMG	–	His Majestys Government
HPCIDBC	–	High Powered Commission for Integrated Development for Bagmati Civilization
IA	–	Implementing Agency
ICOLD	–	International Commission for Large Dams
IEE	–	Initial Environmental Examination
ILO	–	International Labour Organisation
IRBDMP	–	Integrated River Basin Development Management Plan
IWRM	–	Integrated Water Resources Management
KAPRIMO	–	Kathmandu Valley Participatory River Monitoring Programme.
KUKL	–	Kathmandu Upatyaka Khampani Limited
KVDA	–	Kathmandu Valley Development Authority
KVWMP	–	Kathmandu Valley Wastewater Management Project
MDE	–	Maximum Design Earthquake
MPPW	–	Ministry of Planning and Public Works

MoSTE	–	Ministry of Science, Technology and Environment
MOFSC	–	Ministry of Forest and Soil Conservation
NEA	–	Nepal Electricity Authority
NGO	–	Non-Governmental Organisation
NTWL	–	Normal Top Water Level
OBE	–	Operating Basic Earthquake
PCMU	–	Project Coordination and Management Unit
PES	–	Payment of Environment Services
pga	–	Peak Ground Accelleration
PMSC	–	Project Management and Supervision Consultant
PPTA	–	Project Preparatory Technical Assistance
RSPM	–	Respirartory Suspended Particulate Matter
RBO	–	River Basin Organisation
REA	–	Rapid Environmental Assessment
SEA	–	Strategic Environmental Assessment
SNNP	–	Shivapuri Nagarjun National Park
SPS	–	Safeguard Policy Statement
SWTP	–	Surface Water Treatment Plant
TA	–	Technical Assistance
UN	–	United Nations
VDCs	–	Village Development Committees
WBM	–	Water Balance Model
WECS	–	Water and Energy Commission Secretariat
WHO	–	World Health Organisation
WRA	–	Water Resources Act
WQBM	–	Water Quality Balance Model
WUAs	–	Water User Associations
WWTP	–	Waste Water Treatment Plant

Notes

(i) The fiscal year (FY) of the Government of Nepal ends on 15 July. FY before a calendar year denotes the year in which the fiscal year ends, e.g., FY2012 ends on 15 July 2012.

(ii) In this report, "$" refers to US dollars

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EXECUTIVE SUMMARY

A. Introduction

1. The Bagmati River holds a special place in the national identity of Nepal as it is related to the mythological birth of civilization in the Kathmandu Valley. It is also considered a holy river and counts many cremation ghats and temples of great cultural value along its banks that attract Hindu devotees from all over the world who traditionally purify themselves in the holy Bagmati waters. Apart from its cultural and religious significance, the Bagmati river basin also has high economic importance as it must meet the water requirements of the country‟s capital city and downstream communities.

2. Rapid increase in Kathmandu‟s population and related city expansion has put tremendous pressure on the water resources of the Bagmati River Basin. In the absence of orderly planning and financing for sewage collection and treatment, the river has become the main drain. Solid waste is also regularly deposited on the river banks and this causes further deterioration of the river environment. Downstream the Pashupatinath Temple the Bagmati River is biologically dead as the flow remaining is heavily polluted with sewage, thereby endangering the health of downstream water users in greater Kathmandu.

3. During the dry season, around 80% of the Bagmati river flow is diverted for drinking water purposes leaving very little flow to carry waste effluents. Thus there is an urgent need to protect and enhance water resources and increase water discharge to the Bagmati, conserve terrestrial and aquatic biodiversity and to maintain and enhance the river water quality. The concerns for the river environment and the pressing needs for improvement are expressed in the Bagmati Action Plan (BAP) prepared in 2008. It addresses the issues if the health of the Bagmati River is to be restored.[1]. The BAP activities include the expansion of the water recharging capacity by expansion of the existing Dhap.

4. The Government of Nepal (GoN) intends to address the pressing environmental issues in the Bagmati Basin in a systematic manner based on the BAP with the support from the Asian Development Bank (ADB) through the Bagmati River Basin Improvement Project (BRBIP), hereinafter called the Project. A concept for the Project was formulated in early 2011 and in mid-year an ADB mission visited Nepal to define its intended scope and objectives, and to agree upon the scope and Terms of Reference (ToR) for a Project Preparatory Technical Assistance (PPTA). The Project was included in the Nepal Country Operation Business Plan (COBP) together with a PPTA for financing by the Japan Fund for Poverty Reduction (JFPR).

5. At the same time a regional Capacity Development Technical Assistance for Supporting Investment on Water Security (CDTA 7547), approved in 2010, studied the Bagmati river basin with the aim of accelerating economic growth and to improve the living standards in river basins through efficient, effective, and sustainable water resources management, environmental conservation, and water-related disaster risk mitigation. The CDTA prepared a Bagmati River Basin Profile, a Strategic Roadmap for Integrated Water Resources Management (IWRM) and the Bagmati River Environment Management Programme (BREMP) and carried out technical studies which helped to identify the types of physical intervention which would be appropriate for the BRBIP.

[1] Bagmati Action Plan (2009-2014)

6. The BREMP identified key issues affecting the river environment in the Upper Bagmati in terms of its flow, water quality, and riparian environment under future scenarios that include the impact of: (i) future population growth and urbanization; (ii) the Melamchi Water Supply Project generating additional waste water; (iii) planned development of wastewater treatment facilities; and (iv) ongoing river training works being carried out by local authorities.

7. With stakeholders, the BREMP proposes a set of target objectives along the river which include increasing the flow rate and improving the river"s water quality to bathing standard at the main temple sites of Gokarna and Pashupatinath considered to be representative key locations for the river environment. The targets focus on (i) improving the river water"s clarity, odour, and visual cleanliness; (ii) achieving the flow and quality targets for the dry season as needed for cultural festivals and for all of the wet season; (iii) achieving the flow and quality targets all year; and (iv) achieving a healthy ecological environmental flow.

8. The Asian Development Bank (ADB) is supporting the Government of Nepal (GoN) to address these critical water security issues in the Project. The Ministry of Urban Development (MOUD) is the Executing Agency (EA) with the High Powered Commission for Integrated Development for Bagmati Civilization (HPCIDBC) as the Implementing Agency (IA) for river improvement works in the Upper Bagmati. In addition HPCIDBC will establish and host the Project Management Unit (PCMU), to be supported by a Project Management & Construction Supervision Consultant (PM&CS consultant). Department of Irrigation is the IA for the design and construction of increased water storage capacity in the Shivapuri National park.

B. Description of the Project

9. The Project has been envisioned to improve water security and resilience to potential climate change impact in the Bagmati River Basin. It aims to build on the general public"s desire to restore the river environment in the Kathmandu Valley and the Government"s efforts to mitigate the impact of water-induced disasters in the middle and lower reaches of the Basin. The project adopts the principles of IWRM and provides Nepal with its first opportunity to apply this key policy element since it has been adopted under the National Water Plan in 2005.

10. The expected outputs of the Project Phase I are: (1) Systems and capacity for integrated and participatory river basin management established; (2) Riparian environment in Upper Bagmati River improved; (3) Increased Water Availability in the Basin during the Dry Season; (4) Flood forecasting and early warning system in the Bagmati River Basin is functional; and (5) Project is efficiently managed with effective stakeholder communication. The present EIA covers the planning, design, construction activities and operation related to achieve Outputs 2 and 3.

11. The Project is envisaged to be implemented in Phases, with Project Phase I works targeting riparian environment improvement and beautification along the semi-urban/urban river stretches in the Upper Bagmati, and providing a basic storage facility be extending an existing dam at the Dhap site in the headwater of the Nagmati, the main tributary to the Bagmati River in the Shivapuri Nagarjun National Park (SNNP). At the same time, in Phase I, preparations will be made for Phase II through the detailed design of a larger water storage capacity in the SNNP by constructing a dam at the Nagmati River, to be financed in Phase II of the Project. Phase I (to a limited extent) and II are further envisaged to extend the river improvement and beautification works along the Upper Bagmati to other tributaries in Kathmandu, e.g. Bishnumati and Hanumante.

12. In order to assess the technical and economic feasibility of construction of the dams investigative surveys have been carried out including topographic surveys of the dam sites to determine the potential dam volume, and drilling investigations to determine the geo-technical suitability at both sites. Two separate Initial Environmental Examinations (IEEs) were carried out for the investigative surveys and the implementation overseen following the Environmental Management Plans prepared.

C. The EIA Process

13. The present EIA assesses the potential environmental, health, safety and social impacts of the proposed river improvement and beautification works and dam construction and identify adequate remediation, compensation and enhancement actions to ensure compliance with ADB‟s Safeguard Policy Statement (SPS) and Government of Nepal‟s environmental safeguard requirements[2].

14. The EIA has been prepared during the project preparation work in the month from September 2012 to May 2013. The assessments have been carried out based on primary data from field surveys conducted by Kathmandu University during the months of September to January 2013. Besides, secondary data have been collected from a variety of other sources.

15. During the site visits, the Specialists had discussions with various stakeholders including Shivapuri Nagarjun National Park (SNNP) staff, Village Development Committee (VDC) members and local executive powers for their opinions on the proposed project components.

16. Consultations have been held with stakeholders on the overall concepts and designs of the BRBIP, building on the consensus reached during the formulation of the BREMP on the water quality targets to be met at strategic important locations along the Bagmati River, especially at the temple sites at Gokarna and Pashupatinath. The findings of the EIA were presented at a workshop held in Kathmandu on the 23rd April 2013, where government organisations, universities, NGOs and local stakeholders were present and provided valuable feedback for the finalisation of the EIA.

17. The Government of Nepal (GON) has a well-established legal framework for environmental assessment of infrastructure development projects. Foremost relevant to the Project are the Environment Protection Act (EPA) of 1997 and the Environment Protection Rules (EPR) also of 1997 and with Amendments in 2007. Section 3 of the EPA mandates project developers to carry out environmental assessment of projects at the level of IEE or EIA. Rules 2 and 3 of the EPR require a project developer to carry out IEE or EIA for the type and size of projects as listed in the Schedule 1 or 2, respectively. The provisions in EPA (1997) for EIAs relate to the present project.

18. ADB categorizes projects into categories A, B, C, and FI according to the significance of likely impacts. Based on the ADB‟s Safeguard Policy Statement (SPS), Component 2 of the BRBIP is categorized as category A, based on the most sensitive components, construction of water retention reservoirs in the SNNP. This EIA is carried out in compliance with ADB‟s SPS to ensure that potential adverse environmental impacts are identified, avoided where possible and managed or addressed.

2 ADB Safeguard Policy Statement, June 2009

D. Description of the Environment

1. Physical Resources

19. The Bagmati is the principal river of the Bagmati basin. The total catchment area of the Bagmati river is 157 km^2 (15700 ha) with a length of 44 km from its origin at Shivapuri Bagdwar at an elevation of 2732m to Katuwal *daha* at an elevation of 1140m. Out of the total catchment area in the Shivapuri Nagarjun National Park (SNNP), about 328.6ha (9.7%) is covered by agricultural land including settlement areas and the remaining 3057.4ha (90.3%) is covered by forest, bush areas and wetlands.

20. The Bagmati River flows through a Rural Zone from Sundarijal to Gokarna. The land-use here is dominated by agricultural land, with an increasing population density and housing concentrated mostly along the main road from Gokarna to Sundarijal.

21. A Peri-urban area stretches from Gokarna and down to Pashupatinath. The urban growth trend towards the north east of Kathmandu Municipality upstream from Guheshwori [Pashupatinath] and along the Bagmati River corridor is quite extensive. Extension of this growth at Makalbari and Nayabasti has touched the religious site of Gokarna.

22. A highly urbanised area within the project boundary stretches from Pashupatinath and downstream to the Sinamangal Bridge from where there are concentrations of squatters downstream along the river banks. The zone is highly urbanised.

23. The Kathmandu valley is surrounded by high mountain ranges including Shivapuri (2732m) to the North and Phalchauki (2762m) to the South. The valley is composed of Quaternary (Recent and Plio- Pleistocene) sediments overlying Precambrian to Devonian basement rocks.

24. The Kathmandu Valley lies within a very active seismic zone. Several large and devastating earthquakes have occurred in the past, the more recent being in 1833 (Reichter magnitude 7), 1934 (Reichter magnitude 8.4), 1960 and 1988.

25. The upper and middle parts of the Bagmati basin (Kathmandu valley and Mahabharat range) have warm temperate climate. Rainfall is caused mainly due to the Monsoon started from the Bay of Bengal. The monsoon season falls during mid-July to mid-September and about 80% of total annual rainfall occurs during this period.

26. The region is the origin of some of the important river systems including Bagmati, Bishnumati, Nagmati, Syalmati, Rudramati, and Yashomati, which are major watersheds. The outflows from the Dhap area create the headwaters of the Nagmati, the main tributary to Bagmati in the Shivapuri Nagarjun National Park (SNNP).

27. Floods in the past have caused loss of lives and property in the Bagmati basin. The flood events 1993, 2002 and 2004 were very severe. According to secondary sources, severe floods occurred in the Kathmandu valley resulting into loss of lives and damage to infrastructures including 27 deaths and persons missing in 2002. The massive downpour of 22nd -23rd July, 2002 in Kathmandu valley was the highest recorded rainfall in the capital in three decades.

28. Upstream of the confluence between the Nagmati and the Bagmati the small Sundarijal Water Supply Reservoir diverts water from the Bagmati for water supply to Kathmandu. A weir in the Nagmati diverts water to the small Sundarijal Water Supply Reservoir through a small canal during the dry season. In the driest month, the water supply diverts all water from the Bagmati and Nagmati for drinking water supply purposes effectively leaving no flow downstream.

29. The Sundarijal Water Supply Reservoir supplies the Sundarijal Water Treatment Plant with between 12MLD and 18MLD via a 220m gross head 640kW rated mini-hydropower plant. The Sundarijal Water Treatment Plant is one of two major withdrawals from the Upper Bagmati River at the downstream end in SNNP. The second are the cluster of small irrigation off-takes that service most of the irrigated area within the rural areas downstream Sundarijal.

30. The results of the water quality monitoring programme carried out by Department of Hydrology and Meteorology (DHM) shows a a significant deteriorating trend in water quality from Sundarijal with a DO concentration level around 7 mg/l down to Sinamangal Bridge with a DO concentration level around 1-2 mg/l in the mid-2000s. Measurements carried out by HPCIDBC in 2012 supports the findings of the DHM data from the Upper Bagmati, and signify the highly polluted state of the tributaries Dhobi Khola, Tukucha, Bishnumati and Balku Khola.

2. **Ecological Resources**

31. The SNNP area earlier experienced problems of soil erosion owing to deforestation, overgrazing, and cultivation on steep slopes in the past. The quality and quantity of water supplied from this area was also reduced. To overcome these problems, a program was initiated to protect the watershed and wildlife reserve in 1975. It was declared as Nepal"s 9th National Park in 2002. The vegetation of the park represents midhill flora, fauna, and ecosystems in the transition zone between sub-tropical and temperate climate, where the variations is primarily a function of the altitude. SNNP supports rich floral and faunal diversity with a number of protected species of mammals, birds, and plants.

32. Vegetation surveys at the dam sites have shown that in general, most of the forest in the survey area is in secondary stage of succession. Cutting of trees for fire wood happens regularly. As a result there are very few large/mature size trees in the area.

33. Bird surveys have recorded 20 and 16 species at the Dhap and Nagmati sites, respectively. None of the 12 protected bird species known to be found in the SNNP was recorded at the Dhap site, while only one vulnerable species listed as a nationally threatened bird, the White-tailed Stonechat was recorded at the Nagmati Dam site.

34. Wildlife surveys recorded 8 species at the Dhap site, including Large Civet, Wild Boar, Barking Deer, Leopard Cat and Common Leopard. Three species were recorded at the Nagmati site, Jungle Cat, Bengal cat and Large Civet.

35. Macroinvertebrate surveys showed that the Dhap and Nagmati sites falls within Class II. This shows that the Nagmati River is not in a pristine condition. Despite having a good water quality, the aquatic ecosystem is disturbed by human activity in the catchment that dates back from the cutting of the primary forest up the present use of the forest for grazing, cutting of trees for firewood, collection of plants and fishing.

36. The fish surveys at the Dhap in the impoundment and in the river downstream identified only one species which is very common and found in almost every natural water body in Nepal, the Creek Loach. The fish survey at the Nagmati Dam site showed a poor fish assemblage as well. One single species, Snow Trout was found in a very low number.

3. Socio-Economic Resources

37. Almost 90% of the Sundarijal VDC comes under the upstream areas of the Bagmati River basin in the SNNP where the Tamang communities predominate. They grow millet and maize in the upstream areas. However, some vegetables and barley are also cultivated. Most of them are engaged in hoarding livestock while some are seen to be involved in small business like shops and hotels.

38. From Sundarijal to Gokarna the VDCs are relatively sparsely populated with all the VDCs except Sundarijal agricultured based. River banks are all agricultural fields and any settlements are more than half a kilometre away from the banks of the Bagmati River on both sides. The soil is mostly fertile and suitable for agriculture, with irrigation along the river banks and rain fed agriculture in the higher lands.

39. The beauty of the once traditional urban development in Kathmandu Valley was its use of land based on its productive capacity. Settlements were developed in high land, while low land was specifically used for agricultural purposes. Land farther from the river banks and at higher altitude was designated for construction. This prevented the settlements from the risk of floods in the monsoon and on the other hand maintained the pristine character of the river preserving their healthy environment. Over the last three or four decades, population growth and immigration into Kathmandu have led to an increasing urbanisation has been so rapid that the principle of land use based on its productivity could not be continued, and created a market for land based on the demand and supply for urbanisation.

40. The urban growth trend in the Upper Bagmati River stretch from Gokarna to Guheshwori along the Bagmati River corridor is quite fast in nature. Roads have been developed along both sides of Bagmati River and urban development is progressing, turning whatever fragmented agricultural land remaining into housing or commercial areas. Due to urbanization the farmers have found more profit in selling their lands rather than farming.

41. According to the 2011 population census, in Kathmandu district (noting that the project is located in Sundarijal VCD of Kathmandu district), 9 VDCs and Kathmandu metropolitan together have a total population of 1,163,785. Females constitute 47.4% and males constitute 52.6%. The average household size is 3.7 persons. Of the total population 86.5% is urban (Kathmandu metropolitan) and 13.5% rural. The household size in the urban area is slightly lower (3.6 persons).

42. Agriculture accounts for 35% of Nepal"s national Gross Domestic Product (GDP), industry 15% and services (including tourism) the remaining 50%. GDP growth was 3.5% in 2011 and the economy grew by an annual average of 3.4% during the past five years which was led by growth in the service sector by 6% annually, whilst growth in the agriculture sector was only 2.6%. Per capita income was $642 in 2011 and has grown annually by 10.5% during the past five years. In 2011 the Human Development Index (HDI) of Nepal was 0.458, placing it at 157th position in the world.

43. Most of the cultural sites in Kathmandu Valley are located along the banks of the rivers. The major, Important Cultural Heritage sites along the Upper Bagmati River in the Project area are: (i) Gokarneshwar Mahadev Temple of Lord Shiva. People congregate here to bath in the river from the ghats (embankments) on religious ceremony of Fathers" day; (ii) Guheshwori: This Temple without roof is dedicated to the escort of Lord Shiva, Sita. One of the most significant ghats in the complex is the „Gauri Ghat", where people take a dip in the river on the auspicious day of dark moon in January, and (iii) The Pashupatinath Temple is the most important of all the temple complexes along the Bagmati River and the most important religious site in the country. It is even considered as one of the most holy religious centers for Hindus all around the world.

E. Anticipated Environmental Impacts and Mitigation Measures

1. Beneficial Impacts

44. The anticipated beneficial impacts of greenbelt and river beautification along the Upper Bagmati related to Output 2 include: (i) Creating respect for the river environment by communities to avoid disposal of solid waste and defecation; (ii) Create amenities and recreational activity possibilities for local communities; (iii) Prevent encroachment into the riparian land along the river banks; and Improve land values along the river corridor.

45. The anticipated beneficial impacts of river stone walls with forefront protection related to Output 2 include: (i) Stabilisation of river banks; (ii) Protection against flooding; (iii) Safeguarding green zones against river bank erosion; and (iv) Improves aesthetic value by replacing existing gabion walls.

46. The anticipated beneficial impacts of weirs/check dams related to Output 2 include: (i) Increase groundwater recharge; (ii) Improving river water quality by re-aeration; (iii) Create possibility for recreational use (e.g. boating which is not possible now); and (iv) Stabilise river bed and protect against river erosion.

47. The anticipated beneficial impacts of regulator rehabilitation related to Output 2 include: (i) Provide possibilities for the temples at Gokarna and Pashupatinath to regulate water levels at their ghats; (ii) Improve safety of the use the regulators for river crossing; and (iii) Improve the aesthetics value and their value of representing their former use for irrigation as part of the local heritage.

48. The anticipated beneficial impacts of Output 3 related Dams in SNNP include: (i) Securing an environmental flow in the Upper Bagmati River (ii) Increasing the assimilative capacity of the Bagmati River improving the water quality from Sundarijal to Sinamangal Bridge and further downstream; (iii) Increased groundwater recharge from Sundarijal to Sinamangal Bridge and further downstream; (iv) Increased water levels for cultural and religious use of the Bagmati River at temple ghats; (v) Improved hygienic quality of the water from Sundarijal to Pashupatinath reducing health risks of recreational or religious use of the Bagmati River; and (vi) Increased power generation (Phase II) providing income generation for River Basin Improvement and RBO activities.

49. The anticipated beneficial impacts of Output 3 related Rainwater harvesting are: (i) Rainwater harvested from 2500 households providing 45,000 m^3 safe water supply and recharging of 135,000 m^3 annually; and (ii) By-laws reformulated and construction of rainwater

harvesting system made mandatory in new buildings for safe guarding of the groundwater recharge capacity in new urban areas

50. The anticipated beneficial impacts of Output 3 related Watershed Management in SNNP is: (i) Reduced erosion and silt load from the watershed in SNNP; (ii) Improved livelihood for people living in the SNNP; and (iii) Reduced pressure from exploitation of SNNP resources.

2. Impacts and Mitigation due to Project Location and Design

51. No resettlement is foreseen necessary for any of the Project components and their interventions. The Dhap and Nagmati Dam sites are located in the SNNP. The nearest settlements to the sites are Mulkharka and Chisapani, more than 500m and 2km away from the respective sites. Generally, all works will be carried out on Government land. However,during Phase II of the project (for which funds are yet to be ear marked) to establish the small hydropower house on the left bank of the Bagmati River at Sundarijal, it is necessary to acquire 500m^2 of land.

52. No depreciation of land values are foreseen at any Project component intervention sites, even temporarily during construction. Upon completion of the river environment improvement interventions a considerable increase in land value is anticipated in the semi-urban and urban areas around the Bagmati River from Gokarna to Sinamangal Bridge.

53. The prosed Project interventions will not affect any historical or cultural monuments or religious temples or shrines negatively. In the unlikely event of encountering any finding of archaeological value, the Environmental Management Plan (EMP) will have procedures for dealing with this.

54. Creating storage capacity in the Upper Bagmati by enlarging the Dhap and construct a dam at the Nagmati is dictated by the need to increase the environmental flow in the Bagmati River during the dry season. The proposed sites in SNNP do not require resettlement. However, implementation of the prosed dams in the SNNP will replanting of 25 trees for every tree that has to be cleared in the reservoir areas behind the dams, following GoN rules and regulations. The reservoirs will cover approximately 12.5ha and 38ha, respectively, with small areas needed for work sites. Clearing is expected to take 2 and 6 months, respectively, to be carried out during the dry season to minimise any soil erosion. However, sediment retention facilities will be installed to reduce any impacts.

55. The road eastern of SNNP from Sundarijal to be used for the access to the Dhap (18.8km) has two bridges crossing the Nagmati above Mulkhani and at Sundarijal crossing the Bagati. A reconnaissance by a walkover of the Ring Road concluded that: (i) The road, when constructed, was properly engineered. (ii) Everywhere the road is wide enough for trucks of the size needed. No widening needed. Frequent places with space for trucks to pass each other; (iii): No settlements along the road from the Dhap to Mulkharka; (iv) No trees have to be cut inside the park; (v) Road gradients are not steep, therefore safe for trucks; vi) No sharp bends where widening is needed for trucks to turn (except below Mulkharka towards Sundarijal, where the Ring Road joins the (illegal) road through SNNP); (vii): Everywhere needed the existing culverts (more than 30) draining streams under the road are in good condition, except for one, that needs some repair; (viii): Existing bridge crossing Nagmati upstream Mulkharka is designed for, and still considered safe for trucks; (ix): the bridge over Bagmati is new and safe for trucks; and (x): It will be relatively cost effective to upgrade the Ring Road, e.g. clearing, metlling, roadside drain improvement, etc.

56. The existing road from Sundarijal passing Mulkharka to Chisapani will be used as access road to the Nagmati Dam site (6.6km, Pahe II).

57. The Dhap reservoir will inundate the road north to the dhap over a stretch of 200m and the Nagmati reservoir will inundate the road from Mulkharka to Chisapani on a 2 km stretch upstream the dam. The roads will be shifted using GoN road engineering guidelines with slope stabilisation. For the existing access Ring Road to the Dhap, no fill is needed, while for the existing road via Mulkharka to the Nagmati site only small quantities of deposits will be needed.

58. During design of the dams due attention is given to environmental issues. A major issue during operation of a dam is water quality. When filled a reservoir of the depth foreseen at the Dhap and the Nagmati River is foreseen to have an-oxic conditions below the thermocline that will typically be formed at a depth of 10 m. A trunnion intake structure will be provided that takes water in at a prescribed depth below the surface, e.g. 2 m at the Dhap. A valve structure will be implemented at the Nagmati Dam.

59. Another major issue is dam safety. The project area is situated in a high risk seismic zone, and there is an imminent risk of a major earthquake during the lifetime of the dams proposed. The type of dams selected for construction and the sub-sequent design takes due consideration to provide the highest safety possible based on accepted international dam design criteria. As such, the dam design proposed is engineered to withstand the design seismic event and so has an extremely low risk of failure in a seismic event. The type of dams selected (rock faced concrete fill) are known to be best to withstand earthquakes, and they are designed to withstand major earthquakes up to a probability of 1:1000 years occurrence, with a safety factor added.

60. The environmental river improvement interventions in the Upper Bagmati have primarily been identified with respect to their efficiency of providing water security and improved river environment. During the feasibility study of the environmental interventions in Upper Bagmati local architectural elements, design, construction materials and construction methods, especially at the temple sites, have been studied and incorporated into the design of all components in order to achieve an aesthetical beautification of the river environment.

61. The impacts of climate change on rainfall and consequently on the hydrology and the river hydraulics has been assessed up to 2060-80, showing in general a moderate increase in rainfall. The changes identified were used in catchment rain-fall run-off simulations and river hydraulic model calculations to ensure that dam designs and river works designs incorporate expected climate change induced changes.

3. Impacts and Mitigation during Construction

62. Air emissions during construction arise from construction vehicles, blasting and clearing of rubble, operation of quarry pits and hauling of materials. Emissions from rock crushing operations, aggregate drying and hot mix plants also degrade air quality. The contractor will be required to regularly water roadway surfaces wherever there are communities (homes, businesses, schools) nearby, and the vicinity of blasting and rock crunching sites.

63. Noise impacts on human settlements and wildlife in the SNNP will originate from the operation of construction equipment and from rock blasting and rock crushing to provide rock-fill for the dams. Noise impacts at the Sundarijal Bazaar, the housing along the Gokarna-Sundarijal main road, and in the increasingly urbanised areas from Gokarna down to

Sinamangal Bridge will originate from the operation of construction equipment and transport of construction material to the construction sites. Construction activities in the SNNP and in semi-urban, urban sensitive areas will be limited to the daylight hours.

64. The contractor will prepare a blasting procedure requiring area restrictions; prior warning of workers and others passing through the SNNP; restrictions on the timing of blasts; and worker safety procedures. In consideration of its impacts to surrounding environment, the quarry operation shall utilise an environmental friendly blast initiation system in its blasting operation. However, there is no housing or other structures in the vicinity of the dam sites that is considered to be affected by vibration from the blasting.

65. Soil erosion and sediment transport from access roads, shifting of roads and tracks will be minimised and mitigated through the provision of proper road side drainage, provision of culverts and slope protection to avoid any soil erosion and damage, and implementation of soil erosion and mitigation planwhere needed. Though erosion, rock falls, are unavoidable during cutting works, appropriate methods of excavation and benching recommended during the detailed design must be followed to minimize these impacts.

66. The operation of the quarry at the footpring of the Nagmati site, and at the Dhap site may cause eroded soils from denuded area of the quarry and fine rock particles from the drilling of the blast face to enter the Nagmati River leading to deterioration in the river water quality. Hence, the quarry must maintain a buffer zone of 20 meter to the river and all clearing of the quarry site should be restricted to the necessary area of rock extraction. A sedimentation pond for retention of eroded particles should be put in place.

67. The construction at the dam sites will commence at the start of dry the season to minimise the risk of flooding of the damsite. At the Dhap the natural low flow during the dry season is diverted downstream via a 0.4m pipeline. At the Nagmati Dam site a river diversion (pipeline of approx. 1,2m in diameter) releases immediately downstream of the construction site. Consequently, no impact on the Nagmati river hydraulics is foreseen during the construction period.

68. The river improvement works from Gokarna to Sinamangal Bridge will be carried out during the dry season to ease the construction and avoid flooding of construction sites, and minimise any impact on the Bagmati River hydraulics. Any construction works affecting the river flow, such as the construction of weirs, will typically be carried out in two phases, with the construction going on in one half of the cross section, leaving the river to flow in the other half.

69. The area to be inundated by the new Dhap Dam is approximately 12.5 ha. 5.1 ha of forested area will be inundated behind the new Dhap Dam when at full capacity, to be cleared in the dry season at the end of the construction period, before filling the reservoir. However, compensation for loss of trees will be provided according to the Working Policy on Construction and Operation of Physical Infrastructures within Conservation Areas. This will require that for each tree removed, 25 trees have to be replanted. With an estimated 1960 trees to be cleared, planting of 49,100 trees are needed as compensation. With an estimated density of 2500 seedlings per ha this will require 19.6 ha of land for replanting.

70. The area to be inundated by the Nagmati Dam (Phase II) is approximately 38 ha when at full capacity. With an average density of trees of 670 trees per ha, a total of approximately 25,400 trees are estimated to be inundated behind the Bagmati Dam, to be cleared in the dry season at the end of the construction period, before filling the reservoir. Planting of 636,500

trees are needed as compensation. With an estimated density of 2500 seedlings per ha, this will require approximately 255 ha of open land for replanting. All replanting will be carried out by the SNNP authorities.

71. With respect to the construction of the penstock from the Nagmati Dam to the powerhouse at the left bank of the Bagmati River at Sundarijal (Phase II), it is considered feasible to line this without the clearing of major trees, as they are relatively sparse. However, the line will be prepared in close consultation with SNNP staff to minimize any clearing of trees.

72. Clearing will be carried out during the dry season where nesting is less common for most bird species. Of the 12 species listed as threatened in the SNNP, it is only the White-rumped Vulture and the Spot-bellied Eagle Owl that nests during the dry season but they are considered as „least possible" to be found in the dam areas. However, the branches and canopy of the trees must be checked before clearing to make sure that any nests with chicks found in the trees are handled carefully and displaced in other area with the help of an bird expert. It is foreseen the clearing will be done manually, section by section, each section to be checked before clearing starts. No significant impacts on birds are envisaged from the construction of the river improvement interventions in and around the Bagmati River from Sundarijal to Sinamangal Bridge.

73. Of the endangered, near threatened or vulnerable species listed in the IUCN List of Threatened species for Nepal known to live in the SNNP, the Large Civet and Common leopard were recorded at the Dhap during the wildlife survey. Of the other species known to live in the SNNP, the Clouded leopard is likely to be there, and the Himalayan black bear is possibly found there. None of the three wildlife animals recorded at the Nagmati site are listed in the IUCN List of Threatened species for Nepal. However, of the endangered, near threatened or vulnerable species, the Chinese pangolin, Clouded leopard and Common leopard are likely to be in the Nagmati area.

74. The reservoirs created will inundate habitats of wildlife. However, there are no elevated sites in the reservoir area where wildlife may be trapped during the filling of the reservoir. Therefore, wildlife is considered to move to other areas outside the reservoir. While permanent deep water reservoir lakes create a barrier to wildlife movement thus restricting their distribution, the creation of a lake/reservoir environment may be turned into important wildlife habitats. No significant impacts on wildlife are envisaged from the construction of the river improvement interventions in and around the Bagmati River from Sundarijal to Sinamangal Bridge.

75. At present the SNNP authorities remove all aquatic, rooted vegetation along the Dhap. If this practice is abandoned, the naturally adapted rooted aquatic vegetation is considered to return, with same species and densities whether the existing dam is kept, or a new is constructed, forming a larger reservoir. No aquatic rooted vegetation exists in the river environment at the Nagmati Dam site. It is expected that limited aquatic rooted vegetation may be established during operation of the Nagmati reservoir along its fringes.

76. Construction and operation of the extended Dhap Dam will enlarge the existing, impounded reservoir. The future reservoir is considered to provide the same basic conditions for any aquatic fauna, including fish, as the present one. During construction the natural flow will be diverted downstream and during operation of the Dhap Dam an environmental flow of at least 10 l/s will be maintained, to support the existing aquatic fauna including fish in the Nagmati River downstream the Dhap Dam.

77. There are very few fish at the Nagmati site at present due to the natural conditions and disturbance. Several small water falls on this stretch already hinders the Snow Trout in free migration up- and downstream. The construction and operation of the Nagmati Dam will not create a significant additional barrier. The natural flow will be maintained during construction and 100 l/s during operation of the Nagmati Dam, to maintain whatever limited aquatic fauna, including fish, supported by the river ecosystem.

78. The construction activities are not foreseen to have any impact on land-use at the Dhap and Nagmati dam sites. Informal and formal users of the open areas around the existing reservoir can continue to access these areas during construction. During operation visitors can use the areas around the new reservoir as before. The shifting of roads, both at the Dhap and the Nagmati sites will be planned and timed not to interrupt any road traffic.

79. With respect to the implementation of green zones from Gokarna to Sinamangal Bridge, local communities are in-formally using about 4km of the river bank areas for homestead gardening. The construction of the green zones with foot and bicycle paths will dis-continue this. However, based on stakeholder‟s consultations with the local communities, they a willing to give up this in-formal practice in return for the establishment of the green zones.

80. During construction the natural flow in the Nagmati River will be maintained by diverting it downstream the dam construction sites. No significant change in the Nagmati River flow and adverse impact on the diversion of water from the Nagmati to the Sundarijal Water Supply system is foreseen during construction.

81. No significant negative impacts on forest (while the forest cleared are compensated as described above) and on vegetation, birds, wildlife and aquatic fauna are expected during operation of the Dhap and Nagmati Dams. Similarly, no negative impacts are considered from operation of the river improvement works from Sundarijal to Sinamangal Bridge.

4. Cumulative Impacts

82. The Project would potentially contribute to three types of cumulative impacts in relation to the present development in the SNNP: (i) Reduction in forest cover; (ii) Alteration in flora and fauna; and (iii) Alteration in road access. There are no on-going or immediate upcoming projects that are expected to significantly affect forest cover, flora and fauna or the Nagmati/Bagmati River flow in the SNNP, However, there is a proposed project for upgrading the existing (non-formalised) road from Sundarijal via Mulkharka, that passes the Nagmati Dam site, continue further north of the Dhap.

83. Overall the cumulative impacts on forest cover, flora and fauna is considered to be insignificant and with no loss of bio-diversity.

84. With the cumulatively improved access by upgrading of the road to the Dhap site in the SNNP, more visitors can be expected, with an increased need for tourist facilities. The Project includes the provision of walking treks around the extended Dhap, viewpoints and toilet as well as waste handling facilities, as mitigation.

85. The Project would potentially contribute to three types of cumulative impacts in relation to the River Improvement interventions in the Upper Bagmati: (i) Alteration in river water flow; (ii) Alteration in river water quality; (iii) Alteration in the aesthetic value of the riparian river environment. Projects and development with potential cumulative impacts are: (i) The Melamchi

project; (ii) Population growth and urbanisation; (iii) Sundarijal Water Treatment Plant; (iv) Irrigation upstream Gokarna; (v) Upgrade and expansion of Gokarna and Guheshwori Waste Water Treatment Plants; and (vi) Treated wastewater from Guheshwori to be diverted downstream the Project area.

86. Overall, no negative cumulative impacts on water quantity are foreseen. With decreasing irrigation due to urbanisation a positive cumulative impact is foreseen. The upgrading and expansion of the WWTPs at Gokarna and Guheshwori and the diversion of the outlet from Guheshwori WWTP downstream of the Project area will have a high, positive cumulative impact on river water quality.

87. Population growth and urbanisation will increase the pressure on the riparian river environment, and if not curtailed, river banks in the will increasingly be used as a dumping ground for solid waste. The Project mitigates the potential cumulative impact by providing a riparian river environment with green zones, walking and bicycle paths, beautification and amenities in the entire stretch from Gokarna to Sinamangal Bridge. In parallel mobilising and raising awareness of local stakeholders and communities to adopt and protect the improved river environment.

88. However, the present lack of proper solid waste management infrastructure constitutes a risk for a cumulative negative impact on the riparian environment. No other projects or initiatives to provide solid waste management infrastructure has been identified at present. There is a medium risk of a negative cumulative impact if solid waste management infrastructure is not provided in Kathmandu as a whole. The Project provides mitigation in the most urbanised areas downstream in the project area, by training households in solid waste collection and handling on household basis.

F. Alternatives

1. No-Project Alternative

89. Without the Project the water flow and water levels will remain at the present low level that prevents the recreational, cultural and religious use of the Upper Bagmati River.

90. The ADB financed Kathmandu Valley Wastewater Management Project will improve the water quality in the Bagmati River by collection of waste water and expanding the waste water treatment capacity in Gokarna and Guheshwori within the project area of the Upper Bagmati, expected to be completed within a 5-year period. However, if the river flow during the dry season remains at the present level, the targets of reaching a water quality acceptable for the recreational, cultural and religious use of the Upper Bagmati River will not be reached.

91. While the water quality will be improved the full benefits of the Kathmandu Valley Wastewater Management Project (KVWMP) will not be reached if the River Improvement works under the Present Project are not implemented. The river stretch from Tilganga to Sinamangal Bridge will remain in an entirely un-aesthetic condition preventing any recreational use of the river environment. And the river stretch upstream Guheshwori will remain un-attractive and cannot be used to the benefit of the increasing population in this area.

2. Location and Intervention Alternatives

92. Having considered any options for improving the riparian environment along the Upper Bagmati the Project adopts the structural interventions identified under the BREMP: (i) Low check dams that aerate the flow and provide bio-filtration; (ii) Reshaping the riverbed to achieve desired water levels and velocities at temple sites; and (iii) Improving the riverbanks and riparian areas including their management, to be the most feasible to achieve Output 2: An improved riparian river environment along the Upper Bagmati.

93. Having considered any identified options for increasing the storage capacity and increase the water availability in the Upper Bagmati to achieve the water quantity target of 200 l/s and water quality target of bathing water standards at the temple sites at Gokarna and Pashupatinath (BOD< 6mg/l and DO> 3 mg/l) set forth in the BREMP, it is concluded there are no feasible alternatives than to establish this storage capacity in the Shivapuri Nagarjun National Park (SNNP) to achieve Output 3: Increased Water Availability in the Basin during the Dry Season.

G. Consultation, Disclosure and Grievance Mechanism

1. Consultation

94. As part of the EIA, stakeholder and community consultations were carried out during field visits. The consultations included discussions with stakeholders and village level authorities. Field visits were jointly undertaken with a Range Officer from the SNNP to identify the extent of physical activities and likely impacts to forest/vegetation, if any. Also, a number of officials from various agencies, i.e., the Ministry of Forests and Soil Conservation, Department of National Parks and Wildlife Conservation, Ministry of Environment, Science and Technology, Village Development Committee members etc., have been consulted.

95. The findings of the Draft EIA report were presented to Government Agencies, local NGOs, local representatives and other stakeholders at a workshop on the 23rd of April 2012. The Project was presented along with the impacts identified and the proposed measures to mitigate or reduce any adverse impacts, and where this is not possible, provide compensation.

96. The consultation and disclosure process will expand significantly during implementation of BRBIP following the Communication Strategy and Plan. An experienced NGO will be engaged to support the Project Coordination and Management Unit (PCMU) in handling this key aspect of the programme. A wide range of activities will be conducted in all areas covered by the project, to ensure that the needs and concerns of stakeholders are registered, and are addressed in the project design, construction or operation where appropriate.

2. Disclosure

97. During project implementation public information campaigns will be carried out (via news media, posters, etc.) to explain the project to the population in the project area and prepare them for disruption they may experience once the construction programme is underway. Further, regular public disclosure meetings will be arranged at key project stages to inform the public of progress and future plans, and to provide copies of summary documents in Nepalese and English.

98. Formal disclosure of summaries of EIA findings and EMP reports will be carried out by making copies available at the HPCIDBC office, informing the public of their availability, and providing a mechanism through which comments can be made. Further, 3-4 pages hand-outs will be provided in local language at public accessible places like VDC and municipality offices.

3. Grievance Mechanism

99. The process for resolving complaints that may arise in the project will be handled by a grievance redress mechanism to be established by a Safeguard and Monitoring & Evaluation Unit under the PCMU within 12 months from Project start and before construction works begin. As the Project does not entail any land acquisition except for a smal plot of land for the powerhouse at Sundarijal (under Phase II of the project) and there are no resettlement issues, the types of grievances expected to be handled are generally construction-related grievances brought up during construction by households living close to construction sites.

100. Local households and stakeholders will be informed about the setting up of the Grievance mechanism by the PCMU before start of any construction as part of the community mobilisation process under the Communication Strategy Plan implementation. Besides, at the construction sites and at the Chief Warden (SNNP) and the PCMU offices boards will be set up which give the contact details of persons to be contacted in case of any grievances. The information will be specific related to the construction works and provided in local language describing the Project, the grievance mechanism and where and to whom stakeholders can deliver their complaints, and in what form, verbal or written.

H. Environmental Management Plan

1. Environmental Management Plan and Responsible Authorities

101. The Environmental Management Plan (EMP) outlines the environmental management system that will be implemented during the detailed design and construction works of the project to manage minimisation of deleterious effects and implementation of enhancement measures. The primary focus of the EMP is mitigation of environmental impacts occurring in the natural and social environment.

102. The objective of the EMP is to provide a framework for the monitoring and management The EMP outlines the environmental management system that will be implemented during the detailed design and rehabilitation works of the project to manage minimisation of deleterious effects and implementation of enhancement measures. The EMP monitors and manages environmental aspects and issues of the Project during detailed design, implementation of the works and Operation and Management.

103. The primary responsibility for environmental management lies with the PCMU. The PCMU through the project Director is responsible for ensuring that (i) all required mitigation measures that need to be incorporated into the project design are passed onto the design engineers, (ii) the bidding document for contractor contains all required mitigation measures to be implemented during the construction period and contractors' obligations to implement the EMP during construction, (iii) the environmental clearance is obtained before commencement of civil work in the relevant section of project road, (iv) implementation of EMP is monitored regularly as required and the annual report on implementation of the EMP is well documented, (v) other parties and government agencies implement the EMP at all stages of the Project, (vi) remedial actions are undertaken in response to unpredicted environment impacts, and (vii)

additional environmental assessment is undertaken if any change is alignment or project design takes place.

104. To ensure that contractors comply with the provisions of the EMP, the following specifications should be incorporated in all construction bidding documents: (i) the environmental mitigation measures and environmental monitoring works that need to be implemented by the contractor; (ii) environmental clauses for contract conditions and specifications; and (iii) the EIA report.

2. Environmental Monitoring and Reporting

105. The contractors will develop a construction environmental management plan (CEMP) based on the EMP to be approved by the PCMU. The D&B contractors are to submit monthly CEMP implementation status reports to the PCMU. The monthly progress report should contain information on the works carried out and the results of all mitigation, monitoring and investigation works performed during that particular month.

106. The monthly reports should be reviewed by the Safeguard and M&E Unit under the PCMU, who should submit semi-annual monitoring reports to ADB, Project Steering Committee, and MOSTE.

107. The Independent Environmental Monitoring Consultant shall carry out quarterly compliance monitoring and reporting regarding the environmental performance during the construction phase.

I. Conclusions and Recommendations

108. Overall, the BRBIP project will provide substantial environmental benefits and increase water security for the population in the Upper Bagmati. The Project will be implemented over 2 Phases with the major interventions in Phase I being extension of the existing Dhap Dam and reservoir in the Svivapuri Nagarjun Nation Park, and provision of river protection, green zoning and beautification in the Upper Bagmati, with a range of support interventions.

109. During Phase II it is envisaged to implement a larger storage facility at the Nagmati River, a tributary to the Bagmati River in Shivapuri Nagarjun National Park. In addition extend the river protection, green zoning and beautification in the tributaries in the Upper Bagmati basin.

1. Phase I

110. The environmental impacts caused by siting, planning, design, pre-construction; construction and operation of the Dhap are generally minor. The negative impact from clearing of the trees at the borders of the Dhap will be fully compensated through replanting of trees following GoN rules. Extension of the Dhap will provide important benefits for securing a more sustainable low flow during the dry season, and improve water availability and safe bathing standards at temple sites during festivals. It is recommended that the extension of the Dhap is implemented following the Bagmati Action Plan.

111. Watershed management and livelihood initiatives will have no negative environmental impacts. Watershed management initiatives in the SNNP will reduce soil erosion and support income generating through e.g. organic farming, provision of fuel efficient stove cooking

facilities, solid waste and wastewater handling. It is recommended to implement the proposed watershed initiatives.

112. The river improvement works for the Upper Bagmati will have only minor negative impacts that will be reduced or entirely mitigated through the EMP. The considerable environmental benefits over the lifetime of the interventions by far outweigh any minor, temporary impacts during construction. During operation the interventions will provide a sustainable river environment for the benefit of the population along the Upper Bagmati. It is recommended to implement the Upper Bagmati River Improvement works.

113. The implementation of rainwater harvesting in the urbanising areas in the Upper Bagmati will have no negative environmental impacts. Installing rainwater harvesting retains the groundwater recharge capacity in areas, where traditional housing and urbanisation will prevent groundwater recharge. It is recommended to implement the rainwater harvesting facilities.

114. Community mobilisation and awareness raising is an important component of Phase I that will create ownership of the improved river environment among the people living along the Bagmati River with the target that they adopt the river environment and help to protect and maintain it.

2. Phase II

115. Where the extension of the Dhap Dam during Phase I create opportunity for achieving bathing water quality standards at temple sites down to Pashupatinath during festivals in the dry season, establishing the Nagmati dam will provide a storage capacity to achieve year round bathing water quality at the temple sites down to Pashupatinath. The environmental impacts caused by siting, planning, design, pre-construction; construction and operation of the Dhap are generally minor. The negative impact from clearing of the trees in the Nagmati reservoir area will be fully compensated through replanting of trees following GoN rules. It is recommended that the Nagmati Dam is implemented following the Bagmati River Environment Management Plan.

I. INTRODUCTION

A. Project Background

1. The Bagmati River holds a special place in the national identity of Nepal as it is related to the mythological birth of civilization in the Kathmandu Valley. It is also considered a holy river and counts many cremation ghats and temples of great cultural value along its banks that attract Hindu devotees from all over the world who traditionally purify themselves in the holy Bagmati waters. Apart from its cultural and religious significance, the Bagmati river basin also has high economic importance as it must meet the water requirements of the country‟s capital city and downstream communities.

2. Rapid increase in Kathmandu‟s population and related city expansion has put tremendous pressure on the water resources of the Bagmati River Basin. In the absence of orderly planning and financing for sewage collection and treatment, the river has become the main drain. Solid waste is also regularly deposited on the river banks and this causes further deterioration of the river environment. Downstream the Pashupatinath Temple the Bagmati River is biologically dead as the flow remaining is heavily polluted with sewage, thereby endangering the health of downstream water users in greater Kathmandu.

3. Rapid increase in Kathmandu‟s population and related city expansion has put great pressure on the water resources of the Upper Bagmati Basin. During the dry season, around 80% of the Bagmati river flow is diverted for drinking water purposes leaving very little flow to carry waste effluents. Thus there is an urgent need to protect and enhance water resources and increase water discharge to the Bagmati, conserve terrestrial and aquatic biodiversity and to maintain and enhance the river water quality. The concerns for the river environment and the pressing needs for improvement are expressed in the Bagmati Action Plan (BAP) prepared in 2008. It addresses the issues to restore the health of the Bagmati River.[3] The Bagmati Action Plan activities include the expansion of the water recharging capacity by expansion of the existing Dhap (a constructed reservoir lake/wetland within the Shivapuri Nagarjun National Park (SNNP).

4. The Government of Nepal (GoN) intends to address the pressing environmental issues in the Bagmati Basin in a systematic manner based on the BAP with the support from the Asian Development Bank (ADB) through the Bagmati River Basin Improvement Project (BRBIP), hereinafter called the Project. A concept for the BRBIP was formulated in early 2011 and in mid-year an ADB mission visited Nepal to define its intended scope and objectives, and to agree upon the scope and Terms of Reference (ToR) for a Project Preparatory Technical Assistance (PPTA). The Project was included in the Nepal Country Operation Business Plan (COBP) together with a PPTA for possible financing by the Japan Fund for Poverty Reduction (JFPR).

5. At the same time a regional Capacity Development Technical Assistance for Supporting Investment on Water Security (CDTA 7547), approved in 2010, studied the Bagmati river basin with the aim of accelerating economic growth and to improve the living standards in river basins through efficient, effective, and sustainable water resources management, environmental conservation, and water-related disaster risk mitigation. The CDTA prepared a Bagmati River Basin Profile, a Strategic Roadmap for Integrated Water Resources Management (IWRM) and the Bagmati River Environment Management Programme (BREMP) and carried out technical

[3] Bagmati Action Plan (2009-2014)

studies which helped to identify the types of physical intervention which would be appropriate for the BRBIP.

6. The BREMP identified key issues affecting the river environment in the Upper Bagmati in terms of its flow, water quality, and riparian environment under future scenarios that include the impact of: (i) future population growth and urbanization; (ii) the Melamchi Water Supply Project generating additional waste water; (iii) planned development of wastewater treatment facilities; and (iv) ongoing river training works being carried out by local authorities.

7. With stakeholders, the BREMP proposes a set of target objectives along the river which include increasing the flow rate and improving the river‟s water quality to bathing standard at the main temple sites of Gokarna and Pashupatinath considered to be representative key locations for the river environment. The targets focus on (i) improving the river water‟s clarity, odour, and visual cleanliness; (ii) achieving the flow and quality targets for the dry season as needed for cultural festivals and for all of the wet season; (iii) achieving the flow and quality targets all year; and (iv) achieving a healthy ecological environmental flow.

B. Objective and Scope

8. The Asian Development Bank (ADB) is supporting the Government of Nepal (GoN) to address these critical water security issues in the Bagmati River Basin by financing the preparation of the Bagmati River Basin Improvement Project (BRBIP) under a present PPTA. The Ministry of Urban Development (MOUD) is the Executing Agency (EA) with the High Powered Commission for Integrated Development for Bagmati Civilization (HPCIDBC), Department of Irrigation (DOI), and Water and Energy Commission Secretariat (WECS) as the Implementing Agencies (IA). In addition HPCIDBC will establish and host the Project Coordination and Management Unit (PCMU), to be supported by a Project Management and Construction Supervision Consultant (PMSC consultant).

9. The BRBIP has been envisioned to improve water security and resilience to potential climate change impact in the Bagmati River Basin. It aims to build on the general public‟s desire to restore the river environment in the Kathmandu Valley and the Government‟s efforts to improve irrigation development and mitigate the impact of water-induced disasters in the middle and lower reaches of the Basin. The project adopts the principles of integrated water resources management (IWRM) and provides Nepal with its first opportunity to apply this key policy element since it has been adopted under the National Water Plan in 2005.

10. The expected outputs of the Project will be in five main areas: (1) Effective integrated and participatory river basin management; (2) Improved river environment in the Kathmandu Valley; (3) Increased water availability in the basin in the dry season, (4) Reduced water-induced disaster impact on basin communities, and (5) Efficient Project Management and Stakeholders Coordination.

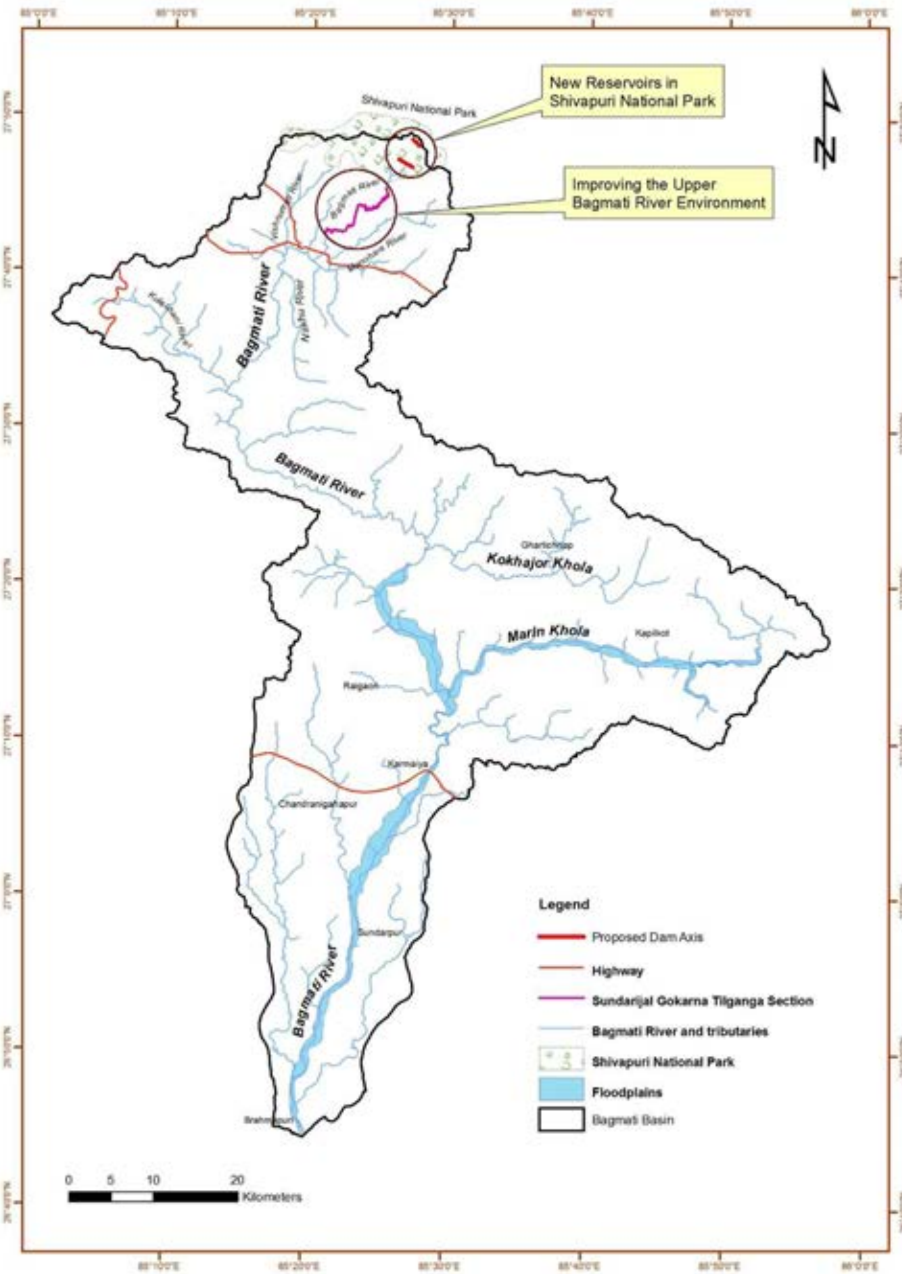
11. The Project is envisaged to be implemented in Phases, with Phase I targeting riparian environment improvement and beautification along the semi-urban/urban river stretches in the Upper Bagmati, and providing a basic storage facility be extending an existing dam at the Dhap site in the headwater of the Nagmati, the main tributary to the Bagmati River in the SNNP. At the same time, in Phase I, preparations will be made for Phase II through the detailed design of a larger water storage capacity in the SNNP by constructing a dam at the Nagmati River, to be financed in Phase II of the project. Phase I and II are further envisaged to extend the river

improvement and beautification works along the Upper Bagmati to other tributaries in Kathmandu, e.g. Bishnumati and Hanumante.

12. The present EIA covers the planning, design, construction activities and operation related to achieve Outputs 2 and 3, as outputs (1), (4) and (5) are related to planning, installation of flood forecasting and project management.

13. A map of the Bagmati River basin and the placing of Project Interventions to achieve Outputs 2 and 3 are shown in Figure I-1.

Figure I-1 The Bagmati River Basin in Nepal. Project Component interventions



Source: PPTA.are indicated.

C. Objective and Scope of the EIA Study

14. The objective of this Environmental Impact Assessment (EIA) is to identify the impacts associated with the planning, design, implementation and operation of the activities and civil works to reach Output 2, River Environment Improvement and Beautification along the semi-urban and urban stretches of the Upper Bagmati River; and for Output 3, establishment of increased storage capacity in the SNNP, promotion of watershed management in the SNNP, and provide incentives for rainwater harvesting in the Upper Bagmati River Basin.

15. The proposed sites for the Dhap and Nagmati Dams are located within the protected area of the Shivapuri Nagarjun National Park (SNNP). The proposed River Environment Improvement interventions are confined to the Bagmati River corridor from Gokarna down to Sinamangal Bridge approximately 1 km downstream of the Tilganga Bridge, see Figure III-2.

16. The scope of this EIA is to assess the potential environmental, health, safety and social impacts of the proposed river improvement and beautification works and dam construction and identify adequate mitigation, compensation and enhancement actions to ensure compliance with ADB"s Safeguard Policy Statement (SPS) and Government of Nepal"s environmental safeguard requirements[4].

D. Methodology

17. The EIA has been prepared during the project preparation work from September 2012 to May 2013. The assessments have been carried out based on primary data from field surveys conducted by Kathmandu University during the months of September and November 2012 and January 2013. Besides, secondary data have been collected from a variety of other sources.

18. In order to assess the technical and economic feasibility of the dams investigative surveys have been carried out including topographic surveys of the dam sites to determine the potential dam volume, and drilling investigations to determine the geo-technical suitability at both sites. Two separate Initial Environmental Examinations (IEEs) were carried out for the investigative surveys and the implementation overseen following the Environmental Management Plans prepared.

19. During the site visits, the Specialists had discussions with various stakeholders including Shivapuri Nagarjun National Park (SNNP) staff, Village Development Committee (VDC) members and local executive powers for their opinions on the proposed project components.

20. Workshops have been held with stakeholders on the overall concepts and designs of the BRBIP, building on the consensus reached during the formulation of the BREMP on the water quality targets to be met at strategic important locations along the Bagmati River, especially at the temple sites at Gokarna and Pashupatinath.

21. The findings of the EIA were presented at a workshop held in Kathmandu on the 23rd April 2013, where government organisations, universities, NGOs and local stakeholders were present and provided valuable feedback for the finalisation of the EIA. Results of the consultations as well as an evaluation of the institutional framework have been incorporated into this assessment, see Table VII-1.

E. Structure of the Report

22. This EIA report is structured (below) in compliance with the outline prescribed in Annexure 1 (Safeguard Requirements 1: Environment) of ADB"s Safeguard Policy Statement.

Section 1: Introduction
Section 2: Policy, Legal, and Administrative Framework
Section 3: Description of the Project
Section 4: Description of the Environment

[4] ADB Safeguard Policy Statement, June 2009

Section 5: Anticipated Environmental Impacts and Mitigation Measures
Section 6: Analysis of Alternatives
Section 7: Information Disclosure, Consultation, and Participation
Section 8: Grievance Redress Mechanism
Section 9: Environmental Management Plan, and
Section 10: Conclusion and Recommendations.

II. POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

A. Government of Nepal Environmental Laws and Regulations

23. The Government of Nepal (GON) has a well-established legal framework for environmental assessment of infrastructure development projects. A number of laws have been passed, dating from the Aquatic Life Protection Act of 1961 to the present. Foremost of these which are relevant to the proposed BRBIP project are the Environment Protection Act (EPA) of 1997 and the Environment Protection Rules (EPR) also of 1997 and with Amendments in 2007.

24. The EPA and EPR are the key legal provisions governing the environmental safeguards in Nepal. Section 3 of the EPA mandates project developers to carry out environmental assessment of projects at the level of IEE or EIA. It prohibits the implementation of any project without receiving environmental clearance from the GON in the form of approved EIA or an IEE reports. Rules 2 and 3 of the EPR require a project developer to carry out IEE or EIA for the type and size of projects as listed in the Schedule 1 or 2, respectively. As per the provisions in EPA (1997) this Project requires an EIA.

25. The most relevant national policies, acts and guidelines of the GON concerning environmental safeguards, which are relevant to the proposed dam construction works and dam operations, are discussed in subsequent paragraphs.

26. **Aquatic Animals protection Act, 1961:** This Act is one of the oldest acts in Nepal that recognizes the value of wetlands and aquatic animals. Under the Act, any party is punishable for introducing poisonous or explosive materials into a water source or destroying any dam, bridge or water system with the intent of catching or killing aquatic life. It also defines “private water” as a lake, pond, ditch, pool or reservoir that is on land used by a person who has been paying land tax to the government. Although the Act has been in effect for quite some time there is no designated agency to administer it.

27. **National Park and Wildlife Conservation Act, 1973, GON:** It addresses the conservation of ecologically valuable areas and indigenous wildlife. The Act prohibits trespassing in park areas, prohibits wildlife hunting, construction works in the park area, damage to plant and animal, construction of huts and houses in park area without permission of authorized persons. It lists 26 species of mammals, 9 species of birds, and 3 species of reptile as protected wildlife. Since some of the activities of the proposed project will be carried out within SNNP, clearance from Department of National Park and Wildlife Conservation (DNPWC) within the Ministry of Forests and Soil Conservation (MFSC) is required. The SNNP officials, DNPWC, and MFSC have been consulted during project preparation and clearances will be obtained as required.

28. **Soil and Watershed Conservation Act, 1982:** The Soil and Watershed Conservation Act empowers the government to declare any area as a protected watershed to limit degradation of land by floods, water-logging, salinity in irrigated areas and acceleration of

siltation in storage reservoirs, and to properly manage the watersheds of Nepal. The Act of 1982 and its regulations of 1985 together provide the legal basis for managing watersheds. The Act also outlines the essential parameters necessary for proper watershed management (including both rivers and lakes).

29. **The Water Resources, Act 1993, GON:** The Water Resources Act contains provisions to minimize environmental impacts, including soil erosion, floods and landslides. The Act empowers government to frame standards while utilizing water resources and to frame rules on environment related matters and controlling pollution. The Water Resources Rules, 1993 oblige the proponent to analyze environmental impacts of a proposal and state that such study should contain environmental control and safety measures and other necessary arrangements to resettle people during hydro-electricity development. Also, in a process for resolving any conflict, the Water Resources Utilization Investigation Committee should consider environmental impacts likely to occur from a proposal. The Irrigation Rules, 1989, prohibits activities, which pollute the canal or irrigation.

30. **Environmental Protection Act, 1997, GON:** It stipulates that any development project, before implementation, shall pass through an environmental assessment, which may be either Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA). Approval of the reports and environment clearance will be provided by a competent government agency as identified by the Act. The Act restricts polluting activities and authorizes government for monitoring and enforcement. The Act has provision of compensation to affected parties from environmental impacts and punishment to polluters. Environmental Protection Rule (EPR) 1997 (amendment, 2007), GON: It provides various step-wise requirements to be followed while conducting EIA and IEE studies. The rules also oblige the Proponent to timely consult and inform the public on the contents of the proposal and EIA and IEE studies. The authority approving EIA reports is the Ministry of Science, Technology and Environment. The practice, however, in some cases is that the final report is routed through the concerned Department or Ministry.

31. **Forest Act, 1993 (amendment, 2007), GON:** This Act requires decision makers to take account of all forest values, including environmental services and biodiversity, not just the production of timber and other commodities. It includes several provisions to ensure development, conservation, management, and sustainable use of forest resources based on appropriate planning.

32. **Forest Rules, 1995, GON:** These rules elaborate legal measures for the conservation of forests and wildlife. Clearance to cut trees is required from Department of Forest. Expenses incurred for cutting trees and transportation is to be borne by the infrastructure developer. As per the Working Policy Relating to Construction and Operation of Physical Infrastructures within Protected Areas, 2008, if a project requires cutting of trees having girth size of more than 10 cm, then the project proponent is required to plant 25 trees for each tree cut including the provision of 5 year maintenance as compensatory afforestation.

33. **Nepal Environmental Policy and Action Plan (NEPAP I and II)**, **1993/1998**: The NEPAP seeks to: (i) Efficiently and sustainably manage natural and physical resources; (ii) balance development efforts and environmental conservation; (iii) Safegurad national heritage; (iv) Mitigate adverse environmental impacts on development projects and human actions, and (v) integrate environment and development through appropriate institutions, adequate legislation and economic incentives. The NEPAP addresses the preservation of endemic and endangered species and their habitats; the promotion of private and public institutions for biological

resources inventory and conservation; and the strengthening of the capacity of the Department of Nature Parks and Wildlife Conservation (DNOWC).

34. **Wetland Policy, 2003, GON:** This policy has been formulated for planned conservation, maintenance and development of Nepal‟s wetlands, while providing support to economic, social and cultural development of local communities by improving their living conditions through wise use of wetlands. In conformity of the wetland‟s policy, Nepal is a signatory to the Ramsar Convention[5]. The major objective of the policy is to involve local people in the management of Nepal‟s wetlands and conserve wetland‟s biodiversity with wise use of wetland resources.

35. **Water Induced Disaster Management Policy, 2003, GON**. The GON adopted the Water Induced Disaster Management Policy with the objectives of: (i) minimizing the loss of public and property related to water induced disaster; (ii) conserving watershed and aquatic ecosystem for the sustainable use of water related infrastructures, (iii) controlling water induced disaster and management of flood affected areas, and (iv) clarifying the role of government and non-government organizations involved in river management activities. The policy has identified five strategic areas for its implementation: (a) emergency protection measures, (b) abatement of water induced disaster, (c) natural resource conservation, (d) utilization of river banks and flood plains, and (e) institutional development.

36. **National Adaptation Program of Action (NAPA) 2010[6]:** The NAPA was launched in 2010[7] and the national Climate Change Policy was approved by the GoN in January 2011. However, in important National Plans climate change still needs to be addressed and incorporated.

37. **Integrated Water Resources Management Policy**: With support for the Irrigation and Water Resources Management Project[8] an IWRM Policy has been drafted. However, it is still to be adopted and approved by GON.

38. **National Environmental Impact Assessment Guidelines, 1993, GON:** These guidelines provides guidance to project proponent on integrating environmental mitigation measures, particularly on the management of quarries, borrow pits, stockpiling of materials and spoil disposal, operation of the work camps, earthworks and slope stabilization, location of stone crushing plants, etc.

39. **Manual for Preparing Initial Environmental Examination (IEE) Report for Hydropower Projects.** Department of Electricity Development, in collaboration with United States Agency for International Development and International Resources Group, has prepared a series of manuals to help a proponent to prepare EIA documents within the framework of existing rules and regulations. These guidelines are recommendations rather than mandates.

40. **Labour Rules (1993).** The labour rules sets out the regulations to be followed in Nepal, with respect to general terms for employment, working hours, remuneration and welfare arrangements, health, sanitation and safety.

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5 The Treaty of 1971 for the conservation of wetlands of international importance, especially the habitat of waterfowls, is popularly called the Ramsar Treaty.

6 http://www.idsnepal.org/nseu/knowledge%20products/NAPA%20TO%20LAPA.pdf

7 http://www.idsnepal.org/nseu/knowledge%20products/NAPA%20TO%20LAPA.pdf

8 Irrigation and Water resources Management Project. http://www.iwrm.gov.np/

B. ADB's Environmental Safeguard Requirements and Policies

41. ADB categorizes projects into categories A, B, C, and FI according to the significance of likely impacts. Based on the ADB"s SPS the Project is categorized as category A, based on the most sensitive component 2(a), construction of water retention reservoirs. Category A projects are judged to have considerable adverse impacts that are irreversible, diverse, or unprecedented.

C. International Agreements and Conventions

42. Nepal has signed a number of international social and environmental conventions and agreements, which all require approval and follow-up legislation from the national parliament. Similarly, Nepal is a member of international organisations and NGOs, working for social or environmental causes.

43. Nepal became a signatory to the Ramsar Convention in 1971 and came into force in December 1975. The present Wetlands policy promulgated in 2003 is in conformity with the Article 3 (1) of the Convention.

44. Nepal is a signatory to The Convention on International Trade in Endangered Species. Department of National Park and Wildlife Conservation is the management authority and National History Museum is the scientific authority for CITES listed fauna.

45. Nepal is also a signatory to the UN Convention on Climate Change with MoSTE as the focal point and DHM under MOSTE being responsible for information dissemination related to Climate Change. As signatory of the UN Framework Convention on Climate Change, Nepal has ratified the Kyoto Protocol in September 2005 and it took effect in December 2005.

46. Nepal signed the Convention on Biological Diversity in June 1992, which was ratified by the Nepal Parliament in November, 1993. Nepal became party to the convention in February 1994.

47. Forest principles. Nepal has accepted the non-binding UNCED principles on forest regulation and management. These principles mainly require increased public participation, respect of indigenous cultures and rights, empowerment of women, comprehensive valuation of forests, sustainable management of natural forests, extension of forest cover, conservation of biodiversity and pre-project environmental assessment.

48. Agenda 21. Nepal is implementing "Agenda 21", a non-binding international statement of goals and principles. It asks countries to promote activities that are well supported in Nepal, such as alleviation of poverty, improved land use, conservation of biodiversity, public participation, empowerment of women, respect of indigenous cultures, working with NGOs development of human resources, etc.

49. In 2007, the Government of Nepal ratified the (International labour Organisation (ILO) Convention 169 on Indigenous and Tribal Peoples and voted in favor of the UN Declaration on the Rights of Indigenous Peoples (UNDRIP). However, the implementation of ILO Convention

169 is still wanting, and it is yet to be seen how the new constitution will bring national laws into line with the provisions of the ILO Convention and UNDRIP[9].

D. Institutions

50. In the following the main institutions to be involved directly in the Project are listed. Their direct involvement and performance are of vital importance to the implementation of the Project. In some of these institutions it is considered that their capacity is inadequate to support the implementation of the Environmental Management Plan for the Project, and for these capacity building and support is included as part of the EMP to be provided by the PCMU supported by the PMSC.

1. Ministry of Science, Technology and Environment

51. The principal national agency charged with environmental protection is the MoSTE. The role of MoSTE is to protect the environment, conserve life support elements (air, soil, and water), create clean and healthy environment and to promote use of science and technology for sustainable development. MoSTE is the responsible body for setting environmental standards for rivers and developing and enforcing standards for disposal of wastewater effluent into natural bodies. The environmental assessment for development projects is also approved by MoSTE. It is also the agency required to respond to any complaints from the public about environmental issues.

52. Under MOSTE is the Department of Hydrology and Meteorology (DHM) that monitors all the hydrological and meteorological activities in Nepal. The scope of work includes the monitoring of river hydrology, climate, agro-meteorology, sediment, air quality, water quality, limnology, snow hydrology, glaciology, and wind and solar energy.

2. Ministry of Forest and Soil Conservation (MFSC)

53. MFSC is responsible for managing forest and watershed areas using participatory approach and protection of biodiversity. The Ministry along with its respective departments is the main policy making bodies for forest, watershed and wildlife management.

a. Department of National Parks and Wildlife Conservation (DNPWC)

54. DNPWC is responsible for conservation and management of protected areas including National Parks in the country. DNPWC has implemented the concept of buffer zone management to manage the area (which could be forest area, agriculture land and other land use types) surrounding the national parks by providing certain share from the national park to the user groups of the buffer zone for their local development. DNPWC has plans to declare a buffer zone around the SNNP with the settlements in the SNNP included in the buffer zone. It may be noted that the settlement close to the Nagmati Dam site will be included in the buffer zone. Work on this is on-going by the SNNP authorities under the Chief Warden. The Project will support community consultations and improvement of watershed management in the buffer areas. However, no definite timeline for the declaration of such a zone is given at present. The Chief Warden of the SNNP has wide powers to give permission for activities to be carried out in the national park.

[9] International Work Group for Indigenous Affairs: http://www.iwgia.org/regions/asia/nepal

55. **Expected role in the Project:** Provide permission for surveys and works in the SNNP. Issue entry permits for staff involved in surveys and works. Oversee surveys and works and take an active role in the implementation of the EMP funded by the Project and help identify land for and monitor planting of trees in the SNNP, buffer zone, or elsewhere, in compensation for the loss of tree in the SNNP. Take an active role in wetlands conservation in the SNNP.

b. Department of Soil Conservation and Watershed Management (DSCWM)

56. DSCWM is established with an overall objective to maintain ecological balance by reducing pressure from natural hazards such as floods, landslides and soil erosion through conservation and development of important watersheds of the country. DSCWM oversee planning, implementing and monitoring soil conservation and watershed management programs and activities based on the principles of integrated watershed management. Their aim is to maintain land productivity, reduce soil erosion and contribute in development of infrastructure protection by scientific management of watersheds.

3. Ministry of Energy

57. Ministry of Energy is responsible for the overall utilization and management of water resources available in the country for the production of energy. As per the Work Division (Second Amendment) Rules, 2009 of Government of Nepal, MOE has been entrusted with the tasks to: (i) develop policies, plan and implement projects for conservation, regulation and utilization of energy; (ii) conduct survey study of energy and its utilization; (iii) construct, operate and maintain multi-purpose electricity project; and (iv) and other matters related to energy and electricity.

a. Water and Energy Commission Secretariat (WECS)

58. WECS was established in 1981 with the primary responsibility to assist Nepal Government, the Ministry of Water Resources and other related agencies in the formulation of policies and planning of projects in the water and energy resources sector. The objectives and mandates of WECS have been revised and modified a number of times since their establishment and currently are: to: (i) formulate and assist in developing policies and strategies in the water resources and energy sector; (ii) provide suggestions, recommendations and guidance in the development of irrigation, hydropower and drinking water projects; (iii) prepare policies and plans related to industrial use of water, flood management, in-land navigation, fisheries and other sectors related with water resources, along with the protection of the environment relating to the above sectors; and, (iv) act as a documentation centre for all regional water resources and energy related issues.

b. Ministry of Physical Planning and Works (MPPW)

59. MPPW is the main ministry for the overall planning, implementing, coordinating and monitoring development of road networks, improvement of housing and urban environment developments and increasing access to water supply and sanitation facilities. It was established in 2000 as a part of re-organization of the government institutions of Nepal. MPPW implements its plans and policies through its many departments.

c. High Powered Commission for Integrated Development of Bagmati Civilization (HPCIDBC)

60. HPCIDBC was established in 1995 as the Bagmati Area Sewerage Construction and Rehabilitation Project (BASCRP) with the mandate to improve the quality of the river flowing through Pashupatinath. This involved construction of wastewater interceptors along both sides of the Bagmati River upstream of Guheshwori WWTP to divert waste water and treat it at Guheshwori WWTP developed and operated by HPCIDBC. To date, HPCIDBC has already constructed interceptors from Gokarna to Guheshwori and is now extending the interceptors downstream of Pashupatinath from Tilganga to Minbhavan. HPCIDBC is also undertaking greenbelt works which involves construction and undertaking of river training, retention wall, and greenbelt and corridor roads.

d. Kathmandu Upatyaka Khanepani Limited (KUKL)

61. KUKL is a public limited company established under the Company Act (2006) using the public private partnership model. It is responsible for operation and management of water supply and sanitation services in the service area within the valley. KUKL currently provide water services to all the five municipalities and VDC surrounding the municipalities. These VDC include most of the VDC (Sundarijal, Nayapati, Gokarneswore, Jorpati) located in the catchment area of upper stretch of Bagmati River Basin. KUKL is not directly involved in the Project, but plays a vital role for the implementation of the improved wastewater treatment in Gokarna and Guheshwori WWTPs[10].

4. Kathmandu Valley Development Authority (KVDA)

62. KVDA is an autonomous body established for the purpose of formulating and implementing physical development plans in Kathmandu Valley and thereby make essential services and facilities available to the public. KVDA is provided with an authority to divide the plan area into different land use and lay down conditions for physical development of the plan area. They also have mandate to formulate and implement necessary projects for proper development and maintenance of any religious, cultural and historical heritage. Another key task of KVDA is to prescribe conditions in respect to construction and other activities to be undertaken in forests, rivers, and streams, ghats and aquatic areas for conservation of nature and environment in the plan area.

III. DESCRIPTION OF THE PROJECT

A. Type of the Project

63. The Project objective is to Improve the Upper Bagmati River Environment: The expected outputs of the Project will be in five main areas: (1) Systems and capacity for integrated and participatory river basin management established; (2) Riparian environment in Upper Bagmati River improved; (3) Increased Water Availability in the Basin during the Dry Season; (4) Flood forecasting and early warning system in the Bagmati River Basin is functional; and (5) Project is efficiently managed with effective stakeholder communication.

[10] The WWTPs to be upgraded under the Kathmandu Valley Wastewater Management Project. ADB project Number 43524

Output 1: Systems and capacity for integrated and participatory river basin management established. Institutional development and capacity development to achieve this output under the project includes:

- Support to formation of a River Basin Organisation (RBO)
- Development of a Decision Support System (DSS) based on the existing water resources information system in WECS.
- Upgrading the water quality monitoring laboratory at HPCIDBC.
- Development of a Bagmati Integrated River Basin Development and Management Plan (IRBDMP)
- Provision of legal support to amend the water act and prepare the legal foundation for establishing a RBO, including new legislation to protect environmental flows, including the increase in flow in the Bagmati River, to be achieved under Output 3, below.

Output 2: Riparian environment in Upper Bagmati River improved: Upper Bagmati River Improvement works, including:

- Eleven 1 meter check dams/weirs between Gokarna and Sinamangal Bridge for river bed stabilization and improvement of river water quality from re-aeration;
- Replacement of gabion walls with river walls over 6.1 km from Gokarna to Guheshwori and provision of river walls over a stretch of 1100 meter from Tilganga to Sinamangal Bridge for river bank stabilisation and flood protection on both sides.
- Rehabilitation of two former irrigation regulator structures at Gokarna and Pashupatinath to enhance water depth and amenity;
- Improving the river channel profile around cultural sites (Gokarna and Guheshwori) and rehabilitate and stabilize 2 temple ghats at Gokarna (Uttarbahini/Kanti Bhairab Temple Complex & Gokarneshwor Mahadev Temple Complex);
- Removal and safe disposal of contaminated and accumulated riverbed material at key sites;
- Riverbank stabilisation at Sundarijal where existing housing structures are under threat of river bank erosion[11];
- Enhancement and management of the riparian banks (green zones with foot and bicycle paths) which are under government ownership from Gokarna to Guheshwori.
- Enhancement and beautification of the riparian banks (green zones with foot paths and amenities areas) which are under government ownership from Tilganga to Sinamangal Bridge.

Further to the riparian river works in the Upper Bagmati the project provides for additional riparian river improvement works in other tributaries to the Bagmati River, e.g. the Bishnumati River. The project will assess the feasibility for these works, providing designs of same aesthetic quality as for the Upper Bagmati

[11] Investigations to date at Sundarijal have not evidenced any significant bank stability issues. However, as part of the Nagmati dam dambreak analysis (i.e. part of feasibility studies - refer Section 6.5.7) the bank erosion from dambreak flows will be evaluated and, if needed, remedial measures considered

during Phase 1 of the Project, and if feasible implement the works, partly under Phase I as funds allow, and complete the works under the proposed phase II.

64. Non-structural interventions will include: (i) Mobilisation of local communities for adopting river stretches for river environment protection; (ii) implementation of a Communication strategy Action Plan for awareness raising and community ownership of the river; (iii) a Gender Action Plan addressing gender needs and issues.; (iv) Mobilisation of Village Development Committees (VDCs) and user community groups to monitor and prevent solid waste disposal into the river corridor; and (v) training of 300 households in improved solid waste management.

Output 3: Increased water availability in the basin during the dry season, through:

- Increasing the storage capacity upstream by of increasing the water retention capacity of the existing Dhap by constructing a 24 m high dam a short distance downstream the existing dam an, storing 853,000 m^3 of water, sufficient to provide a dry season environmental flow of 40 l/s.
- Promoting and provide incentives for rainwater harvesting and groundwater recharge via soak away pits for 2500 households along the Upper Bagmati River;
- Improving watershed management in the Shivapuri Nagarjun National Park (SNNP) in general and in the Bagmati River catchment in particular.
- Detailed design for a larger 80 meter high dam at the Nagmati River storing up to 8 million m^3 of water, sufficient to provide a dry season environmental flow of 400 l/s with construction foreseen to be financed during Phase II of the Project.

Output 4: Flood forecasting and early warning system in the Bagmati River Basin is functional

- Upgrade existing flood forecasting system in DHM and provide an operational early warning system for the Bagmati Basin.

Output 5: Project is efficiently managed with effective stakeholder communication. This will include the provision of consultancies under the project for:

- Project Management and Construction Supervision support to a Project Coordination and Management Unit (PCMU) set-up by the EA and IAs.

65. The present EIA covers the planning, design, construction activities and operation related to achieve Outputs 2 and 3.

B. Need for the Project

66. The Bagmati River holds a special place in the national identity of Nepal as it is related to the mythological birth of civilization in the Kathmandu Valley. It is also considered as a holy river and counts many cremation ghats and temples of great cultural value along its banks that attract scores of Hindu devotees from all over the world who traditionally purify themselves in the holy Bagmati waters. Apart from its cultural and religious significance, the Bagmati River Basin also has great economic importance as it plays a crucial role in meeting the water supply

requirements of the country"s capital city and downstream communities, as well as in sustaining irrigated agriculture in the Kathmandu Valley and throughout the basin.

67. Rapid increase in Kathmandu"s population and related city expansion has put tremendous pressure on the water resources of the Bagmati River Basin. In the absence of orderly planning and financing for sewage collection and treatment, the river has become the main drain. Solid waste is also regularly deposited on the river banks and this causes further deterioration of the river environment. Rapid urbanisation has put great pressure on the valley"s water supply distribution system. During the dry season, some 80% of flow in the Bagmati River is diverted for drinking water purposes leaving very little flow for irrigation and other uses including cultural / religious and environmental.

68. As the water supply demand cannot be met from surface sources, the major part is now supplied directly from groundwater. The quantity extracted is estimated to be four to five times higher than the natural recharge and has depressed the water table by up to 35 meters (m) in only 20 years. The situation is further aggravated by (i) rapid disappearance of recharge areas as they are converted into residential areas; (ii) ground subsidence within the city, aggravating local flooding problems; (iii) lowering river stream and sand mining leading to riverbed deepening which further contribute to low recharge; and (iv) upstream catchment degradation which also contributes to lowering the river stream and groundwater recharge. As it exits the city, the river is biologically dead and the little flow that can be seen is heavily polluted with sewage, thereby endangering the health of downstream water users.

69. Competing and uncontrolled use of water in the Bagmati Basin is having an increasing negative impact on sustainable development in the basin as a whole. Plans to improve Kathmandu"s water supply from the Bagmati river basin water sources were developed without consideration for downstream users and environmental flow. Flood protection works and irrigation development are also planned in isolation of other sector requirements. Similarly, discharge of urban wastewater effluent, groundwater extraction, sand mining and solid waste disposal in the river are not regulated. The strong civil society movement and the public"s general interest in the restoration of the Bagmati River is potentially a strong asset for improving many of these fundamental problems.

1. **Dam Storage Requirements**

70. The purpose of the dams under Phase I and II is to provide for a continuous „environmental flow" release into the upper Bagmati River throughout the dry season. Quantification of the level of this „environmental flow" release has been undertaken by a RETA[12]. A Water Balance and Quality Model (WBQM) were developed under the RETA. Using the WBQM, the RETA concluded that flow and water quality along the Upper Bagmati River could be improved by increasing the river"s dry season flow.

71. After excluding options using drinking water from either the Melamchi tunnel or Sundarijal water supply off-take, the only remaining option to increase flows is developing new storage reservoirs in the SNNP. The reservoirs will retain excess wet season runoff for release during the dry season. To determine the necessary storage of the new reservoirs, stakeholder consultations decided their prime objective is achieving perennial flow and water quality targets at Gokarna and Pashupatinath, namely a minimum flow target of 200 l/s and a water quality target of at least bathing standard.

[12] Supporting Investments in Water Security in River Basins. River Basin Profile. ADB TA 7547-REG. JWA May 2012.

72. For determining the size of the reservoirs, future development scenarios were analysed using the WBQM. The target scenario comprises of: (i) the projected 2030‟s population; (ii) post-Melamchi wastewater generation; (iii) urbanization within the catchment with no irrigation off-takes; (iv) a new WWTP at Gokarna servicing all upstream habitations with an effluent standard of BOD=15mg/l, discharging into the river at Gokarna[13]; (v) an upgraded Guheshwori WWTP that treats all wastewater generated between the plant and Gokarna to an effluent standard of BOD=15mg/l[13], discharging to the Bagmati River at its current outlet location immediately downstream of Pashupatinath; and, (vi) all wastewater generated downstream of Guheshwori being collected and diverted away from the basin area (to Dobhighat WWTP).

73. To determine the necessary storage of the new reservoirs, stakeholder consultations decided their prime, and first objective is: (i) Achieving perennial flow and water quality targets at Gokarna and Pashupatinath, namely a minimum flow target of 200 l/s and a water quality target of at least bathing standard (BOD< 6 MG/L, Dissolved Oxygen> 3 mg/l). A second desirable objective in addition to the first, if both economically and technically feasible, is: (ii) To improve the water quality downstream of Pashupatinath in synergy with the planned upgraded Guheshwori waste water treatment plant (WWTP). The river will likely to remain anaerobic even with an upgraded WWTP, and hence continue producing strong odours, unless the WWTP‟s effluent is significantly diluted with additional oxygenated river flow.

74. Having set the water quality targets from the results of the WQBM, a separate and more detailed water balance model (WBM) of the SNNP catchments has been developed by the PPTA. Using the WQBM and WBM sequently, the total reservoir volumes needed to achieve the water quality targets with various reliability were estimated, see Table III-1. Firstly, the WQBM determines the target minimum flow at Sundarijal for the dry season (December to April) based on downstream flow and water quality needs. This target flow is then set in the WBM which iteratively determines the necessary reservoir volume. Lastly, once the reservoir volume is chosen, the reliability of the volume to achieve the target flow is estimated by how many times the reservoir completely empties over the simulated 15-year period.

Table III-1: Total Reservoir Volumes to Achieve Objectives

Reliability	**Total Reservoir Volume (MCM)**	
	First Objective	First and Second Objective
1/2 years (50%)	3.0	4.5
2/3 years (66%)	3.0	8.0
3/4 years (75%)	5.5	10.0
4/5 years (80%)	5.9	11.0

Source: PPTA

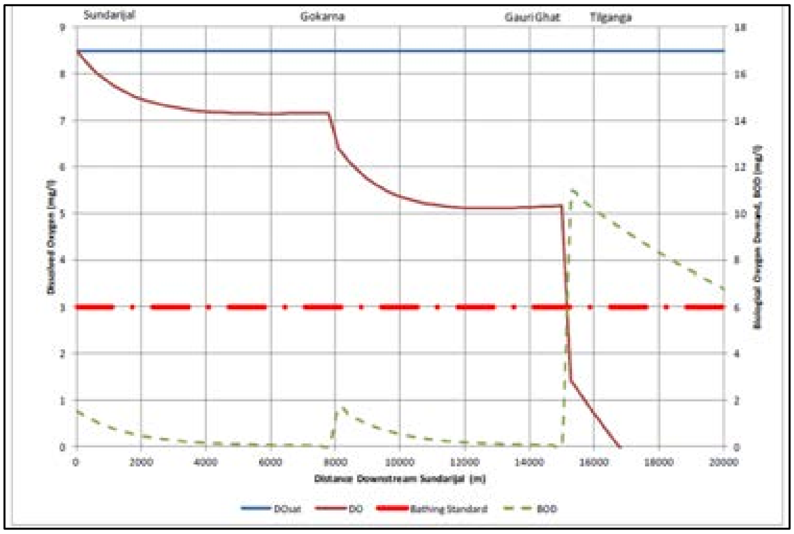
75. The modelling results show that the benefits for the river are directly proportional to the total storage size of the reservoirs: additional storage equates additional benefits in terms of higher flow rates, improved water quality and a longer reach of river improved. An example of the water quality analysis is shown in Figure III-1. This figure shows the dissolved oxygen (DO) and BOD profiles in February, the driest month, along the Upper Bagmati River in a scenario with release of 400 l/s from the reservoir(s) in SNNP[14]. The DO profile shown in the figure exceeds the bathing water quality standard (> 3 mg O_2/l) until downstream of Pashupatinath where the Guheshwori WWTP effluent discharges into the river: within this reach the DO drops to zero and the river becomes anaerobic. Similar to the DO profile, the BOD concentration

[13] To be financed under the ADB Proj.no. 43524: Kathmandu Valley Wastewater Management Project (Approved)

[14] The shown water quality will be reached with release of 400 l/s during festivals by Project Phase I, while the water quality will be achieved throughout the dry season by Project Phase II in two out of 3 years.

profile along the river shows that BOD will be within bathing standards (< 6 mg BOD/l) until downstream of Pashupatinath.

Figure III-1: Example of WQBM Output (Scenario 3.4)



Source: RETA 7547

76. Creating a reservoir with a storage capacity of approximately 850,000 m^3 at the Dhap, would support a continuous release rate of 40 l/s over the 8 month long dry season. However, with a continuous release of 40 l/s the water quantity and quality objectives will not be met at the temple sites. Alternatively, water can be strategically released to provide enough water at the temple sites to achieve bathing water quality standards during festival periods.

77. If a second dam is constructed at Nagmati (during a subsequent Phase II of the Project) with a total storage of 8MCM: (i) a perennial minimum flow rate of 200 l/s, meeting bathing water quality standards will be achieved almost continuously at Gokarna and Pashupatinath temples; while, (ii) the river downstream of Pashupatinath will be aerobic and have little or no odour at all times. In this reach, the water quality will be further improved with the planned provision of check dams, managed wetlands/phyto remediation, household rainwater harvesting systems, and riparian beautification and management. These features will also provide some degree of reassurance on the water quality standards that will be achieved under the project, including accounting for the limitations of the WBQM as discussed above.

C. Locations and Features of the Project Components

78. Table III-2 lists the nature and size of the structural outputs 2 and 3 of the BRBIP.

Table III-2: Output 2 and 3

River Improvement Works	Function	Description	Location
2. Riparian environment in Upper Bagmati River improved			
2.1 River profile rehabilitation and phyto-remediation			
River walls/ embankments. Boulders and river bed plants.	Low-flow control, enhancement of aesthetics and in-river water quality improvement	Approx. 7.2km of river corridor is improved through strengthened river walls and beautification with green zones and recreational amenities employing 30% of women and DAG worker. 1.1km river corridor banks with boulders of a size that will prevent them from being misplaced during floods will be used to shape river profiles and flow channels for low and medium flows. Planting of suitable vegetation among boulders for beautification and phyto-remediation.	Gokarna to Jorpati Bridge. Tilganga to Sinamangal Bridges.
2.2 Check dams/Weirs			
Eleven 1 meter high checkdams/weirs	River bed stabilisation and re-aeration for in-river water quality improvement	30-40m stone-faced reinforced concrete, increased crest lengths (labyrinth or duck-bill profiles) with scour protection.	Proposed Chainages 8+982, 10+825, 11+213, 11+661, 12+512, 13+380, 14+068, 14+602, 15+700 15+994, 16+104.
2.3 Regulators			
2 existing regulators replaced	Visually attractive fitting cultural heritage. Enhanced re-aeration. Provide safe recreational amenity. Maintain access pedestrian links. Allow control of upstream water levels within the temples.	Regulators with same features as the present. Stone faced reinforced concrete for main structure. Sluice gates for water level regulation. Safe walking path as part of the structure.	1 regulator downstream Gokarna temple. 1 regulator immediate downstream Pashupatinath temple.
2.4 River channel profile through cultural sites			
River channel profile improvement through	Maintaining desired flow depths under	Concept designs prepared and presented to temple	

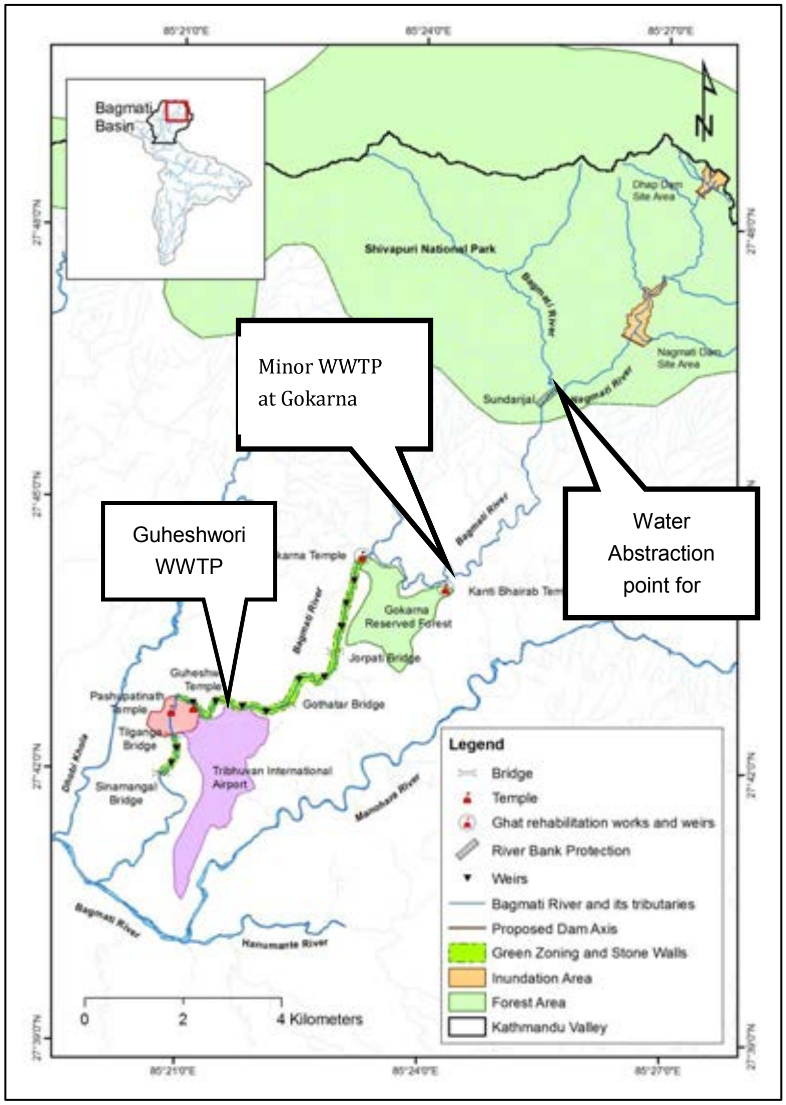
River Improvement Works	Function	Description	Location
temples.	current and future dry season flow regimes.	trusts for their approval and direction for implementation. Design incorporates the creation of low structures that direct the flow and increase the water depth at the Ghats.	
2.4 Temple ghats			
Stabilisation and rehabilitation of ghats	Conserving the heritage and functioning of ghat for religious use.	Provision of weir to reduce erosion and scouring at ghat. Stabilising ghat foundation. Rehabilitation of the ghat itself.	Uttara Bahini Temple.
2.5 River bed material			
Removal of river bed material	Removal of contaminated and accumulated riverbed material at key sites.	Removal of 1000m^3 of contaminated riverbed material and safe disposal at i.e. the Sisdol Landfill site,	E.g. at Pashupatinath and Gokarna temples
3. Increased Water Availability in the Basin during the Dry Season			
3.1 Dhap Dam			
Extension of existing Low-level dam	Increase of impounded water in a storage reservoir for release during the dry season	Extension of the reservoir at Dhap that would increase the water retention capacity of the existing Dhap by constructing low-level concrete faced, rock fill dam of 24 meters height approximately 375 m downstream of the existing dam with capacity to store 850,000m^3. A saddle dam of a height of 9 meter needed in the northern part to prevent overflow. The presently inundated area of approx. 1.5 ha will be increased to 12.5 ha.	The proposed Nagmati Dhap Dam site is located $27^0$48"493" North latitude and $85^0$27"496" East Longitude approximately 2075m above mean sea level in the headwaters of the Nagmati River.
3.2 Nagmati Dam			
Medium sized dam (Phase II of the Project)	Provide an additional flow in the Bagmati River during the dry season to obtain bathing and flow targets at Gokarna and Pashupatinath temple ghats.	80 m high rock-filled dam with spill-way with a storage capacity of 8 MCM. The maximum inundated area is approximately 38 ha.	Nagmati River right upstream Mulkharka and 2 km north-east of the confluence with Bagmati River. 27°46' 49.26"N, 85°26' 32.26" E.

River Improvement Works	Function	Description	Location
Hydropower development (Phase II of the Project)	Provide a hydropower scheme similar to the existing Sundarijal hydropower scheme.	Offtake from Nagmati Dam via. 1 m diameter outlet.	Penstock conveying water along the left (east) bank of Nagmati River and later the Bagmati River. Powerhouse on left (east) bank at Sundarijal.
3.3 Rainwater Harvesting			
Rainwater harvesting and groundwater recharges.	Maintain groundwater recharge in areas under urbanisation.	Provision of subsidies at household level to encourage the instalment of RWH systems in 2500 households with groundwater recharge through soak-away pits. Provision of pilot rainwater harvesting systems in 10 schools. Provision of training programmes to, engineers, architects, plumbers, students and households on RWH systems from installation to O&M.	In the increasing urbanising areas from Sundarijal to Guheshwori.
3.4 Watersheds			
Watershed management.	Maximise rainfall-runoff rates and maintain high water quality standards. Compensate for loss of trees in reservoir areas.	Planting of 25 trees for each tree cleared in reservoir area with a need for 19.6 ha for replanting for the Dhap and 255 ha for the Nagmati reservoir. Slope stabilisation covering 12.5 ha. Promotion of energy saving stoves to 250 households in SNNP to minimize harvesting of wood from the SNNP Training and awareness programme for all households in SNNP.	Estimated 2 ha. of bush land is potentially available in the SNNP. Remaining land needed for re-planting to be identified in the remaining SNNP, in „buffer zone, etc. Re-planting will be carried out by SNNP authorities.

Source: PPTA

The location of the Project Component interventions is shown in Figure III-2.

Figure III-2: Location of project Component interventions in the Upper Bagmati.



Source: PPTA.

D. Riparian River Environment Improvement

79. This sub-component will cover environmental improvements in the Upper Bagmati in the Sundarijal-Gokarna reach and in the Gokarna-Sinamangal reach. Improvements will include:

- (i) 11 Check dams and phyto-remediation between Sundarijal and Sinamangal Bridge;
- (ii) Replacement of two former irrigation regulator structures at Gokarna and Pashupatinath to enhance water depth and amenity;
- (iii) Improving the river channel profile through cultural sites (Gokarna, Guheshwori and Pashupatinath);

(iv) Removal of contaminated and accumulated riverbed material at key sites for safe disposal at Sisdol controlled landfill;
(v) Riverbank stabilisation at Sundarijal (1.2km) where existing structures are under threat of river bank erosion;
(vi) Enhancement and management of the riparian banks which are under government ownership (7.2km from Gokarna to Guheshwori; 1.1km from Tilganga to Sinamangal Bridge) ;
(vii) Training and support to improved solid waste collection and handling in downstream urban areas (300 households);
(viii) Implementation of a communication strategy for engaging the local community, NGOs, CSOs and private sector to support improving, adopt and maintaining the river environment.

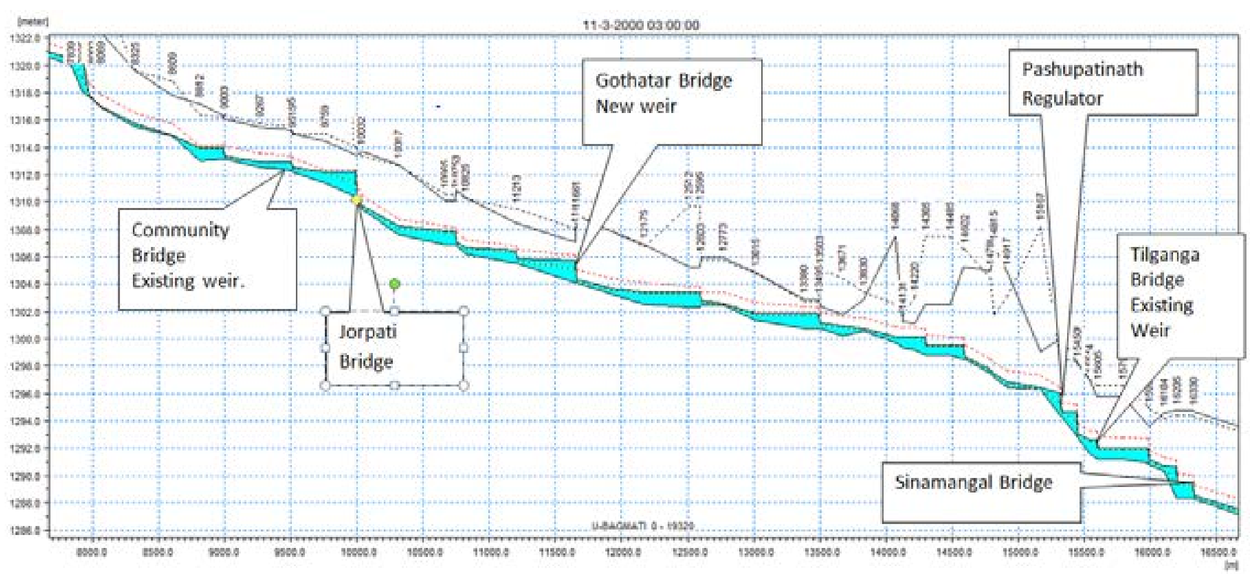
1. **Check Dams/Weirs**

80. It is proposed to install 11 new check dams (weirs) in the bed of the Bagmati River between Sundarijal and Sinamangal Bridge. The weirs are located where there is enough elevation to provide a head of 1m, and still allow the river to flow freely in the river channel for a distance down to the next weir. (Figure III-13 shows the tentative weir locations). The purpose of the weirs is to aerate the flow and promote increased groundwater recharge (i.e. by increasing wetted area above the weir and in turn the contact area between the water and the river bed). Further, the weirs are also to be designed to be aesthetically attractive.

81. The form of construction of the weirs is as follows:

(i) Weir height: 1 m
(ii) Type: mortared rock incorporating soling and PCC foundation) – to constructed in the dry season
(iii) Weir shape: horseshoe (i.e. arching upstream)

Figure III-3: Tentative location of check dams/weirs from Gokarna to Tilganga Bridge.



Source: PPTA.

2. River Walls

82. Over the river reaches covered by the sub-project (i.e. Gokarna to Guheshwori and from Tilganga to Sinamangal Bridge the Bagmati River channel is delineated by either gabion walls, or natural ground. Where there is currently no wall, a new wall is required to delineate the channel and form the river-side edge of the proposed riverfront improvement works (i.e. as addressed in Sections 7.8 and 7.9). Elsewhere, in sections with gabions, the gabion walls are in a generally poor state of repair (e.g., due to age, subsidence) and are proposed to be replaced.

83. To meet longevity and aesthetic requirements, traditional mortar stone walls are recommended. Stone walls of this type are very robust and have low maintenance requirements. Nevertheless, walls should be inspected periodically (e.g. every 2 years) to check for structural damage (egg subsidence, cracks) and repairs made.

3. Rehabilitation of River Regulators

84. The regulators at Gokarna and Pashupatinath were constructed in about 35 years ago to divert flows from the Bagmati River into irrigation canals. Since then the irrigated land has been urbanised and the regulators have been abandoned and allowed to fall into a state of disrepair.

85. As part of the river improvement works, the plan is to rehabilitate these regulators, both to preserve their historical heritage and improve their aesthetic values, and allow them to be used to improve the local amenity values of the river (e.g. to regulate the water level upstream at the temple ghats, and locally create pools suitable for swimming, albeit with their usage being subject to the proposed river water quality improvements being realized).

86. In summary, the proposed rehabilitation works comprise the following:

- (i) Heavy-duty waterblasting of the structure
- (ii) Repairs to structural cracks in concrete, typically involving breaking concrete back to reinforcing steel and filling with epoxy-type mortar
- (iii) Plastering of irregular concrete surfaces (requiring roughening the surface to improve bonding)
- (iv) Aesthetical stone facing of concrete etc.
- (v) Complete replacement of the gates, gate guides and manual gate hoist mechanisms (noting that replacement with electric-powered hoists is not seen as justified, especially given the intermittent electricity supply in Kathmandu)
- (vi) Installation of a cast metal plaque giving both the historical details and the date of the rehabilitation

87. In parallel, a plan setting out the way the regulators will be used (egg gates closed for swimming, special events at the temples, etc.) should be prepared, based on extensive public stakeholder consultation. Additionally, an operation and maintenance plan should be prepared, including budgets, with operation and maintenance responsibilities assigned.

4. Riverfront Improvement Works – Gokarna to Guheshwori

88. The key existing features in the Gokarna to Guheshwori reach typically comprise the following:

(i) Unused strip of land approximately 10 m wide between gabion walls/river bank and road
(ii) Barbed wire fences at some location
(iii) Existing sewer manholes at some locations
(iv) Existing gabion wall at the riverfront to be replaced by stone wall

89. Based on extensive research and consultation, a riverfront improvement strategy has been formulated embodying the following principles:

(i) Create „nature for people" neighborhood environment and encourage public to take pride in the riverfront
(ii) Make optimum use of available space (approx. 10 m between gabion wall and road)
(iii) Need for „green zone" to separate road and riverfront access
(iv) Footpath, cycle way to open up the riverfront to the public (to be complemented later with improved river quantity/quality)
(v) Resting areas at intervals
(vi) Cost effective, low maintenance solution

90. In turn, the design basis for the riverfront improvement has accounted for the following facets:

(i) Options for „green" zone: trees with grass under, or mass plantings of bushes
(ii) Consider footpath and cycle way
(iii) Widen path periodically (e.g. sitting areas) to avoid „tunnel" feeling
(iv) Research appropriate surface treatments, with a reference for traditional/indigenous (e.g. brick, stone instead of concrete – and pay close attention to detailing to achieve good aesthetics)
(v) Account for public safety (e.g. in setting wall height)
(vi) Designs to be robust, durable and low maintenance
(vii) Seek buy-in to designs by stakeholders
(viii) Capital costs to be modest
(ix) Implementation of pilot by HPCIDBC with the remainder under the BRBIP

5. Riverfront Improvement Works – Tilganga to Sinamangal Bridge

91. The Tilganga to Sinamangal Bridge section of river is about 1.100m in length. The key existing features in the river reach typically comprise the following:

(i) River is incised more deeply than in the Gokarna to Guheshwori section
(ii) No existing river walls
(iii) The width available for the river channel and riverfront improvements varies from a few meters up to about 10 m
(iv) At some locations large trees are found
(v) The riverbanks are free of squatters down to Sinamangal, except for a 50 m stretch at the right bank, with a nursery and few houses

92. Based on a research and consultation exercise comparable to that applied to the Gokarna to Guheshwori section, a riverfront improvement strategy and plan has been formulated. The main differences from the features applied in the Gokarna to Guheshwori section are as follows, reflecting the local characteristics:

(i) Account for the river channel being narrower and deeper (hydraulic analysis under way to test 25 m channel width)
(ii) Riverbank space is narrower (e.g. insufficient space for cycleway), but seek to retain a „greening" component where practicable
(iii) Due to its location in high-density populated area, design needs to cater for higher level of usage (instead of „rest areas", create „amenity areas" with steps down to river, „Pati", etc.)
(iv) Due to higher foot traffic, use more durable surface treatments (e.g. stone instead of brick)
(v) Allow for greater investment in decorative brick work „detailing" (e.g. on tree planter boxes)

93. River walls are to be built to delineate the river channel. Matching the hydraulic requirements, the walls are to provide for a 30 m channel width. Typical wall heights to meet hydraulic profile are 4-5m.

E. Increased Water Availability in the Basin during the Dry Season

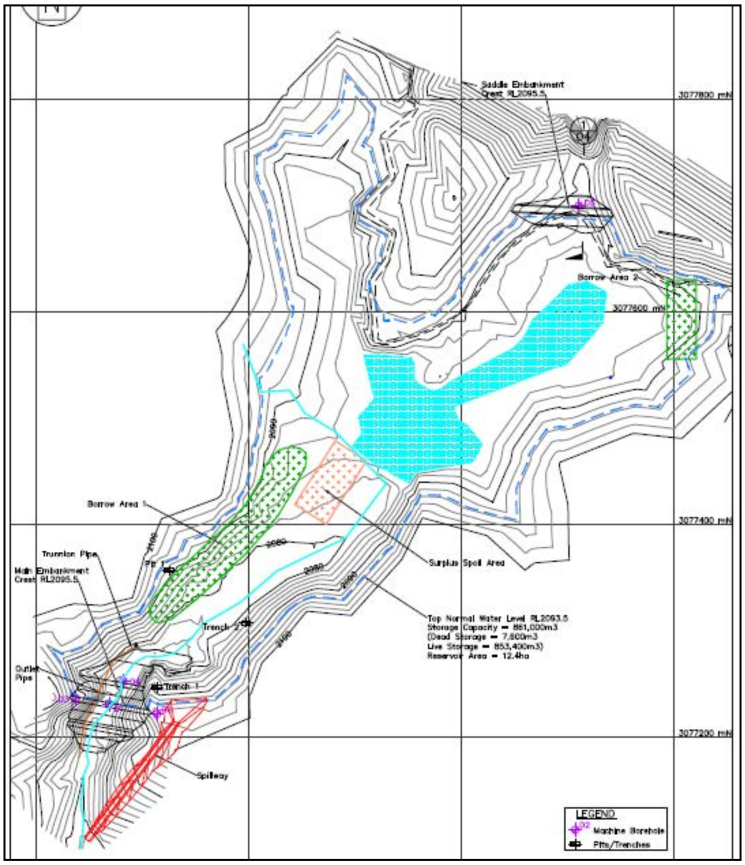
1. Dhap Dam

94. The proposed Dhap Dam site is located in the headwaters of the Nagmati River near Chisapani. At this point the elevation of the river bed is approximately 2,075 m and the contributing catchment area is 0.8 km^2. The existing dam, with a presently 1.5 ha inundated area, will be submerged under the reservoir to be created by the proposed Dhap Dam. The land use in the catchment feeding the dam lies entirely within the Shivapuri Nagarjun National Park and is comprised of sparse forest, interspersed with patches of open grassland, see Figure III-4.

Figure III-4: Proposed Dhap Damsite - Location Map.

Source: PPTA

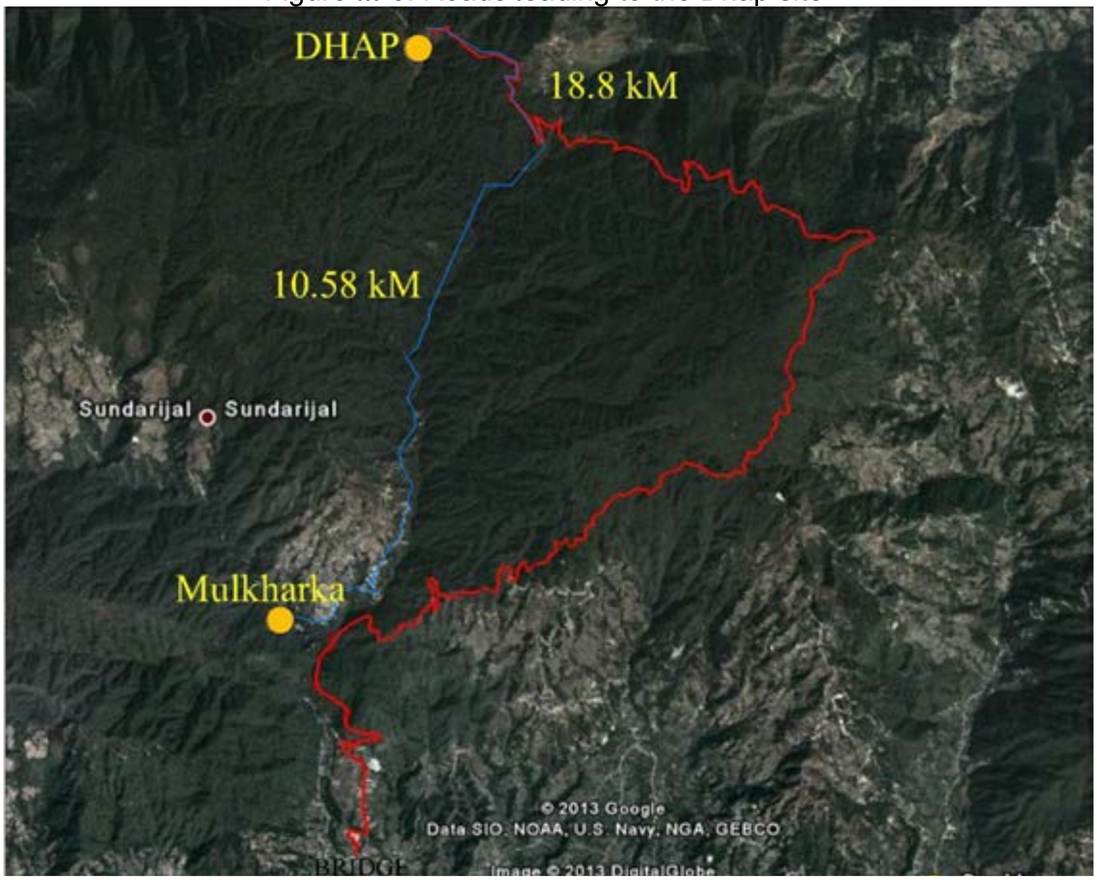
Figure III-5: Surveyed topography of the Dhap Site



*The light blue area is the present inundated areas. The green area is the site for the proposed borrow area for the dam. The light red area for surplus spoil. The red area the location of the spill way. The black drawings showing the saddle dam in the north-east end and the dam in the south-wet end.   Source: PPTA

95. Access to the damsite by road is possible via either the rough vehicle track from Sundarijal through Mulkharka and up alongside the Nagmati River or the Ring Road from Sundarijal around east side of the National Park to Dhap, see Figure III-6. However, the road through the SNNP has still an un-official status and is therefore not considered feasible for use as access road to the Dhap by the Project. Besides, the SNNP authorities are in favour of upgrading the eastern road as this will help them in their law enforcement activities.

Figure III-6: Roads leading to the Dhap site.



Source: PPTA

96. The road from Mulkharka to Chisapani forms the upstream boundary of the Dhap. The existing reservoir is surrounded by grassland/scrub at both sides, and below the existing dam is a large area with rush. Further away and downstream the area is surrounded by mostly secondary semi-dense forest.

a. **Geology of the Dhap Dam Site**

97. The geology of the Dhap damsite area is shown on the published „Engineering and Environmental Geological Map of the Kathmandu Valley, 1:50.000" as within the Sheopuri Gneiss Formation, Precambrian Age. The proposed damsite is located at about co-ordinates: 27°48' 21.70"N, 85°27' 20.33"E, about 375 m downstream of the existing Dhap dam. At this location there is rock bluff about 5 m high alongside the track consisting of moderately weathered banded gneiss with very wide (3 m) jointing. The banding in the gneiss strikes 20 degrees, dipping 10 degrees NW. Joints occur along the banding as well as a joint set striking at 100 degrees with a vertical dip.

98. The right bank above the bluff is very steep up to about 8 m and the slope above continues to rise steeply although no rock is exposed at high level. The valley floor at this location is about 15 m wide, flat and swampy, but the stream bed is bouldery and in-situ rock is present in the stream left bank. The left bank rises steeply at some 35 degrees and several very large (3 - 4 m) platy boulders of hard gneiss occur up to about 10 to 15 m above stream level.

b. **Hydrology of the Dhap Dam Site**

99. The proposed site of the Dhap dam is located in the headwaters of the Nagmati River near Chisapani. At this point the elevation of the river bed is approximately 2,075 m and the contributing catchment area is 0.8 km^2. For the Dhap, the estimated catchment mean annual rainfall is estimated to be approximately[15] 3,000 mm and the mean discharge from the 0.8 km^2 catchment area is approximately 52 l/s. This converts to an annual runoff volume 1.6 Mm^3, or about double the proposed reservoir storage capacity, indicating that the reservoir will refill over the wet season, even in extreme dry years. The old dam will be submerged under the reservoir to be created. The landuse in the catchment feeding the dam lies entirely within the Shivapuri National Park and is comprised of sparse forest, interspersed with patches of open grassland.

c. **The Dhap Dam Proposal**

100. The Dhap Dam will be constructed as a concrete-faced rock-fill dam. Based on the February 2013 topographic survey, a reservoir elevation-area-volume relationship has been established. It should be noted that the elevation of the rim of the catchment on the northern edge is 2,090 m, requiring a „saddle dam" to contain the reservoir at higher elevations.

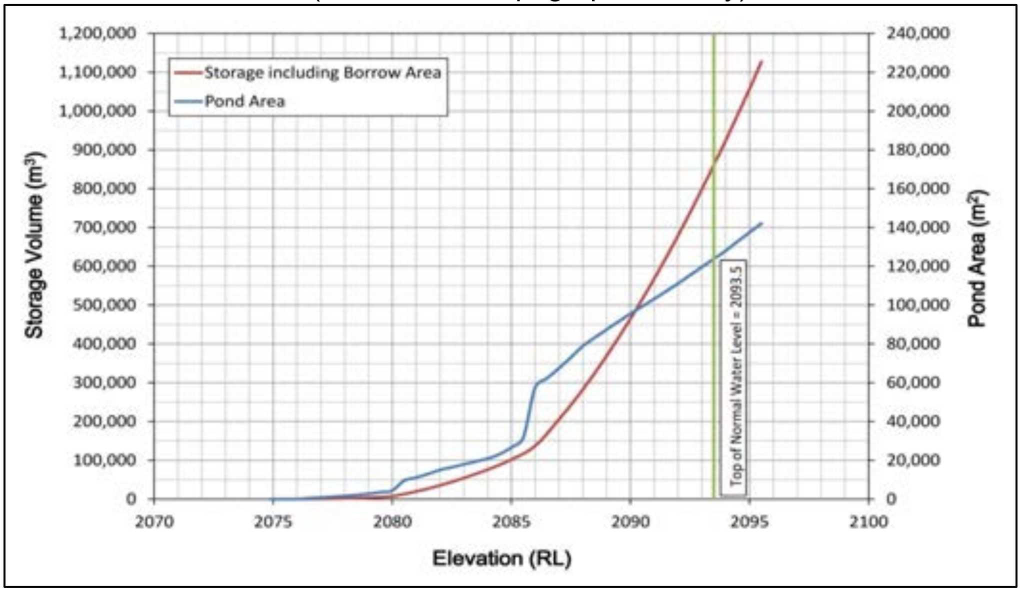
101. With a saddle dam height of 9 m (this is close to the maximum feasible height given the geotechnical issues with a dam at this location – especially the steep drop on the northern side) and allowing for flood rise and freeboard, the proposed normal top water level (NTWL) is 2,093.5 m. A 24m high dam is required, creating a reservoir with a live storage capacity of approximately 853,000m^3, see Table III-3.

Table III-3: Dhap Reservoir Storage Capacity Statistics

Category	**Elevation Range (m)**	**Storage Capacity (m3)**
Dead storage	Below 2080	7,600
Live storage	2080 - 2093.5	853,400
TOTAL		861,000

[15] Annual rainfall amount is uncertain due to the absence of rain gauges in the area (3,000 mm is considered to be a conservative estimate – it could be as high as 3,800 mm)

Figure III-7: Dhap Reservoir Elevation-Area-Volume Relationship
(Basis: 2013 topographic survey)



Source: PPTA.

102. Table III-4 sets out preliminary details of each of the components of the Dhap dam project works.

Table III-4: Dhap Dam Project Components

Component	Description	Statistics
Access road	The existing road east on the border of the SNNP (18.8km) will be used as access road. Upgrading and use of the road in the SNNP has been considered non-feasible due to its unofficial status and the disturbance to the SNNP.	
Main Dam	Concrete-faced rockfill embankment	Height 24 m Dam fill volume approx. 43,500 m^3 of weathered rock to be quarried within the footprint of the reservoir.
Spillway	Crest and chute on left abutment, with flip bucket energy dissipation device at base	Design discharge capacity approx. 17m^3/s
Saddle dam	Homogeneous earthfill embankment	Height 9 m Earthfill volume approx. 8,500 m^3
Outlet works	Pipe and outlet valve (fixed cone dispersion type)	
Reservoir		Area at NTWL (2,093.5 m) : 12.4 ha Live storage capacity (at NTWL): 853,400 m^3

Source: PPTA

103. Compared to the proposed Nagmati dam, which has sufficient storage capacity to substantially boost the dry season flow regime in the Bagmati River[16], the proposed Dhap has only about 10% of the Nagmati capacity. If the Dhap live storage capacity of 853,400 m^3 is released continuously over the 8 month dry season, the release rate would be 40 l/s. Alternatively, higher rates could be applied over shorter periods.

104. It is envisaged that the contractor would, subject to approval by the SNNP authorities, construct a camp and staging areas (i.e. to store plant and materials) in the open grass covered areas around the Dhap, see Figure III-4 and Figure V-4.

105. Inundation of the dam footprint is prevented through the construction of upstream and downstream cofferdams. The stream diversion pipeline is constructed with sufficient capacity to pass the 5 year return period flood – in the event that a larger flood occurs during construction, the risk of overtopping is accepted. In this case, assuming a start in October, the diversion, cofferdams and initial dam construction can be constructed during the dry season so that by the onset of the wet season, the dam is constructed to a height that will avoid it being damaged in all but a very large flood. As a consequence, the appropriate design standard for the diversion pipeline is the 5 year dry season flood, estimated at 0.4 m3/s

106. In relation to construction of the dam, the duration of construction is approximately 9 months. The time needed to fill reservoir will be the majority of a wet season (filling to commence when the dam is substantially complete).

107. Based on the feasibility study, the capital cost of the 24 m high dam (including the appurtenant works listed in Table III-4) is estimated at approximately $3.72 million plus contingencies.

2. **Nagmati Dam**

108. The proposed site of the Nagmati „B" dam is located in Sundarijal Village Development Committee (VDC) of Kathmandu District where the Nagmati River enters a narrow and steep-sided gorge. At this point the elevation of the river bed is approximately 1,840 m and the contributing catchment area is 12 km^2. In terms of river distances, the site is approximately 11 km from the headwaters near Chisapani (the elevation at the catchment divide is 2,320 m) and 3 km upstream of the point where the Nagmati River joins the Bagmati River above Sundarijal. The land use in the catchment feeding the dam lies entirely within the Shivapuri Nagarjun National Park and is comprised of forest, albeit primarily re-growth without pristine large trees that would have been felled decades ago. Figure III-8 shows the location map on the proposed dam site on a topographical map.

[16] Refer Nagmati Dam Feasibility Report for details

Figure III-8: Location of the proposed large dam at the Nagmati River and the lower dam at the Dhap. The position of the earlier considered site for a dam at the Bagmati River is shown as well.

Source: PPTA.

109. Access to the Nagmati damsite is via either the rough vehicle track from Sundarijal through Mulkharka and up alongside the Nagmati River, or the road from Sundarijal around east side of the National Park to Dhap and Chisapani and back down the Dhap-to-Mulkharka vehicle track, see Figure III-6.

a. **Nagmati Dam Site Geology**

110. The geology of the Nagmati damsite area is shown on the published „Engineering and Environmental Geological Map of the Kathmandu Valley, 1:50.000" as within the Sheopuri Gneiss Formation, Precambrian Age. These rocks are described on this map as „Mica gneiss and biotite schist with intrusions of muscovite granite. Intensively weathered at surface. Forest conservation is vital for slope stability and protection from erosion." Other publications describe the Sheopuri Gneiss as varying from fine to coarse grained banded gneiss, ribbon gneiss and augen gneiss composed of quartz, feldspar (plagioclase and K- feldspar), biotite, muscovite and other accessory minerals.

111. The river at this location enters the start of a narrow gorge section with waterfalls, cascades and rapids which continue to the confluence with the Bagmati River. Very large boulders 5 m or more in size occur in the river bed. The area is known locally as „Nagdaha". The river section is very narrow and high steep bluffs of hard, fresh to slightly weathered banded gneiss occur on both abutments. The average right bank abutment slope was measured to be about 50 degrees and the left abutment of the order of 60 degrees.

112. The Nagmati Dam would be constructed using rock sourced from a quarry located upstream of the dam within the footprint of the reservoir. From the engineering geological reconnaissance work to date, there appears likely to be an ample source of blast-able rockfill

from the high very steep tree covered slopes immediately upstream on the left bank of the Nagmati River.

b. Nagmati Dam Site Hydrology

113. Records providing information on the hydrological characteristics of the Nagmati catchment are available from the rainfall station at Mulkharka (named „Sundarijal" station – elevation 1,490 m) and the Sundarijal gauging station on the upper Bagmati River (catchment area 16.25 km2) – the location of both stations are shown in Figure IV-5.

114. The long-term mean annual rainfall at the Sundarijal station is 2,190 mm, with mean monthly totals typically under 50 mm over the dry season (October to May), but up to 600 mm in the wettest month, July. There are no rain gauges at higher elevations in the catchment, but a water balance exercise applying the mean annual discharge at the aforementioned Sundarijal gauging station suggests that the rainfall at elevation 2,320 m on the catchment divides may reach as high as 4,000 mm pa, indicative of a strong orographic effect.

115. Given the similarity of the catchment characteristics of the Bagmati and Nagmati rivers in their headwaters, the flow regime of the Nagmati River can be inferred from statistics from the Sundarijal gauging station. The Bagmati River at Sundarijal has mean flow of 1.24 m3/s from its 16.25 km2 catchment (i.e. 76 l/s/km2), suggesting a mean annual flow at the Nagmati „B" damsite of approximately 0.82 m3/s. This converts to an annual runoff volume 25 Mm3, or about three times the proposed reservoir storage capacity (refer Table 5.4), indicating that the reservoir will refill over the wet season, even in extreme dry years.

116. The seasonal pattern of the flow will mirror that of the rainfall, with very low flows over the dry season (e.g. typically 0.15 – 1.0 m3/s), but with sizeable floods in storm events in the wet season. Over the 44 year record at Sundarijal (i.e. 1963 – 2006), the highest recorded discharge was 75 m3/s in 1993 – from studies by others, this is widely regarded as being about a 1 in 100 year event. Transposing this figure to the Nagmati damsite puts the estimated 100 year return period discharge at about 50 m^3/s.

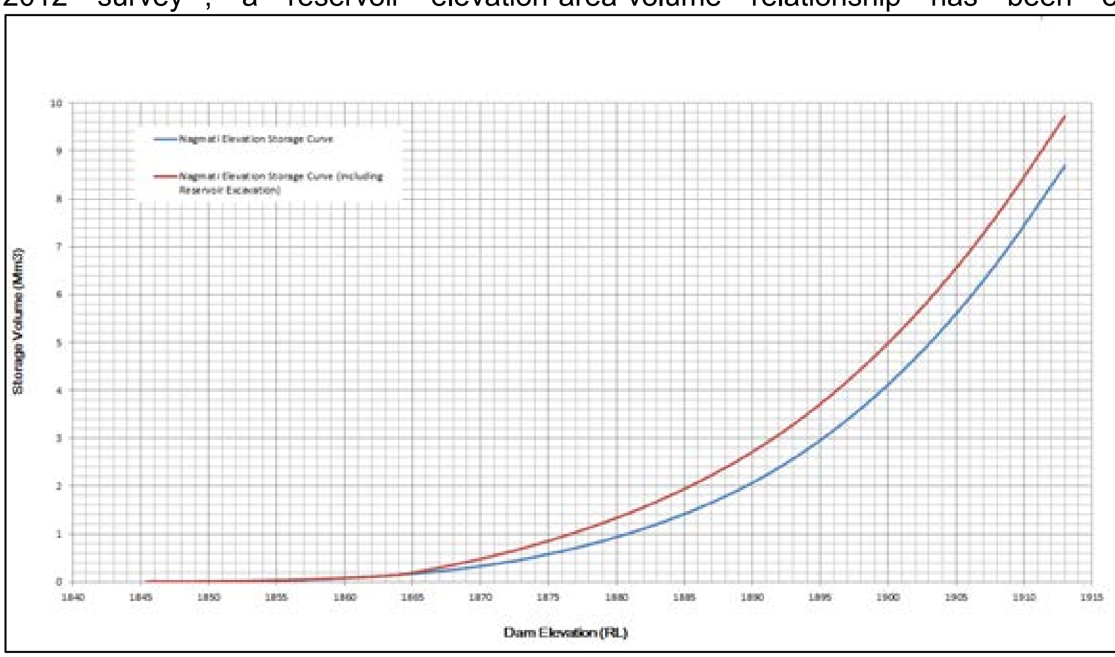
c. The Nagmati Dam Proposal

117. Various dam centreline locations and alignments have been examined for the Nagmati Dam, seeking to minimise the volume of rockfill needed for the dam and at the same time to minimise the adverse effects of problematic topographical and geological features. Arising from this, and after testing eight options, Figure III-9 shows the currently-preferred dam centreline.

Figure III-9: Preferred Nagmati Dam Location.

Source: PPTA

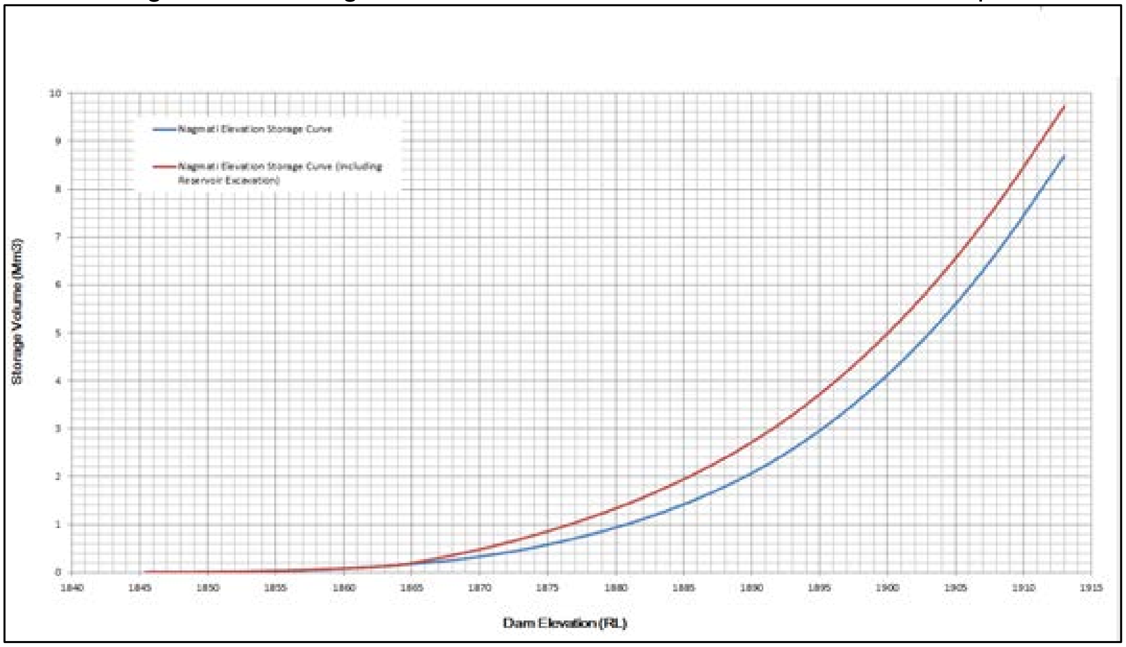
Accounting for the site characteristics and the availability locally of suitable dam construction materials, the most cost-effective type of dam is concrete faced rockfill dam (CFRD). Rock would be sourced from a local quarry opened-up for project, most likely located a short distance upstream of the dam on the left bank where a geological reconnaissance has identified potentially suitable rock in the required quantities. Based on topography from the September 2012 survey[17], a reservoir elevation-area-volume relationship has been established



). From this, the required normal top water elevation to store 8 Mm^3 is approximately 1,910 m, and with 3 m freeboard, this requires a 80 m high dam.

[17] To be superseded by the January 2013 „cutting" survey

Figure III-10: Nagmati reservoir elevation-area-volume relationship.



Source: PPTA

Table III-5: Nagmati Dam Project Components

Component	Description	Statistics
Access road	Upgrade existing road from Sundarijal via Mulkharka, plus spur road down to damsite and across river to quarry site	Length of new road to damsite and quarry approx. 1.5 km
Dam	Concrete-faced rockfill	Rockfill volume approx. 1.2 Mm3
Spillway	Side channel crest, leading to 1:1.5 concrete chute, with stilling basin or flip bucket at base	Capacity approx. 120 m^3/s
Outlet works	Valve tower connecting to discharge pipe and outlet valve (e.g. cone valve)	
Reservoir		Area at normal top water elevation (1,910 m): 38 ha
Hydropower facilities (if required)	Power station on left bank of Bagmati River at Sundarijal, fed by penstock from dam	Capacity to be determined

Source: PPTA

118. In relation to construction of the Nagmati Dam, the following points are noteworthy:

(i) Establishment and camp: to be established at a suitable site within the future reservoir area

(ii) Diversion and cofferdams: to enable foundation preparation and rockfill placement to be done in the dry, a pipeline would be constructed to divert the river, with upstream and downstream cofferdams (note that, in order to minimise the diversion pipe capacity, it should ideally be constructed at the start of the dry season so that, by the start of the wet season, rockfill placement has advanced to the point where the dam is high enough to not be overtopped by a flood)

(iii) Quarry: A quarry would be established upstream of the dam, on the left bank, in the area to be inundated by the reservoir. Following overburden stripping (to be placed nearby, in the area to be inundated by the reservoir) quarrying would proceed by drilling and blasting, with a fleet of dump trucks conveying the rock to the damsite.

(iv) Duration of construction: approximately 18 months

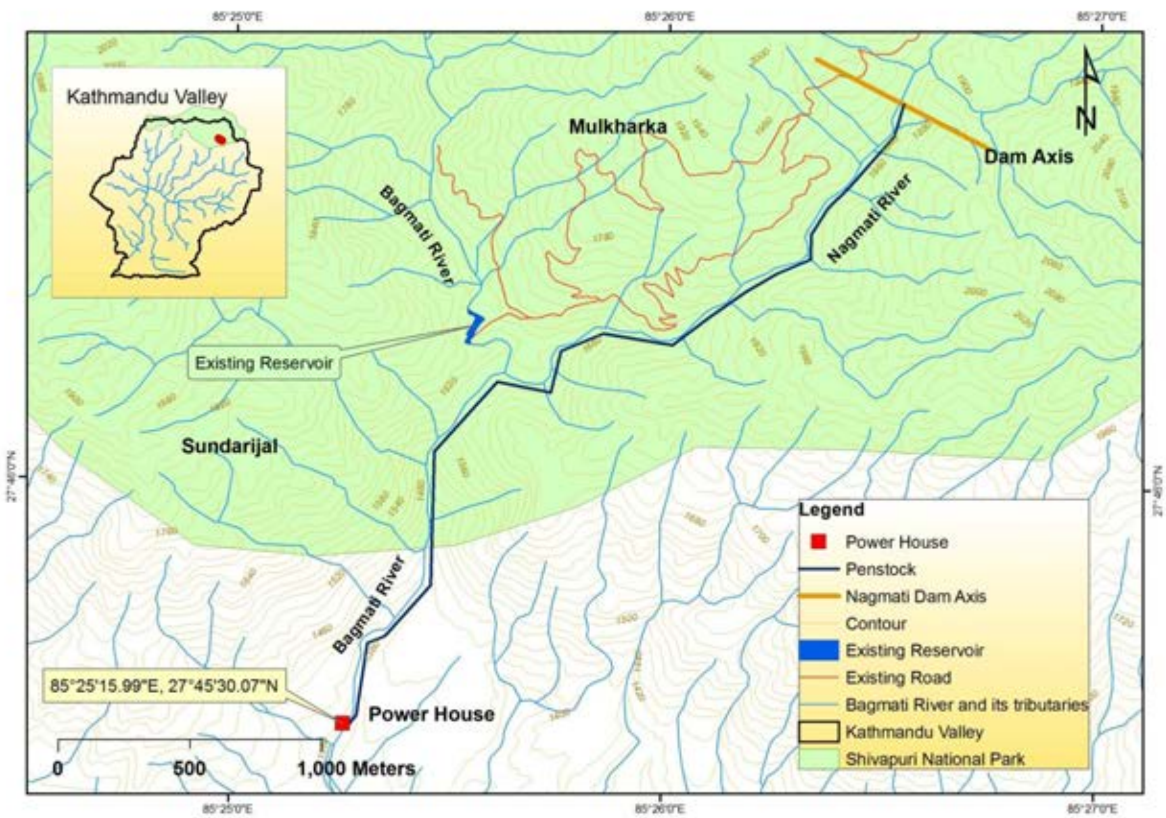
(v) Time to fill reservoir: the majority of a wet season from June to September (to commence when the dam is substantially complete)

119. Based on current pre-feasibility level studies, the capital cost of the 80 m high dam is estimated at approximately $45 million, including implementation of environmental and social mitigation measures. It should be noted, however, that as part of the feasibility study to be completed, the cost estimate will be refined. Construction of the Nagmati Dam is proposed in Phase II of the Project.

d. **Hydropower**

120. During the proposed Phase II of the Project, if the Dam at Nagmati will be constructed, the project will also support the expansion of the hydropower generation of which details are provided below.

Figure III-11: Layout of the Proposed Nagmati Hydropower Scheme



121. A 3 km long concrete-lined steel pipe (penstock) conveys water from the offtake to the power station. As with the existing Sundarijal hydropower scheme, the penstock will be

constructed to follow the river bank (in this case the left bank of the Nagmati River, and then once it joins the Bagmati on down the Bagmati River, see Figure III-11.

122. The „optimum" diameter of the penstock is computed by considering a range of pipe diameters and for each computing the head loss. A penstock optimisation showed the optimum size of the penstock diameter to be 450 mm and 600 mm for alternative capacities of 400 l/s and 800 l/s, respectively.

123. The proposed Nagmati powerhouse is located on the left bank of Bagmati River a short distance downstream from the existing Sundarijal power station on the right bank. Given the very high generation head (i.e. 485 m), the preferred turbine type is a horizontal Pelton, see Figure III-12. The Pelton outlet discharges freely through the powerhouse floor (Elevation 1,375 m) above the flood level of Bagmati River. Each Pelton turbine is connected to a synchronous generator.

The powerhouse also houses the following principal ancillary equipment:

- Turbine governor (i.e. controls the nozzle size to match the desired flow)
- Control panel
- Crane (i.e. for lifting turbine or generator for maintenance)
- Fire protection system

The powerhouse is constructed with reinforced concrete foundations and floor (i.e. to support the turbine/generator) with a suitable superstructure (egg brick walls and tile roof, but with a structural steel gantry system to support the crane).

Table III-6 sets out the power station details for the two capacity alternatives. It is noted that for Alternative B (800 l/s), two Pelton units are proposed to ensure good machine efficiency over the full range of flows.

Table III-6: Power station Details

Alternative	Pelton Units	Power station Plan Dimensions (approx.)
A (400 l/s)	1 No at 1,630 kW	5 m x 4 m
B (800 l/s)	2 No at 1,630 kW	8 m x 4 m

Figure III-12: Pelton Turbine Wheel

An outdoor switchyard will be located adjacent to the powerhouse building, housing transformers to step-up the voltage from that delivered by the generator to the desired transmission voltage (i.e. most likely 11 kV). In this case, it is assumed that a transmission line would cross the Bagmati River to connect to the transmission line at the existing Sundarijal hydropower station (note that, to date, no contact has been made with NEA to ascertain the connection voltage, or the capacity of the transmission line at the existing Sundarijal hydropower station to absorb the output from the proposed Nagmati hydropower scheme[18]).

The construction of the Nagmati hydropower scheme components would be scheduled to ensure completion to match that of the Nagmati dam, which in turn requires a 2-1/2 year construction period (refer Main Feasibility Report Section 8.1). For the Nagmati hydropower scheme, the penstock and powerhouse would be constructed in parallel. Depending on the manufacturer, the turbine/generator units would likely have lead time of approximately 12 – 18 months (i.e. the time from placing the order to delivery of the unit on-site.

F. Improvement Proposals

1. Watershed Management

124. Different watershed management measures such as preventive, rehabilitative, conservation education, and extension and income generating activities will be applied in the watershed area to minimize land degradation and increase the productivity. Generally the following measures are applied for the conservation and management of the watersheds.

a. Preventive Measures

125. These measures are implemented before hazardous/severe erosion occurs. The measures include on-farm conservation, terrace improvement, conservation plantation, and fruit

[18] Pending dialogue with NEA, a provisional sum is allowed for the transmission component of the Nagmati hydropower scheme (refer Section F6.1) – note that the output of Nagmati is not large and should be able to be handled by a conventional 11 kV transmission line

tree plantation, pasture improvement, improved fuel efficiency etc. Specific locations for implementation will be identified during project implementation in collaboration with local stakeholders and SNNP staff.

126. There are 323 households in the watershed area. 20 fruit saplings per household will be distributed to at least 250 households. Altogether 5000 saplings will be distributed to the farmers. This will cover about 12.5 ha of land. Only native fruits trees will be distributed to farmers.

127. 296 households use traditional stoves for cooking their food. When cooking is done in such stoves, energy is wasted due to its low efficiency and more fuel wood will be required. Traditional stoves also cause health problems like lungs diseases to the people. Energy saving stoves save at least 30 % fuel wood. Energy saving improved cook stoves will be promoted in the watershed area and training and demonstration will be done to at least 250 households.

128. Ten trainings will be conducted during the project period. There will be 25 participants in each training program. 250 household members will be trained in energy saving improved cooking stoves. A group of 5 participants will be formed and there will be altogether 50 groups in SNNP watershed area. One improved cooking stove will be installed in one of the house of each group for demonstration purpose. This will help the participants to obtain practical knowledge on construction, maintenance, and operation of the stove.

b. **Rehabilitative Measures**

129. These measures should be applied where erosion is severe and degradation has already taken place, especially along existing roads. The activities may include gully control, landslide treatment, stream bank protection, irrigation channel improvement, trail improvement, road slope stabilization etc. Under these activities, various engineering and vegetative measures may be applied, such as check dams, retaining walls, diversion channels, tree planting, grass sowing etc.

130. VDCs and local people in and outside the Shivapuri watershed have constructed the earth road from Chisapani to Sundarijal without providing an adequate drainage system. Runoff water has caused severe soil erosion and created gullies. The southern part of the road from Sundarijal to the Nagmati dam site via Mulkharka (total 6.6km) will serve as an access road for the construction of the Nagmati Dam. Proper rehabilitation and provision of adequate drainage will be provided to safeguard the road and minimize soil erosion.

131. At Sundarijal the right slope will be stabilised and protected to avoid any risk for further bank erosion that would constitute a threat to the Sundarijal Bazaar settlement. The right bank stabilisation will provide protection against erosion at high flows and in the unlikely situation that a Nagmati Dam failure would occur.

c. **Conservation Education, Awareness and Extension Measures**

132. These measures are applied to create awareness of erosion problem and benefit of well managed watershed among general public and stakeholders and to show the implementation of different conservation measures through field demonstration and use of films, filmstrips, slideshows, flipcharts, calendars, newsletters, posters, study tours, and training to users groups. These activities can be broadly categorized into demonstration, conservation education and

material production, study tours and trainings, audiovisual show, exhibition and conservation award.

133. There are three main settlements in the SNNP watershed area i.e. Mulkharka, Chilaune and Okhreni. Thirty training events will be organized for different stakeholder i.e. local people, user groups and SNNP staff during the project period.

134. In each training programme, there will be 25 participants. During the project period 750 people will receive training on different subjects which will enrich their knowledge and motivate them in conservation and protection of the watershed area. Within this period all households will get training.

d. **Income Generating Measures**

135. Diversification of the local economy through income generating activities is necessary to relieve pressure on the watershed. Income generating activities, in discussion with the SNNP officials will be initiated and may include such as beekeeping, private nursery, mushroom growing, organic farming, sericulture, poultry farming, fish farming, rabbit farming. These activities are launched as a demonstration program and these activities should be linked with the conservation measures. Further income generating training initiatives may include eco-tourism activities.

136. Ten trainings will be conducted during the project period. There will be 25 participants in each training program. 250 household members will be trained in mushroom and vegetable farming. A group of 5 participants will be formed and there will be altogether 50 groups in the SNNP watershed area. Materials for mushroom farming and vegetable seeds for vegetable farming will be given to each group for demonstration purpose. This will help the participants to gain practical knowledge on vegetable and mushroom farming.

2. **Rainwater Harvesting**

137. Bagmati Action Plan (BAP) has included rain water harvesting (RWH) at household level as well as community level by constructing soak pits or through existing wells as one of its activities. Department of Urban Development and Building Construction (DUDBC) have formulated Rainwater Harvesting Guidelines 2009 to promote rainwater harvesting systems.

138. The Building Bylaw in the Kathmandu Valley does not include provision for rainwater harvesting. However, the Kathmandu Metropolitan city (KMC) has initiated to promote RWH systems. KMC has approved to give 10% rebate on building construction drawing approval tax if the house owner includes RWH system in the construction drawing and the rebate is given only after the construction of the building.

139. Though the guideline has been formulated and is under implementation, it has not been widely publicized. Even though different programs have been implemented by governmental and nongovernmental organizations, people have not installed RWH system in their building whether it is new or old. There is a large potential for promotion of RWH in the Upper Bagmati.

140. For effective promotion of rain water harvesting systems in the Upper Bagmati, the Project includes the following interventions:

(i) Reformulation of by-laws to make the construction of rain water harvesting system mandatory in the new buildings.
(ii) Provision of subsidies at household level to encourage the instalment of RWH systems in 2500 households including groundwater recharge through soak-away pits.
(iii) Schools and government buildings to be encouraged to install rainwater harvesting system as these organizations require more water for cleaning and irrigating gardens. Provision of pilot systems in 10 schools.
(iv) Capacity building training programmes to be conducted to train sub engineers, engineers, architects, plumbers, students and housewives to impart knowledge on different aspects of RWH systems from installation to O&M.
(v) Help desk to be established for providing technical backstopping and related technical materials to the people for installation of RWH systems.
(vi) Demonstration sites to be established to provide practical knowledge on different components, functioning, installation, operation and maintenance of the RWH systems.
Different materials such as brochures, guidelines etc. on RWH system will be produced and distributed and Radio and TV programmes should be conducted to disseminate the RWH technology, installation and its advantages to the people.

3. Solid Waste, Sanitation and Waste Water Treatment Facilities

141. The households in the settlements in the SNNP lack the most basic solid waste handling, sanitation and wastewater facilities. This intervention is aimed at reducing the waste generation in the settlements, reduce wastewater discharges, improve sanitation and the general hygienic standards in the households. All households will be covered, providing:

(i) Improved Solid waste management, including training and introduction of home composting.
(ii) Improved sanitation with training on hygeiene and introduction of decentralized Waste water treatment facilities or similar

4. Support to SNNP Management

142. The SNNP management lack resources for carrying out their duties with respect to overseeing activities in the Park, controlling the borders, deal with the local stakeholder in settlements inside and around the park.

143. A major problem is transport and communication. The Project will provide support the SNNP management providing transport and communication material to help improve law enforcement and conservation activities within and around the SNNP.

G. Project Activities

1. Storage Dam sub-component

Pre-construction Activities / Site Preparation

144. The pre-construction activities related to geological and other site investigation surveys: topographical surveys, environmental and engineering studies carried out under the PPTA, have been covered by EMPs prepared as part of the IEEs for the Dhap and the Nagmati Dam

and implemented by the PPTA consultant on behalf of the Project Proponent. Any subsequent investigative surveys, if needed, will be covered by updates of the IEEs, including the EMPs.

145. The mobilisation stage of the Project includes non-structural activities such as obtaining necessary permits, arranging human resources, procuring construction equipment and planning and design of structural interventions.

146. Structural mobilisation includes construction of local access roads, construction of site infrastructure such as housing, water supply, sanitation facilities, solid waste handling facilities etc.

147. Site mobilisation includes site stripping, removal of vegetation, establishment of quarry, batching plants, borrow areas, establish provision of power supply, etc.

a. Construction Activities, Dhap Dam

148. **Access, Saddle Dams & Camps**:

(i) Upgrade existing Ring Road around the eastern edge of the SNNP to Dhap (length 18.8km), (note: minor diversion needed before Dhap and saddle dam), providing gravel resurfacing, slope stabilisation and drainage where required.
(ii) Construct saddle dam with a length of 66m and height of 9 m above reservoir level. Clearing of about 2,000 m^2 of land is required of which about 1,300 m^2 is covered by forest.
(iii) Re-route the section of road to Chisapani north of the saddle dam to be above El 2094 m
(iv) Construct access road from the main road to the damsite (note that the last 200 m of this road will be inundated when the reservoir is filled, requiring a new access road to the dam crest)
(v) Construct staging/storage area, workers camp area and site offices – and services/utilities. The area needed is estimated to approximately 500 m^2, with the worker‟s camp accommodating on average 70 skilled workers/professionals. (Location to be finalised in consultation with SNNP officials, expected to be within the future reservoir area now covered by grass/rush).

149. **Quarry**

(i) Strip vegetation and overburden from area to be quarried (overburden to be piled-up on adjacent land)
(ii) Drill/blast to break rock and dig out (with digger)
(iii) Crush rock (in crusher plant to be installed at quarry site in the footprint of the reservoir) to required sizes
(iv) Stockpile rock

150. **Reservoir Clearing**:

(i) Clear reservoir area of all vegetation (wood to be recovered, vegetation to be composted, overseen by the SNNP staff).

151. **Dam**:

(i) Empty the existing Dhap dam (i.e. by digging a slot through it) and later reinstate the dam (i.e. to store the flow and so make diversion easier)
(ii) Construct river diversion (i.e. pipeline, approx. 0.4 m in diameter) on the streambed
(iii) Construct cofferdams at the upstream and downstream ends of the diversion (i.e. to prevent the dam foundation area being inundated)
(iv) Strip vegetation from the dam footprint area (approx. 7000 m^2 of which about 5000m^2 is covered by forest and remaining by grass land)
(v) Prepare the dam foundation (cut back to hard rock) and grout if needed
(vi) Place rockfillor to form the dam (applied to CFRD type dam only)

152. **Spillway:**

(i) Excavate for spillway
(ii) Construct spillway weir
(iii) Construct spillway chute and stilling basin

153. **Water Intake:**

(i) Install trunnion intake system to release water above any anoxic levels in the reservoir
(ii) Release to be integrated with the natural configuration of the Nagmati River right downstream the dam.

154. **Finishing Works:**

(i) Construct access road spur from existing dam access road to the dam crest
(ii) Install instrumentation to dam and reservoir
(iii) Install fencing, guardhouse & signage

b. **Operation, Dhap Dam**

155. Following reservoir filling operation can commence; the normal sequence will be:

(i) Continuous release of 40 l/s (see Section 1) made from the dam via the release valve
(ii) Reservoir fills during the wet season
(iii) Reservoir spillway will operate once reservoir is full, until drawdown commences (see bullet below) [note: spillway sized to discharge the probable maximum flood]
(iv) Reservoir draws down progressively over the dry season, to reach minimum operating level (i.e. 2080 m) at the end of the dry season

c. **Construction Activities, Nagmati Dam**

156. The following describe work methodologies during the construction stage which includes access roads, dam construction and associated infrastructure (power station, transmission lines, etc.). It also includes impoundment of the reservoir upon completion of dam construction.

157. **Access and Camps**:

(i) Upgrade existing road from Sundarijal to the damsite via Mulkharka providing gravel resurfacing, slope stabilisation and drainage where required.
(ii) Construct access road to damsite and on upriver to quarry
(iii) Construct staging/storage area , workers camp area and site offices – and services/utilities (most likely on/near flat land near the junction of the existing and access road)

158. **Borrow:**

(i) Strip vegetation and overburden (soil & soft rock) from area to be quarried (overburden to be piled-up on adjacent land – and ultimately inundated by the reservoir)
(ii) Dig out earthfill
(iii) Drill/blast to break out rock and dig out (with digger)
(iv) Crush rock (in crusher plant) to required sizes for partly rock-fill
(v) Stockpile rock

159. **Reservoir Clearing**:

(i) Relocate any existing roads/tracks that will be inundated by the reservoir. The road north of the dam side on the right (western side of Nagmati will be lifted to a safe height taking into consideration slope stability etc. in collaboration with SNNP staff).
(ii) Clear reservoir area of all vegetation (wood to be recovered, vegetation to be composted overseen by the SNNP staff).

160. **Dam**:

(i) Construct river diversion (i.e. pipeline, approx.. 1.2 m in diameter) on the river bed
(ii) Construct cofferdams at the upstream and downstream ends of the diversion (i.e. to prevent the dam foundation area being inundated)
(iii) Strip vegetation from the dam footprint area (approx. 5000 m^2)
(iv) Prepare the dam foundation (egg cut back to hard rock) and grout if needed
(v) Place rockfill to form dam – place and compact in layers (to be brought from quarry in 50 T trucks)
(vi) Place concrete-face on upstream dam face

161. **Spillway**:

(i) Excavate for spillway
(ii) Construct spillway weir
(iii) Construct spillway chute and stilling basin

162. **Valve Tower and Release Valve**:

(i) Construct valve tower (up to above reservoir top water level)
(ii) Construct civil works
(iii) Install valve

163. **Hydro Works**:

(i) Construct hydro intake at dam
(ii) Construct pipeline (approx. 1.0m diameter steel pipe x 3 km long approx., see Figure III-11 along river bank, either on excavated bench or on concrete piers on rock (pipeline to be above 100 year flood level)
(iii) Construct powerhouse: excavation, structure, finishing
(iv) In powerhouse, install turbine, generator and auxiliary M&E equipment (including control system)
(v) Construct switchyard & install switchgear
(vi) Construct transmission line to (nearest 33 kV transmission line at Sundarijal)

164. **Finishing Works**:

(i) Install compensation release pipe within river diversion pipe and block-off rest of diversion with concrete plug (i.e. initiates reservoir filling)
(ii) Construct access road from existing road to Chisapani to dam crest
(iii) Install instrumentation to dam and reservoir
(iv) Install fencing, guardhouse & signage

d. **Operation, Nagmati Dam**

165. Following reservoir filling operation can commence; the normal sequence will be:

(i) Continuous compensation flow to be released to the river at the foot of the dam (tentatively 100 l/s)
(ii) Balance of 400 l/s to be taken into the hydro intake, along pipeline to power station and then released back into the Bagmati River
(iii) Reservoir fills during the wet season
(iv) Reservoir spillway will operate once reservoir is full, until drawdown commences [note: spillway sized to discharge the probable maximum flood]
(v) Reservoir draws down progressively over the dry season, to reach minimum operating level (i.e. 1,840 m, as in Section 1) at the end of the dry season

2. **Upper Bagmati River Environment Improvement works**

166. The River Environment Improvement Sub-component is set to cover environmental improvements in the Upper Bagmati in the Sundarijal - Gokarna reach (8.2 km, primarily rural, agricultural), and in the Gokarna-Sinamangal reach (9.7 km, semi-urban/urban area). The proposed improvements addressed in this Section include:

(i) Check dams between Sundarijal and Sinamangal Bridge;
(ii) Replacement of gabion walls with river walls from Gokarna to Guheshwori and provision of river walls from Tilganga to Sinamangal Bridge.
(iii) Rehabilitation of two former irrigation regulator structures at Gokarna and Pashupatinath to enhance water depth and amenity;
(iv) Improving the river channel profile around cultural sites (Gokarna and Guheshwori);
(v) Removal and safe disposal of contaminated and accumulated riverbed material at key sites;

(vi) Riverbank stabilisation at Sundarijal where existing structures are under threat of river bank erosion[19];

(vii) Enhancement and management of the riparian banks (green zones with foot and bicycle paths) which are under government ownership from Gokarna to Guheshwori.

(viii) Enhancement and beautification of the riparian banks (green zones with foot paths and amenities areas) which are under government ownership from Tilganga to Sinamangal Bridge.

(ix) Solid waste management improved in 300 households

a. **Check Dams/Weirs**

167. It is proposed to install 11 new check dams (weirs) in the bed of the Bagmati River between Sundarijal and Sinamangal Bridge. The weirs are located where there is enough elevation to provide a head of 1m, and still allowing the river to flow freely in the river channel for a distance down to the next weir. (Figure III-13 shows the tentative weir locations). The purpose of the weirs is to aerate the flow and promote increased groundwater recharge (i.e. by increasing wetted area above the weir and in turn the contact area between the water and the river bed). Further, the weirs are also to be designed to be aesthetically attractive.

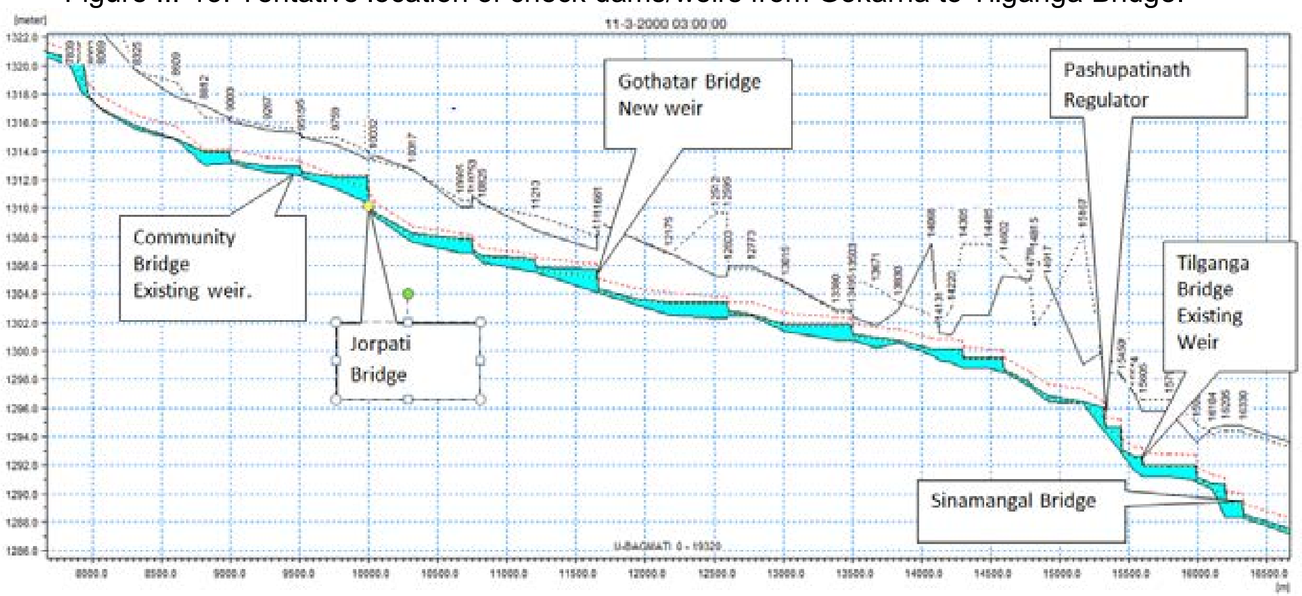
168. The form of construction of the weirs is as follows:

(i) Weir height: 1 m

(ii) Type: mortared rock incorporating soling and PCC foundation) – to constructed in the dry season to minimise

(iii) Weir shape: horseshoe (i.e. arching upstream)

Figure III-13: Tentative location of check dams/weirs from Gokarna to Tilganga Bridge.



Source: PPTA.

[19] Investigations to date at Sundarijal have not evidenced any significant bank stability issues. However, as part of the Nagmati dam dambreak analysis (i.e. part of feasibility studies - refer Section 6.5.7) the bank erosion from dambreak flows will be evaluated and, if needed, remedial measures considered

b. River Walls

169. Over the river reaches covered by the sub-project (i.e. Gokarna to Guheshwori and from Tilganga to Sinamangal Bridge the Bagmati River channel is delineated by either gabion walls, or natural ground. Where there is currently no wall, a new wall is required to delineate the channel and form the river-side edge of the proposed riverfront improvement works. Elsewhere, in sections with gabions, the gabion walls are in a generally poor state of repair (e.g., due to age, subsidence) and are proposed to be replaced.

170. To meet longevity and aesthetic requirements, traditional mortar stone walls are recommended. Stone walls of this type are very robust and have low maintenance requirements. Nevertheless, walls should be inspected periodically (e.g. every 2 years) to check for structural damage (egg subsidence, cracks) and repairs made.

c. Rehabilitation of River Regulators

171. The regulators at Gokarna and Pashupatinath were constructed in about 35 years ago to divert flows from the Bagmati River into irrigation canals. Since then the irrigated land has been urbanised and the regulators have been abandoned and allowed to fall into a state of disrepair.

172. As part of the river improvement works, the plan is to rehabilitate these regulators, both to preserve their historical heritage and improve their aesthetic values, and allow them to be used to improve the local amenity values of the river (e.g. to regulate the water level upstream at the temple ghats, and locally create pools suitable for swimming, albeit with their usage being subject to the proposed river water quality improvements being realized).

173. In summary, the proposed rehabilitation works comprise the following:

(i) Heavy-duty waterblasting of the structure
(ii) Repairs to structural cracks in concrete, typically involving breaking concrete back to reinforcing steel and filling with epoxy-type mortar
(iii) Plastering of irregular concrete surfaces (requiring roughening the surface to improve bonding)
(iv) Aesthetical stone facing of concrete etc.
(v) Complete replacement of the gates, gate guides and manual gate hoist mechanisms (noting that replacement with electric-powered hoists is not seen as justified, especially given the intermittent electricity supply in Kathmandu)
(vi) Installation of a cast metal plaque giving both the historical details and the date of the rehabilitation

174. In parallel, a plan setting out the way the regulators will be used (ex. gates closed for swimming, special events at the temples, etc.) should be prepared, based on extensive public stakeholder consultation. Additionally, an operation and maintenance plan should be prepared, including budgets, with operation and maintenance responsibilities assigned.

d. Riverfront Improvement Works – Gokarna to Guheshwori

175. The key existing features in the Gokarna to Guheshwori reach typically comprise the following:

(i) Unused strip of land under government ownership, approximately 10 m wide between gabion walls/river bank and road
(ii) Barbed wire fences at some location
(iii) Existing sewer manholes at some locations
(iv) Existing gabion wall at the riverfront to be replaced by stone wall

176. Based on extensive research and consultation, a riverfront improvement strategy has been formulated embodying the following principles:

(i) Create „nature for people" neighborhood environment and encourage public to take pride in the riverfront
(ii) Make optimum use of available space (approx. 10 m between gabion wall and road)
(iii) Need for „green zone" to separate road and riverfront access
(iv) Footpath, cycle way to open up the riverfront to the public (to be complemented later with improved river quantity/quality)
(v) Resting areas at intervals
(vi) Cost effective, low maintenance solution

177. In turn, the design basis for the riverfront improvement has accounted for the following facets:

(i) Options for „green" zone: trees with grass under, or mass plantings of bushes
(ii) Consider footpath and cycle way
(iii) Widen path periodically (e.g. sitting areas) to avoid „tunnel" feeling
(iv) Research appropriate surface treatments, with a reference for traditional/indigenous (e.g. brick, stone instead of concrete – and pay close attention to detailing to achieve good aesthetics)
(v) Account for public safety (e.g. in setting wall height)
(vi) Designs to be robust, durable and low maintenance
(vii) Seek buy-in to designs by stakeholders
(viii) Capital costs to be modest
(ix) Implementation of pilot by HPCIDBC with the remainder under the BRBIP

e. Riverfront Improvement Works – Tilganga to Sinamangal Bridge

178. The Tilganga to Sinamangal Bridge section of river is about 1,100m in length. The key existing features in the river reach typically comprise the following:

(i) River is incised more deeply than in the Gokarna to Guheshwori section
(ii) No existing river walls
(iii) The width available for the river channel and riverfront improvements various from a few meters up to about 10 m
(iv) At some locations large trees are found
(v) The riverbanks are free of squatters down to Sinamangal, except for a 50 m stretch at the right bank, with a nursery and few houses

179. Based on a research and consultation exercise comparable to that applied to the Gokarna to Guheshwori section, a riverfront improvement strategy and plan has been formulated. The main differences from the features applied in the Gokarna to Guheshwori section are as follows, reflecting the local characteristics:

(i) Account for the river channel being narrower and deeper (hydraulic analysis under way to test 25 m channel width)
(ii) Riverbank space is narrower (e.g. insufficient space for cycleway), but seek to retain a „greening" component where practicable
(iii) Due to its location in high-density populated area, design needs to cater for higher level of usage (instead of „rest areas", create „amenity areas" with steps down to river, „Pati", etc.)
(iv) Due to higher foot traffic, use more durable surface treatments (e.g. stone instead of brick)
(v) Allow for greater investment in decorative brick work „detailing" (e.g. on tree planter boxes)

180. River walls are to be built to delineate the river channel. Matching the hydraulic requirements, the walls are to provide for a 30 m channel width. Typical wall heights to meet hydraulic profile are 4-5m.

H. Construction Materials

181. For the construction of the dams and river improvement works materials such as concrete aggregate, cement, reinforcing steel, pipes, roading materials, bricks, stones, timber for concrete formwork, release valve will have to be brought in.

182. Quantities are determined and described in details as part of the Feasibility Studies.

I. Project Cost and Implementation Schedule

Table III-7: Summary of Cost Estimates for interventions under Output 2. Phase I.

Component	**COST DATA**
	Total Cost ($)
River Improvement, Upper Bagmati[1]	17,724,000
Other tributaries[2]	1,270,000
Social Mobilisation and Awareness Raising	156,600
Solid Waste Management	323,500
TOTAL COST	**19,474,100**

1: Includes detailed design of the Nagmati Dam. 2: Feasibility Study including EIA to be carried out under Phase I. Source: PPTA

Table III-8: Summary of Cost Estimate for interventions under Output 3, including contingencies. Phase I & II

Component	**COST DATA**
	Total Cost ($)
Dhap Dam	4,180,000
Nagmati Dam	45,000,000[1]
Watershed Management	1,175,800
Support Park Management	43,000
TOTAL COST	**50,398,800**

1: To be updated after completion of FS for Nagmati Dam. Source: PPTA

J. Duration of Constructions

1. Construction Duration for Dhap Dam

183. The estimated duration of construction of the Dhap Dam is shown in Table III-9. Diversion is to commence at start of the dry season (i.e. to minimise risk of flooding of damsite). Some activities are done in parallel with main activities determining the timeline.

Table III-9: Estimated duration of construction and filling of reservoir.

Principal Activity	Month	Parallel Activities
Contractor mobilisation & camps, etc.	2	Construct access
River diversion	1	Clear dam footprint Clear reservoir area (ongoing*) Establish quarry
Dam: foundation preparation	1	
Dam: place rockfill	3	Construct spillway
Dam: place concrete face	1	Install release valve
Finishing works	1	
Sub-total	**9**	
Reservoir filling	3	
Total	**12**	

*Denotes parallel activity going on past the end-time of the listed „principal activity".
Source: PPTA

2. Construction Duration for Nagmati Dam

184. The estimated duration of construction of the Nagmati Dam is shown in Table III-10. Diversion is to commence at start of the dry season (i.e. to minimise risk of flooding of damsite). Some activities are done in parallel with main activities determining the timeline. Compensation flow of 100 l/s (tentative figure only) to be released continuously during filling.

Table III-10: Estimated duration of construction and filling of reservoir

Principal Activity	Months	Parallel Activities
Contractor mobilisation & camps, etc.	3	Construct access
River diversion	2	Clear dam footprint Clear reservoir area (ongoing*) Establish quarry
Dam: foundation preparation	3	
Dam: place rockfill	12	Construct spillway Hydro works (ongoing*)
Dam: place concrete face	3	Install release valve
Finishing works	3	
Sub-total	**26**	
Reservoir filling	3	
Total	**29**	

*Denotes parallel activity going on past the end-time of the listed „principal activity". Source: PPTA.

IV. DESCRIPTION OF THE ENVIRONMENT

A. Physical Resources

1. Physiography and Land use

185. The Bagmati is the principal river of the Bagmati basin. The total catchment area of the Bagmati river is 157 km^2 (15700 ha) with a length of 44 km from its origin at Shivapuri Bagdwar at an elevation of 2732m to Katuwal *daha* at an elevation of 1140m[20]. Based on the morphology and land-use, the Upper Bagmati basin can be divided into 4 zones according to the Bagmati Action Plan[21], see Figure IV-1.

186. Zone 1 has a total area of about 3386 ha. Out of the total catchment area in the Shivapuri Nagarjun National Park (SNNP), about 328.6ha (9.7%) is covered by agricultural land including settlement areas and the remaining 3057.4ha (90.3%) is covered by forest, bush areas and wetlands, see Figure IV-2. The land use areas are seen in Table IV-1.

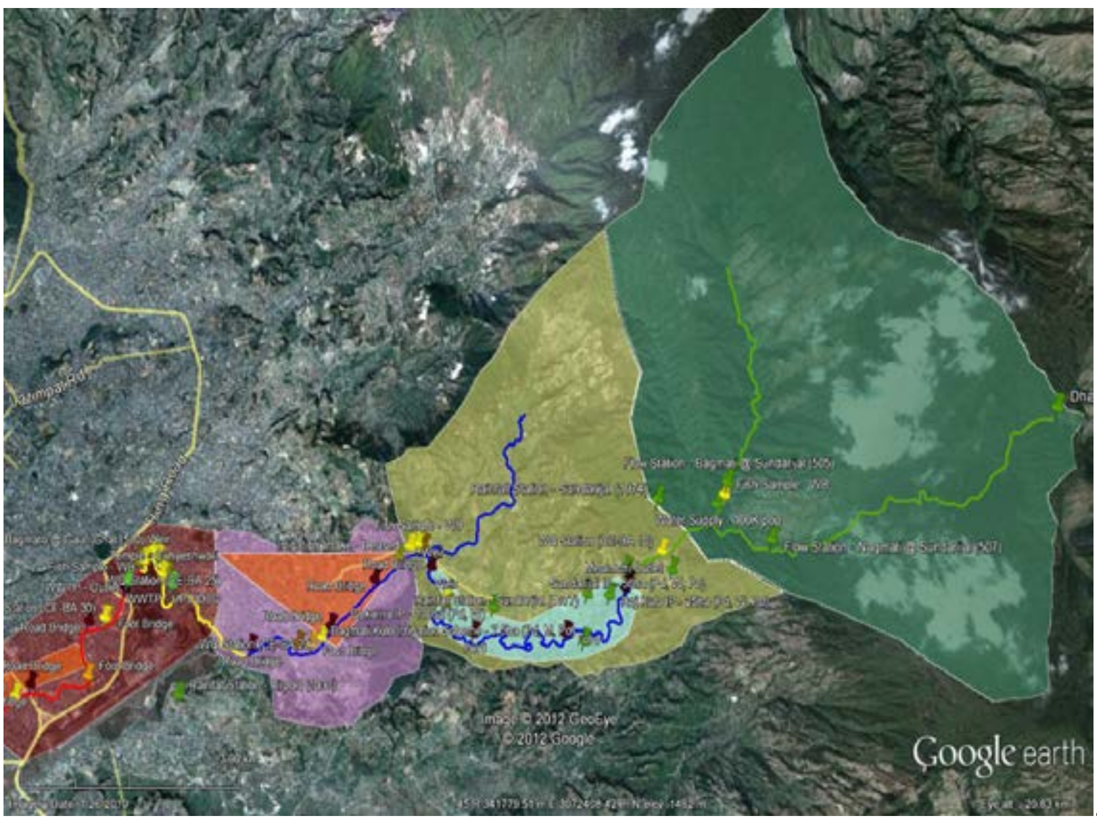


Figure IV-1: Zones in the Upper Bagmati. Source: BREMP derived from BAP.

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[20] Topography map, Department of Survey, 1998.

[21] Bagmati Action Plan (2009-2014).

Figure IV-2: Landuse map of the Shivapuri watershed. Source: PPTA

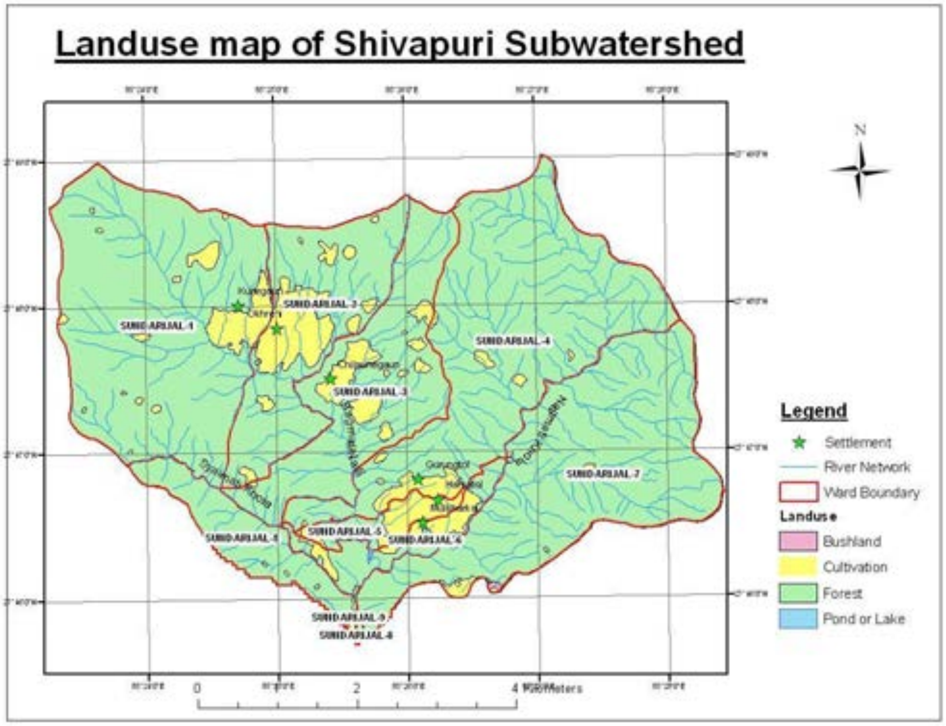


Table IV-1: Landuse in the Shivapuri watershed

S.No	Land use	Area (ha)	% Coverage
1	Cultivation	328.6	9.70
2	Forest	3055.0	90.23
3	Bush land	2.0	0.06
4	Wetlands	0.57	0.01
	Total	3386.0	100.00

Source: GIS section in Department of Soil Conservation and Watershed Management

187. Lying on the northern fringe of the SNNP is the major recharge zone for the Bagmati River along with its tributaries: Bishnumati, Manohara, Dhobikhola, Balkhu and Nakkhu have their origin in the SNNP.

188. The Bagmati Action Plan raises major issues related to land use in the Natural Conservation Zone:

(i) Decreasing water discharge due to intensive water diversion.

(ii) Degrading terrestrial biodiversity due to increasing settlements, trend of converting forest area into agricultural land, felling of trees and other forest resources for fuel wood, building construction and other commercial activities, new constructions like monasteries, roads and other infrastructures, animal hunting and use of pesticides for farming.

(iii) Degrading water quality due to poor sanitation and unmanaged waste generated by households, tourists, picnickers and other recreational activities and use of rivers for household purposes.

(iv) Deteriorating culture and heritage due to new construction, encroachment, changes in land use etc.

a. **Rural Zone**

189. The Bagmati River flows through the Rural Zone from Sundarijal to Gokarna. The land-use here is dominated by agricultural land, with an increasing population density and housing concentrated mostly along the main road from Gokarna to Sundarijal:

190. The Bagmati Action Plan raises major issues related to land use:

(i) Decreasing river water discharge due to river diversion for drinking and irrigation purposes at Sundarijal, tanker services for commercial benefits of VDC"s and local settlements.

(ii) Narrowing and deepening of water way due to excessive sand mining,

(iii) Degrading water quality and aquatic biodiversity due to loss of riparian vegetation, untreated sewage disposal from households and industries, dumping of waste, use of chemical fertilisers and pesticides.

(iv) Changes in river side land use for agriculture, dyeing and cleaning materials for cottage industries, workshops, road construction.

(v) Eroding aesthetic value due to loss of riparian vegetation, improper management of ritual and cremation waste, commercial hoarding boards, solid waste dumped along the river banks and into the river, etc.

(vi) Deteriorating culture and heritage due to replacement of original architecture encroachment, alteration of use, and lack of responsiveness from concerned authorities.

191. The trend of urban growth has no sign of containment in the present limit at Gokarna. Availability of the road linkage from Gokarna to Sundarijal towards the north parallel to the river gives ample opportunity for further urban development. Availability of sufficient agricultural land exposed to the land market of Kathmandu Valley with comparatively low land prices are very attractive to land developers and individual house owners alike

b. **Peri-Urban Zone**

192. The Peri-urban zone stretches from Gokarna and down to Pashupatinath. The urban growth trend towards the north east of Kathmandu Municipality upstream from Guheshwori [Pashupatinath] and along the Bagmati River corridor is quite extensive. Extension of this

growth at Makalbari and Nayabasti of Jorpati VDC (Zone III) has touched the religious site of Gokarna.

193. The Bagmati Action Plan raises major issues related to land use:

(i) Direct discharge of untreated sewage, solid waste dumped by municipalities, industries and households, storm water drainage.

(ii) Changes in river side land use from agricultural to residential and commercial use.

(iii) Eroding aesthetic values due to loss of riparian vegetation, commercial hoarding boards, solid waste dumped along the river banks and in the river.

(iv) Deteriorating culture and heritage use due to encroachment and alterations of use.

c. **Urban Zone**

194. The Urban Zone within the project boundary stretches from Pashupatinath and downstream to the Sinamangal Bridge. From the Sinamangal Bridge and downstream there a concentrations of squatters along the river banks. The zone is highly urbanised.

195. The Bagmati Action Plan raises major issues related to land use:

(i) Encroachment of land by private as well as illegal settlements

(ii) Degradation of water quality and aquatic biodiversity due to discharge of waste water, leachate produced by huge volumes of solid waste dumped by municipalities and private organisations along the river banks.

(iii) River side road construction, temporary sites for construction material.

(iv) Eroding aesthetic values due to loss of riparian vegetation, filthy and un-healthy river surroundings, construction of toilets.

2. **Demography**

196. Kathmandu Valley being the economic and administrative center of Nepal is experiencing a very high population growth rate. The total population in the catchment upstream Pashupatinath was 268.115 in 2011 with an expected increase to 692.343 by 2030[22]. The total population distributed on sub-catchments is shown in Table IV-2.

Table IV-2: Population in the Project area catchment of the Bagmati and expected growth[23].

Catchment upstream:	Population 2011 (Thousands)	Population 2030 (Thousands)
Gokarna	68	122
Gaurighat	253	406
Pashupati	128	155
Total	449	683

Source: GHD, 2010

197. The total number of the household in the Bagmati watershed in SNNP is 323 with a total population of 1666[24]. The male population is 819 (49.2%) whereas female population is 847 (50.9%).

Table IV-3: Households and male – female population in SNNP

Household	Female	Male	Total
323	847	819	1666

Source: Sundarijal VDC, village profile, 2010.

Major ethnic groups in the watershed are Tamang, Newar, Brahmin, Chhetri, Damai, Gurung, and Sherpa.

3. Meteorology and Climate

198. The upper and middle parts of the Bagmati basin (Kathmandu valley and Mahabharat range) have warm temperate climate. Rainfall is caused mainly due to the Monsoon started from the Bay of Bengal. The monsoon season falls during mid-July to mid-September and about 80% of total annual rainfall occurs during this period.

a. Temperature

199. The monthly maximum and minimum air temperatures recorded during 2001-10 at Kathmandu Airport are shown in (Tables IV-4 and IV-5). The highest mean monthly maximum temperature of 29.6 ^{o}C is found in June. The lowest mean monthly maximum temperature of 20.1 ^{o}C is observed in January. Further, the highest mean monthly minimum temperature of 20.5 ^{o}C is observed in July. The lowest mean monthly minimum temperature of 2.9 ^{o}C is found in January.

[23] GHD, 2010, Conceptual Wastewater Master Plan, for ADB TA 4893-NEP: Kathmandu Valley Water Supply and Wastewater System Improvement.
[24] Sundarijal VDC, village profile, 2010

Table IV-4 Monthly Maximum Temperature of Kathmandu Airport

Year	Maximum Temperature (°C)										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
Jan	20.7	19.0	19.2	18.2	17.9	22.3	19.1	19.4	22.5	22.3	20.1
Feb	24.6	22.7	20.7	22.0	22.0	25.2	19.1	21.3	25.8	23.2	22.7
Mar	26.7	25.2	24.5	27.3	25.8	26.3	24.7	26.0	27.5	29.2	26.3
Apr	29.6	27.1	28.6	27.7	28.6	27.8	29.1	29.3	31.4	31.9	29.1
May	28.2	27.3	29.7	28.6	29.4	28.4	29.8	29.0	29.1	30.3	29.0
Jun	28.6	29.3	28.8	28.8	30.5	29.5	29.6	29.3	30.6	31.1	29.6
Jul	28.9	28.5	28.7	27.7	29.1	29.5	28.4	29.3	29.8	29.5	28.9
Aug	29.0	29.0	29.1	29.1	29.0	29.6	29.2	29.5	29.1	29.2	29.2
Sep	28.5	28.1	28.5	28.1	29.5	28.3	28.1	29.4	29.4	28.6	28.7
Oct	27.7	26.7	27.6	26.0	26.4	27.2	28.0	28.4	27.4	28.0	27.3
Nov	25.2	23.8	23.6	22.7	23.3	23.8	24.7	25.3	24.0	24.8	24.1
Dec	20.6	19.8	19.6	20.6	21.0	20.2	20.9	22.2	20.5	20.8	20.6

Source: Department of Hydrology and Meteorology

Table IV-5 Monthly Minimum Temperature of Kathmandu Airport

Year	Minimum Temperature (°C)										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Mean
Jan	2.1	2.7	2.0	3.1	4.3	2.0	2.9	3.0	3.7	3.1	2.9
Feb	4.8	5.4	5.4	5.2	5.9	9.1	6.5	3.3	5.9	4.8	5.6
Mar	7.4	9.3	9.0	10.7	10.1	8.6	9.3	9.5	8.2	10.9	9.3
Apr	11.2	12.8	13.3	13.2	11.6	12.4	13.8	12.5	13.3	13.9	12.8
May	16.4	16.7	14.5	16.5	14.9	17.3	16.8	15.4	16.0	16.8	16.1
Jun	19.2	19.6	19.1	19.1	19.2	19.4	19.5	19.6	18.9	19.5	19.3
Jul	20.1	20.2	20.3	20.2	20.6	20.9	20.6	20.3	20.7	20.6	20.5
Aug	19.9	19.8	20.5	20.6	20.6	20.3	20.5	20.1	20.5	20.6	20.3
Sep	18.5	18.2	19.4	19.3	19.5	18.9	19.2	18.7	18.6	19.2	19.0
Oct	14.3	13.5	14.8	13.1	14.0	13.7	15.3	13.5	14.4	14.9	14.2
Nov	8.5	8.4	9.3	7.5	8.4	9.2	8.9	8.7	7.8	9.9	8.7
Dec	3.7	4.0	4.4	4.5	3.5	5.1	3.8	6.0	5.3	2.9	4.3

Source: Department of Hydrology and Meteorology

b. **Rainfall**

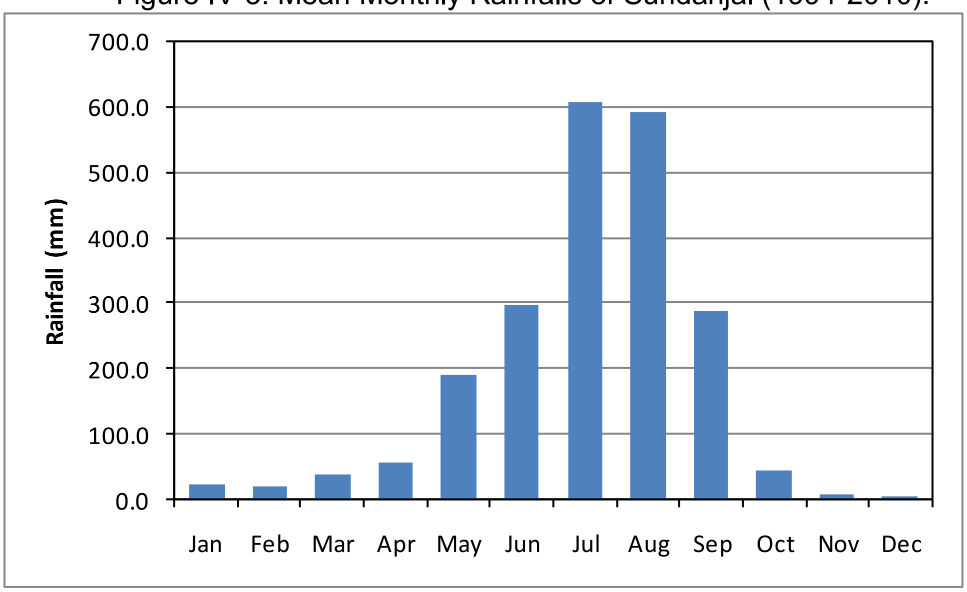
200. In the Upper Bagmati one rain-gauge station close to the convergence of Bagmati and Nagmati at Sundarijal is operated by Department of Hydrology and Meteorology. The daily rainfall for the period of 1994-2010 has been analysed to arrive at the monthly rainfall pattern of the Sundarijal station. Based on the analysis, the maximum mean monthly rainfall of 607.4 mm has been observed in the month of July and the minimum mean monthly rainfall of 7.2 mm in December (Table IV-6 and Figure IV-3).

Table IV-6 Monthly and Annual Rainfall of Sundarijal

Year	Monthly Rainfall (mm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1994	35.4	24.1	21.6	28.2	262.0	619.3	875.7	878.8	676.2	0.0	19.8	0.0	3441.1
1995	19.6	47.2	42.0	9.6	102.6	326.4	815.0	588.0	357.0	41.0	60.8	0.0	2409.2
1996	73.6	9.2	14.8	51.0	67.6	492.8	680.4	897.8	480.2	64.4	0.0	0.0	2831.8
1997	28.0	8.2	27.4	125.6	113.0	329.0	1176.0	752.8	227.0	34.8	47.0	64.4	2933.2
1998	1.8	0.0	97.0	133.4	308.8	440.2	808.0	852.0	203.6	22.4	0.0	0.0	2867.2
1999	6.2	2.2	0.2	19.5	219.2	455.6	822.8	695.8	381.4	194.6	0.0	0.0	2797.5
2000	0.3	2.4	20.4	87.4	343.0	514.1	734.9	706.6	361.7	2.8	0.0	2.0	2775.6
2001	7.0	1.5	12.1	26.8	183.3	420.1	597.9	636.9	124.6	18.0	0.0	0.2	2028.4
2002	37.3	38.1	111.4	90.6	271.2	133.8	536.6	512.4	128.7	47.3	0.4	0.2	1908.0
2003	49.9	64.5	61.7	14.5	29.1	68.8	584.1	549.6	329.8	0.0	0.0	20.4	1772.4
2004	48.9	0.3	31.4	30.3	233.0	101.8	392.2	287.9	183.8	44.9	30.4	0.0	1384.9
2005	93.8	14.6	15.3	11.8	21.7	49.7	190.1	208.6	137.5	146.6	0.0	0.0	889.7
2006	0.0	0.0	37.4	112.6	410.3	257.1	295.8	424.8	181.1	11.2	0.0	22.2	1752.5
2007	0.0	104.7	54.5	154.2	114.7	245.5	428.4	571.5	406.8	30.2	0.0	0.0	2110.5
2008	1.8	0.0	104.8	25.8	111.8	234.9	294.9	321.8	286.2	41.4	0.0	13.2	1436.6
2009	0.0	0.0	17.4	0.0	290.0	92.4	684.9	426.4	326.9	37.3	0.0	0.0	1875.3
2010	0.0	24.7	28.4	79.2	157.5	306.4	407.4	782.2	128.1	52.9	0.0	0.0	1966.8
Mean	**23.7**	**20.1**	**41.0**	**58.9**	**190.5**	**299.3**	**607.4**	**593.8**	**289.4**	**46.5**	**9.3**	**7.2**	**2187.1**

Source: DHM Data analysed by PPTA

Figure IV-3: Mean Monthly Rainfalls of Sundarijal (1994-2010).



DHM data analysed by PPTA.

201. Based on a frequency analysis using various distribution functions the probable daily rainfall of Sundarijal for 2, 5, 10, 20, 50 and 100 years return periods are 90.5 mm, 124.1 mm, 146.3 mm. 167.6mm, 195.2 mm and 215.9 mm, respectively[25] (Figure IV-4, Table IV-7).

Figure IV-4: Frequency Analysis of Maximum Daily Rainfalls of Sundarijal. Data from DHM analysed using various statistical methods.

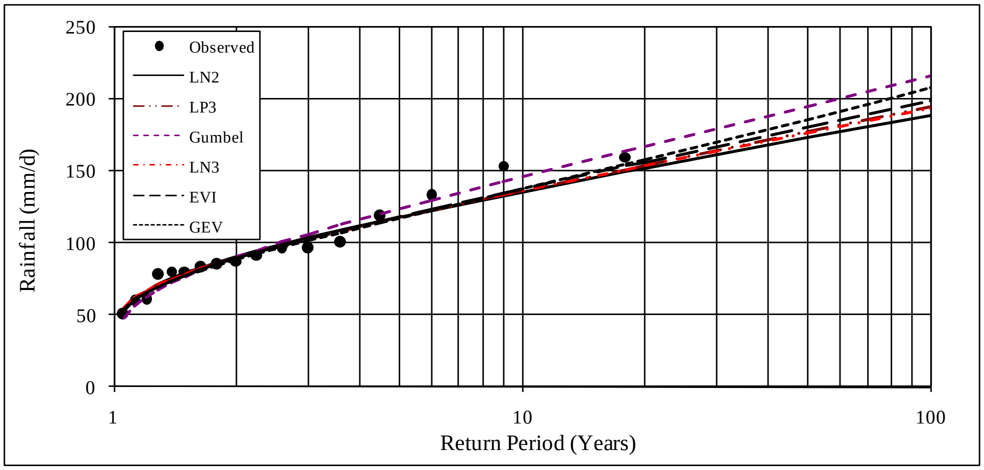


Table IV-7 Probable daily Rainfall of Sundarijal

Return Period (Years)	Probable Daily Rainfall (mm)
2	90.5
5	124.1
10	146.3
20	167.6
50	195.2
100	215.9

Source: DHM Data analysed by PPTA

4. Hydrology

202. The region is the origin of some of the important river systems including Bagmati, Bishnumati, Nagmati, Syalmati, Rudramati, and Yashomati, which are major watersheds. The outflows from the Dhap area create the headwaters of the Nagmati, the main tributary to Bagmati in the Shivapuri Nagarjun National Park (SNNP).

203. In the upper Bagmati catchment, a hydrological station upstream the Sundarijal Water Supply Reservoir monitors both stage and discharge in the Bagmati River (Figure IV-5). In the Nagmati a hydrological station at Mulkharka was operated during 1963-71. Further downstream DHM operates a hydrological station at Gaurighat. A Rain Gauge station is situated south of Mulkharka, named the Sundarijal Rain Gauge station by DHM.

[25] PPTA Hydrology Report.

Figure IV-5: Hydrometric stations in the Upper Bagmati Basin operated by DHM.

Red circle = Sundarijal rainfall station
Orange diamond = Bagmati at Sundarijal River Level Recording Station

Source: PPTA

204. A monthly flow analysis based on the observed daily discharge data in the Bagmati recorded over the period of 1963-2006 shows a maximum average monthly flow of 5.70 m^3/s observed in September 1983, whereas the minimum average monthly flow of 0.08 m^3/s was observed in March 1971. Mean monthly flows of the river during dry season are 0.32 m^3/s, 0.29 m^3/s, 0.28 m^3/s and 0.37 m^3/s in February, March, April and May, respectively. Mean monthly flows of river during the wet season are 2.80 m^3/s, 3.93 m^3/s and 3.01 m^3/s in July, August and September, respectively (Table IV-8).

205. The highest maximum flow of 74.8 m^3/s was observed in 1978 and the lowest maximum flow of 3.5 m^3/s was observed in 1979. Further, the highest minimum flow of 0.43 m^3/s was observed in 2006 whereas the lowest minimum flow of 0.03 m^3/s was found in 1970.

Table IV-8: Monthly Discharges of Bagmati at Sundarijal

Year	River Flow (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1963	0.22	0.13	0.14	0.19	0.18	0.42	2.04	4.83	2.65	1.10	0.54	0.34
1964	0.22	0.15	0.12	0.12	0.15	0.28	1.76	3.73	3.60	1.39	0.56	0.41
1965	0.33	0.26	0.22	0.23	0.21	0.40	1.55	3.26	1.50	0.81	0.56	0.28
1966	0.25	0.22	0.19	0.16	0.49	1.19	3.11	4.88	3.27	0.96	0.38	0.28
1967	0.25	0.20	0.19	0.20	0.18	0.39	3.70	4.51	3.25	1.45	0.73	0.40
1968	0.26	0.20	0.24	0.22	0.18	1.37	4.20	4.72	3.39	1.92	0.61	0.29
1969	0.20	0.21	0.19	0.17	0.19	0.20	1.32	3.10	2.92	1.29	0.55	0.33
1970	0.22	0.21	0.20	0.19	0.15	0.45	2.65	4.97	3.15	1.75	0.66	0.38
1971	0.15	0.11	0.08	0.14	0.14	2.24	2.95	4.27	2.44	0.99	0.56	0.31
1972	0.28	0.25	0.23	0.20	0.24	0.45	2.45	2.99	2.99	0.99	0.59	0.39

Year	River Flow (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1974	0.24	0.20	0.16	0.10	0.26	0.26	1.98	3.01	3.14	1.79	1.16	0.90
1975	0.75	0.68	0.69	0.51	0.36	0.71	1.33	1.11	2.63	1.75	0.93	0.72
1976	0.57	0.44	0.29	0.30	0.68	4.95	5.56	5.83	5.54	1.53	0.46	0.46
1977	0.38	0.35	0.30	0.37	0.42	1.08	3.26	3.55	2.05	0.90	0.48	0.38
1978	0.32	0.23	0.26	0.24	0.38	0.61	2.51	5.19	3.39	1.87	0.60	0.24
1979	0.16	0.10	0.08	0.11	0.13	0.30	2.12	2.64	2.36	1.00	0.50	0.40
1980	0.20	0.15	0.11	0.12	0.19	1.55	3.19	2.96	2.86	1.60	0.92	0.62
1981	0.36	0.26	0.26	0.29	0.45	0.89	2.68	3.27	2.65	1.37	0.78	0.50
1982	0.34	0.40	0.30	0.48	0.27	0.42	1.55	2.75	3.03	0.98	0.38	0.35
1983	0.24	0.19	0.17	0.21	0.23	0.31	3.92	5.66	5.70	3.00	1.19	0.73
1984	0.57	0.43	0.40	0.40	0.62	1.26	4.71	4.87	4.50	1.18	0.55	0.40
1985	0.40	0.25	0.21	0.22	0.34	0.56	2.11	2.83	2.98	1.43	0.73	0.48
1986	0.55	0.46	0.40	0.40	0.43	0.93	3.31	4.00	3.80	1.64	0.73	0.50
1988	0.26	0.19	0.19	0.18	0.31	1.28	3.68	5.04	2.71	1.13	0.64	0.49
1989	0.45	0.34	0.29	0.23	0.39	0.75	2.63	5.07	3.87	2.11	1.02	0.69
1990	0.56	0.51	0.47	0.48	0.51	1.76	3.25	3.43	2.88	1.46	0.78	0.46
1992	0.24	0.18	0.15	0.13	0.16	0.28	1.48	3.83	3.90	1.64	0.99	0.65
1993	0.45	0.29	0.20	0.26	0.45	1.04	3.03	4.15	2.89	1.49	0.62	0.36
1994	0.51	0.52	0.63	0.59	0.64	0.99	2.91	4.03	2.82	0.71	0.35	0.20
1995	0.16	0.16	0.16	0.13	0.17	0.92	2.70	3.13	1.56	0.62	0.49	0.42
1996	1.39	1.27	1.20	1.19	1.20	1.62	3.66	4.21	2.30	1.47	0.40	0.24
1997	0.22	0.19	0.14	0.18	0.15	0.48	3.35	2.40	1.68	1.19	0.68	0.48
1998	0.30	0.25	0.29	0.27	0.36	0.66	2.98	3.98	2.23	1.40	0.77	0.47
1999	0.29	0.23	0.21	0.21	0.23	0.87	3.04	4.11	3.63	2.18	1.08	0.66
2000	0.48	0.36	0.30	0.32	0.59	1.34	2.96	3.42	1.91	1.11	0.40	0.33
2001	0.24	0.14	0.14	0.17	0.64	0.91	2.89	4.41	3.46	1.48	0.90	0.77
2002	0.77	0.76	0.61	0.30	0.74	1.45	4.12	5.62	2.01	1.18	0.51	0.34
2003	0.33	0.33	0.30	0.21	0.22	0.43	2.32	3.58	3.46	1.31	0.65	0.39
2004	0.42	0.35	0.32	0.28	0.29	0.40	1.91	3.75	2.53	1.59	0.83	0.58
2005	0.52	0.40	0.39	0.37	0.38	0.40	1.13	3.80	2.72	1.44	0.92	0.68
2006	0.60	0.51	0.50	0.52	0.72	1.22	2.93	4.35	2.86	1.38	0.95	0.73
Mean	**0.38**	**0.32**	**0.29**	**0.28**	**0.37**	**0.93**	**2.80**	**3.93**	**3.01**	**1.40**	**0.69**	**0.46**
Min	**0.15**	**0.10**	**0.08**	**0.10**	**0.13**	**0.20**	**1.13**	**1.11**	**1.50**	**0.62**	**0.35**	**0.20**
Max	**1.39**	**1.27**	**1.20**	**1.19**	**1.20**	**4.95**	**5.56**	**5.83**	**5.70**	**3.00**	**1.19**	**0.90**

Source: DHM Data analysed by PPTA

206. The average monthly flows of Bagmati at Gaurighat during 1991-2006 are presented in Table IV-9. The maximum average monthly flow of 22.30 m^3/s was observed in August 2002 whereas the minimum average monthly flow of 0.05 m^3/s was observed in April 1995. Mean monthly flows of the river during dry season are 0.45 m^3/s, 0.38 m^3/s, 0.45 m^3/s and 0.74 m^3/s in February, March, April and May, respectively. Mean monthly flows of river during wet season are 7.35 m^3/s, 11.12 m^3/s and 6.91 m^3/s in July, August and September, respectively.

207. The highest maximum flow of 108 m3/s was observed in 2002 and the lowest maximum flow of 21.6 m3/s was observed in 1992. Further, the highest minimum flow of 0.69 m3/s was observed in 2003 whereas the lowest minimum flow of 0.03 m3/s was observed in 1995.

Table IV-9: Average Monthly Discharges at Gaurighat

Year	Average Monthly Discharge (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1991	0.60	0.16	0.18	0.25	0.44	0.80	3.40	6.42	6.90	1.95	0.94	0.71
1992	0.48	0.25	0.11	0.19	0.33	0.73	2.45	6.05	6.19	2.34	1.31	0.83
1993	0.41	0.42	0.35	0.58	0.89	1.64	4.97	8.43	4.16	1.93	0.82	0.38
1994	0.32	0.19	0.08	0.10	0.29	2.16	6.68	10.60	8.09	1.48	0.44	0.22
1995	0.08	0.07	0.06	0.05	0.62	4.73	8.39	7.06	4.01	2.18	1.14	0.52
1996	0.47	0.23	0.21	0.18	0.18	1.53	4.83	11.10	5.91	3.02	1.15	0.59
1997	0.40	0.29	0.22	0.56	0.36	1.06	8.51	10.90	4.05	1.79	0.85	0.84
1998	0.38	0.30	0.54	0.60	0.90	1.14	8.14	11.80	5.25	2.35	1.00	0.47
1999	0.35	0.32	0.29	0.31	0.43	2.08	7.54	11.00	6.58	4.83	1.40	0.55
2000	0.27	0.22	0.18	0.27	1.24	2.64	7.47	11.70	6.17	2.19	0.87	0.70
2001	0.65	1.55	0.37	0.31	0.60	1.91	7.04	16.10	10.50	5.19	2.20	0.98
2002	0.76	0.59	0.88	0.93	1.99	2.01	17.00	22.30	9.33	2.72	0.87	0.30
2003	1.41	1.56	1.51	1.39	1.16	2.13	13.30	16.90	17.10	4.98	1.77	0.97
2004	0.72	0.37	0.54	0.68	1.07	1.25	9.15	12.00	7.43	3.68	1.18	0.55
2005	0.44	0.24	0.20	0.16	0.16	0.70	3.05	8.70	3.45	1.69	0.58	0.21
2006	0.09	0.54	0.39	0.62	1.13	1.88	5.73	6.88	5.37	2.23	0.58	0.25
Mean	0.49	0.45	0.38	0.45	0.74	1.77	7.35	11.12	6.91	2.78	1.07	0.57
Min	0.08	0.07	0.06	0.05	0.16	0.70	2.45	6.05	3.45	1.48	0.44	0.21
Max	1.41	1.56	1.51	1.39	1.99	4.73	17.00	22.30	17.10	5.19	2.20	0.98

Source: DHM Data analysed by PPTA

a. Flooding in the Bagmati River Basin

208. Floods in the past have caused loss of lives and property in the Bagmati basin. The flood events 1993, 2002 and 2004 were very severe. According to secondary sources, severe floods occurred in the Kathmandu valley resulting into loss of lives and damage to infrastructures including 27 deaths and persons missing in 2002. The massive downpour of 22nd -23rd July, 2002 in Kathmandu valley was the highest recorded rainfall in the capital in three decades. On 23rd July, 2002, the flood overtopped the natural banks of rivers at many locations within the valley. An extreme flood also occurred in the valley in 1954. Huge flash floods hit the valley on 27-28 July 1954. Heavy rainfall of 173 mm on 27th and 99 mm on 28th July 1954 were recorded in meteorological station situated at Indian Embassy, Kathmandu.

209. A major flood disaster also occurred in Bagmati river basin on 19-21 July, 1993 which was caused by intensive rainfall in the central region of Nepal. 540 mm of 24 hour rainfall with intensity as high as 65 mm/hr was recorded which was the highest ever recorded in the history of Nepal. The floods caused heavy damages to the Bagmati barrage and Kulekhani Hydropower Plant. Many villages and several bridges were washed away and the disaster claimed many lives.

5. Geology and Soils

210. The Kathmandu valley is surrounded by high mountain ranges including Shivapuri (2732m) to the North and Phalchauki (2762m) to the South. The valley is composed of Quaternary (Recent and Plio- Pleistocene) sediments overlying Precambrian to Devonian basement rocks. The valley is bounded by faults associated with the Main Central Thrust zone and which separate the Gneiss and Granite complex of the Higher Himalaya Tectonic Zone to the North.

211. The Quaternary sediments within the Kathmandu valley are mainly lacustrine and fluvial comprising clays, silts, sands and gravels with a thickness in excess of 550m. The lacustrine sediments were deposited in an ancient lake which occupied the valley from about 2.5million to 29000 years ago and include an extensive dark coloured organic clay with fine sands and peats known as the Kalimati Formation which covers the central part of the valley. The northern part of the valley is underlain mainly by poorly graded and poorly sorted clays, silts, sands and gravels. Along the river systems the lake deposits are overlain by recent unconsolidated fluvial deposits of sands, silts and gravels. The lacustrine sediments overlie coarse sand and gravel beds deposited within an ancient deep Bagmati River system.

212. The basement rocks which underlie the valley consist of an intensely folded and faulted Precambrian to Devonian thrust mass composed of Phyllites, schists, slates, limestones and marbles. To the north of the valley the rising mountains are composed of gneiss and granite of the Sheopuri injection complex and through which rises the upper Bagmati River catchment. Further to the North lies a branch of the Main Central Thrust fault. The topography in this northern area is steep and rugged and landform development is governed by deep weathering, erosion and landslides. Deep rock related failures are very frequent on steep slopes.

213. The Kathmandu Valley lies within a very active seismic zone. The high seismic activity is due to movement along thrust faults and the gradual uplift of the mountains caused by the collision of the Indian and Eurasian tectonic Plates. Several large and devastating earthquakes have occurred in the past, the more recent being in 1833 (Reichter magnitude 7), 1934 (Reichter magnitude 8.4), 1960 and 1988. Extensive liquefaction within the unconsolidated loose sands and silts occurred in parts of the valley during the strong earthquake events. The high ground water table within the valley makes these sediments particularly vulnerable to liquefaction.

214. Two large active transverse faults, as shown in Figure IV-6, are located close to the site. They are the Motihari Gourisankar Fault located approximately 29 km south-east of the site and the Bhimphedi-Kathmandu Fault located approximately 4 km west of the site[26]. The faults are assessed as being capable of producing Mw8 and Mw7.5 earthquakes, respectively based on correlations between fault length and Mw developed by Wells and Coppersmith[27] and Papazachos et al[28]. A summary of the features of these faults is provided in Table IV-10.

Table IV-10: Summary of Geology and Major Active Faults close to Proposed Dam Sites

Name	**Fault Length (km)**	**Distance from Site (km)**	**Magnitude (Mw)**	**Horizontal PGA-median (g)**
Motihari Gourisonkar	400	29	8.0	0.29
Bhimphedi-Kathmandu	135	4	7.5	0.50

[26] Dasgupta, S., Mukhopadyay, M. and Nandy, D.R. (1987) 'Active Transverse Features in the Central Portion of the Himalaya' Techtonophysics, Volume 136, pp.255-264.
[27] Wells, D.L. and Coppersmith, K.J. (1994) 'New Empirical Relationships Among Magnitude, Rupture Length, Rupture Width, Rupture Area, and Surface Displacement'. Bull. Seismic Soc. Am, Vol.84, No.4, pp974-1002,
[28] Papazachos,B.C., Scordilis, E.M., Panagiotopoulos, D.G., Papazachoa, C.B. and Karakaisis, G.F. (2004) 'Global Relations Between Seismic Fault Parameters and Movement Magnitudes of Earthquakes', Bull. Geological Soc. Of Greece, Vol.XXXVI, pp1482-1489.

Estimates of seismic hazard in terms of peak ground acceleration (pga) have been derived for the Operating Basic Earthquake (OBE[29]) (I in 100 AEP) and maximum design earthquake (MDE) levels of ground motion. The OBE peak ground acceleration (pga) (0.2g) has been obtained from a probabilistic seismic hazard analysis by Pandey et al [30]. This study provided estimates of pga for a 1 in 500 Annual Exceedence Probability (AEP)0.28g. The adopted 1 in 100 (AEP) pga of 0.2g is 71% of the 1 in 500 AEP. This is considered conservative. The MDE pga has been based on a deterministic approach and taken to be the highest pga predicted to occur at the site from all known active faults. The horizontal pga's associated with the Motihari Gourisankar and Bhimphedi-Kathmandu Faults are estimated to be 0.29g and 0.5g respectively at the site based on the Chiou and Youngs (2008) attenuation model[31]. The highest pga (0.5g) is associated with the Bhimphedi-Kathmandu Fault and this has been taken as the MDE pga.

Arising from this analysis, for design/analysis purposes at feasibility-level the design OBE and MDE pga's are as follows:

OBE: pga = 0.2g
MDE: pga = 0.5g

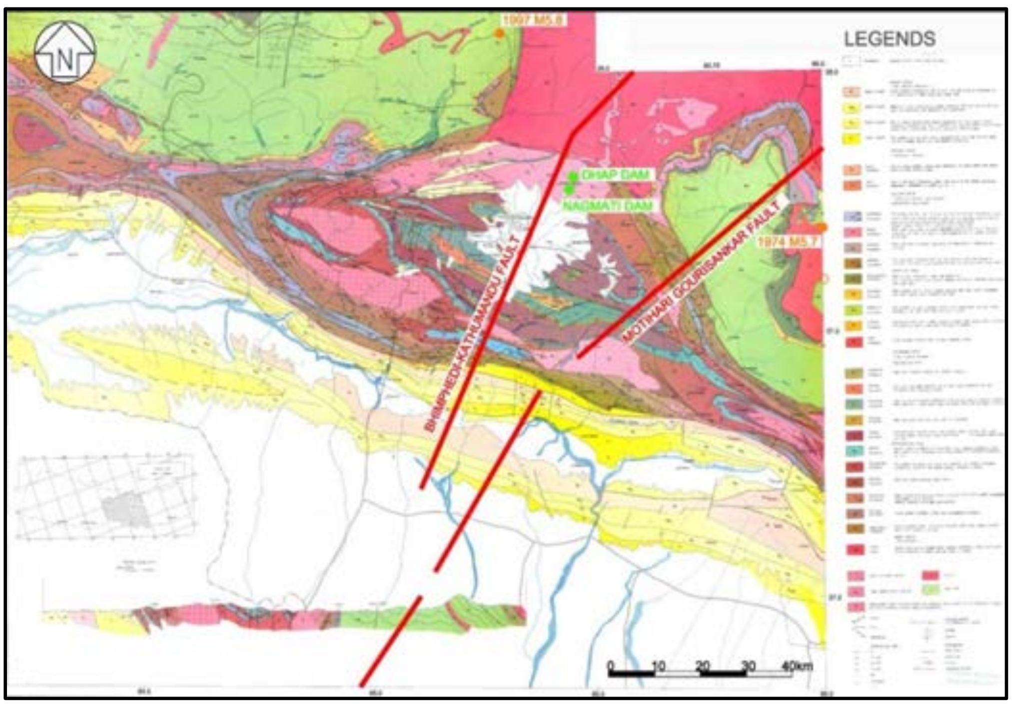


Figure IV-6: Summary of Features of Nearby Active Faults

215. The dominant soil textures in the Bagmati watershed in SNNP are sandy loams, loamy, gravely to course sandy with mica particles and sandy loam with brownish colour. In higher hills

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[29] OBE: The earthquake for which a structure is designed to remain operational, with the damage being readily repairable following the event

[30] Pandey, M.R., Chitrakar, G.R., Kafle, B., Saptoka, S.N., Rajaure, S and Gantam, U.P (2002) 'Seismic Hazard Map of Nepal', Dept. of Mines and Geology, Kathmandu, Nepal.

[31] Chiou and Youngs R.R. (2008)' An NGA Model for the Average Horizontal Component of Peak Ground Motion and Response Spectra', Earthquake Spectra, Vol. 24, pp173-216.

and steep slopes in the cultivated and settlement areas, because of such soil characteristic, the area is more prone to soil erosion and landslides.

6. **Air Quality**

216. Air quality monitoring was carried out from 21 November until 26 November 2012 along the Bagmati at five locations at the Dhap, the Nagmati Dam site, Sundarijal, Gokarna and Pashupati – Tilganga.

217. 24 hour air samples were collected to measure and analyse for Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO_2), Nitrogen Oxides (NOx) and Lead (Pb). The results are presented in Table IV-11.

Table IV-11: Measured Air Quality at project intervention sites in the Upper Bagmati basin.

Air Quality Data Locations	**Average Air Temperature 0C**	**Non - RSPM (µg/m^3)**	**RSPM – PM10 (µg/m^3)**	**SO_2 (µg/m^3)**	**NO_2 (µg/m^3)**	**Lead (µg/m^3)**
Pashupati	22.6	384.1	506.4	<1.0	<1.0	<0.04
Gokarna	14.0	239.1	87.9	<1.0	<1.0	<0.04
Sundarijal	18.0	86.6	52.5	<1.0	<1.0	<0.04
Nagmati	12.0	64.4	26.6	<1.0	<1.0	<0.04
Dhap	8.0	13.2	12.9	<1.0	<1.0	<0.04

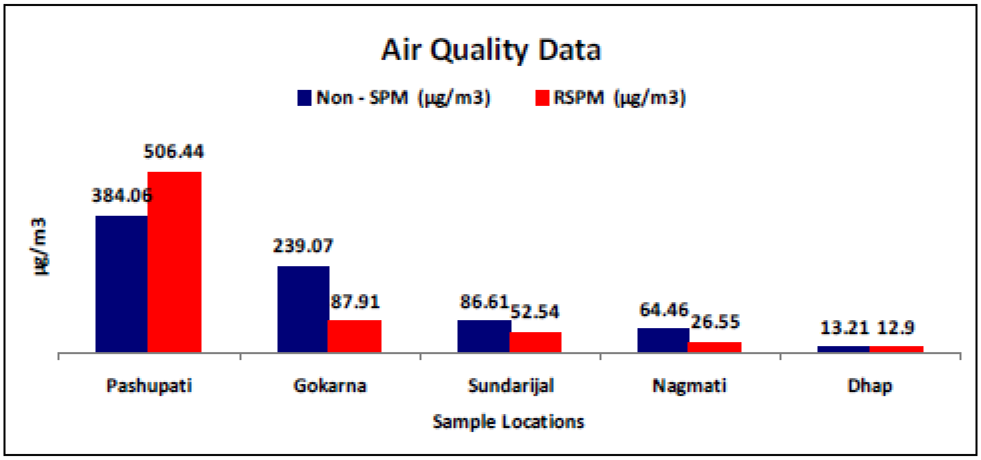
Source: PPTA

218. Throughout the survey area SO_2, NO_2 and Lead concentrations measured were below the detection limit. The non respirable particulate matters (Non-RSPM) were detected at significant levels at the Pashupati and Gokarna site i.e. 384.1 µg/m^3 and 239.1 µg/m^3, respectively. Neither Nepal, nor WHO standard is given for Non-RSPM.

219. The respirable particulate matter (RSPM) concentration of 506.4 µg/m^3 measured at Pashupati was found to be substantially above the standards Nepal standards of 120 µg/m^3 for a 24 hour mean. At the other sites the measured RSPM values were below the Nepal standards, however above WHO standards of 50 µg/m^3 at Gokarna and Sundarijal.

220. The trend in measured concentrations of particulate matter with high levels at Pashupati going upstream at the sites along the Bagmati/Nagmati Rivers to the expected very low levels in the SNNP at the Dhap is illustrated in Figure IV-7.

Figure IV-7: Concentrations of Particulate Matters measured from Pashupati to the Dhap site along the Bagmati/Nagmati rivers.



Source: PPTA

7. Noise

221. Ambient noise survey monitoring (24 hour on one hour interval) for measurement of Lmax (dBA), Lmin (dBA) and Leq (dBA) were carried out at the same positions as where air quality measurements were done, at the Dhap, the Nagmati Dam site, Sundarijal, Gokarna and Pashupati – Tilganga from 21 November until 26 November 2012.

222. A Sound Pressure level Meter was used to measure the noise level for 24 hour on hourly interval, except that in Dhap area. Considering the risk of destruction by wild life only fifteen hours of data was collected here. "A" weighting was used for the entire area, as it is suitable acoustic frequency for human ear response. The "Fast" response was followed equivalent to human ear response with a fraction of time of 0.125 seconds.

223. The noise data of 10 minutes were directly recorded in the instrument and downloaded to the computer for analysis. The maximum and minimum sound pressure levels were obtained by sorting the data in ascending order; whereas the equivalent sound level was determined by using appropriate formula prescribed by the instrument manual.

224. The averaged sound pressure level (day and night) of all the five selected points along with number of observations are presented in Table IV-12. The maximum (Sundarijal Location) and minimum (Pashupati) noise level recorded are 72.4 dBA and 46.9 dBA, respectively.

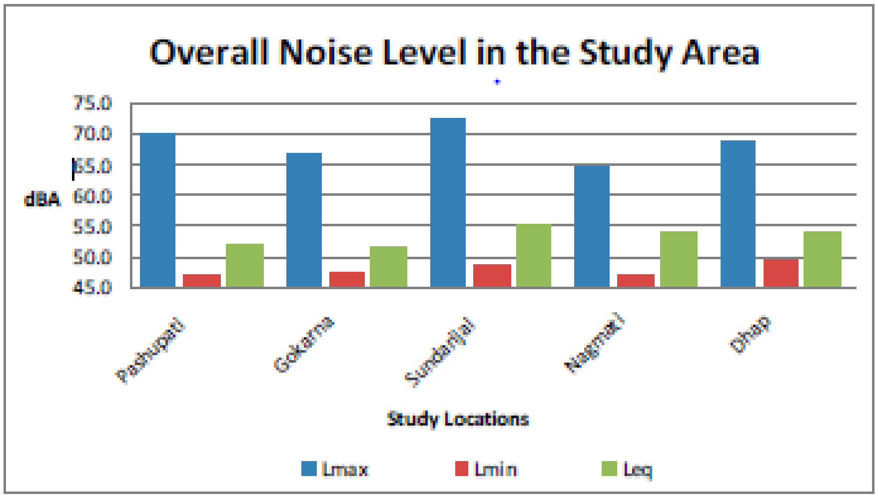
Table IV-12: Average noise level of the sampling points along the Baghmati and Nagmati Rivers

Location	Number of observations	Average Sound Pressure Level		
		Lmax	Lmin	Leq
Pashupati	24	69,7	46,9	51,5
Gokarna	24	66,6	47,1	51,3
Sundarijal	24	72,4	48,4	55,2
Nagmati Dam site	24	64,4	46,8	53,8
Dhap	15	68,5	49,0	53,7

Source: PPTA

225. The maximum sound levels recorded are attributed to vehicular movement. Pashupati, Gokarna and Sundarijal sites have maximum vehicular and human movement compared to the Nagmati Dam site and the Dhap. With no noise standards for Nepal, the results are compared to the WHO guideline value (70 dBA, see Appendix 3). The maximum sound pressure level at the Sundarijal area crossed the prescribed standard, while all other measured levels are below the WHO standard. The overall noise levels at the sites along the Bagmati and Nagmati Rivers are illustrated in Figure IV-8.

Figure IV-8: Overall noise levels in the study area.



Source: PPTA

226. At the Pashupati, Gokarna and Sundarijal site the high sound pressures were mainly caused by the vehicular movement along with their pressure horn. The noise level was also found to be relatively high due to the sound of moving water in the Bagmati River at the Gokarna site and the Nagmati River site. At the Dhap the sound level was mainly attributed to natural sounds such as the chirping sound of birds and occasional movement of motor bikes and mini trucks at the road bordering the Dhap to the north.

8. **Water Resources**

a. **Water Use**

227. At the upstream of the confluence between the Nagmati and the Bagmati the small Sundarijal Water Supply Reservoir diverts water from the Bagmati for water supply to Kathmandu (Figure III-2). A weir in the Nagmati diverts water to the small Sundarijal Water Supply Reservoir through a small canal during the dry season. In the driest month, the water supply diverts all water from the Bagmati and Nagmati for drinking water supply purposes effectively leaving no flow downstream of the weir in the Nagmati and the Sundarijal Water Supply Reservoir.

228. The Sundarijal Water Supply Reservoir supplies the Sundarijal Water Treatment Plant with between 12MLD and 18MLD via a 220m gross head 640kW rated mini-hydropower plant. The Sundarijal Water Treatment Plant is one of two major withdrawals from the Upper Bagmati River at the downstream end of Zone I. The second are the cluster of small irrigation off-takes that service most of the irrigated area within Zone II. Indicative SWTP monthly withdrawals are

shown in Table IV-13 based on quarterly reports prepared by KUKL for the 2008/9 period, along with the estimated monthly irrigation withdrawals.[32]

Table IV-13: Sundarijal Water Treatment Plans and Irrigation withdrawals in Zone I and II, respectively

	Average Monthly Discharges (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sundarijal Water Treatment Plant	0.29	0.34	0.34	0.28	0.28	0.42	0.47	0.50	0.51	0.50	0.49	0.44
Irrigation	0.30	0.30	0.30	-	-	0.70	0.70	0.70	0.70	0.70	0.30	0.30

Source: KUKL 2008/09 and WECS 1994

b. Water Quality

229. The most important parameter for the assessment of the water quality in any river system is Dissolved Oxygen being essential to all forms of aquatic life, including those organisms responsible for the self-purification processes in natural waters. Determination of DO concentrations is a fundamental part of a water quality assessment since oxygen is involved in, or influences, nearly all chemical and biological processes within water bodies. Concentrations below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish. The measurement of DO can be used to indicate the degree of pollution by organic matter, the destruction of organic substances and the level of self-purification of the water[33].

i. DHM Water Quality Monitoring Results

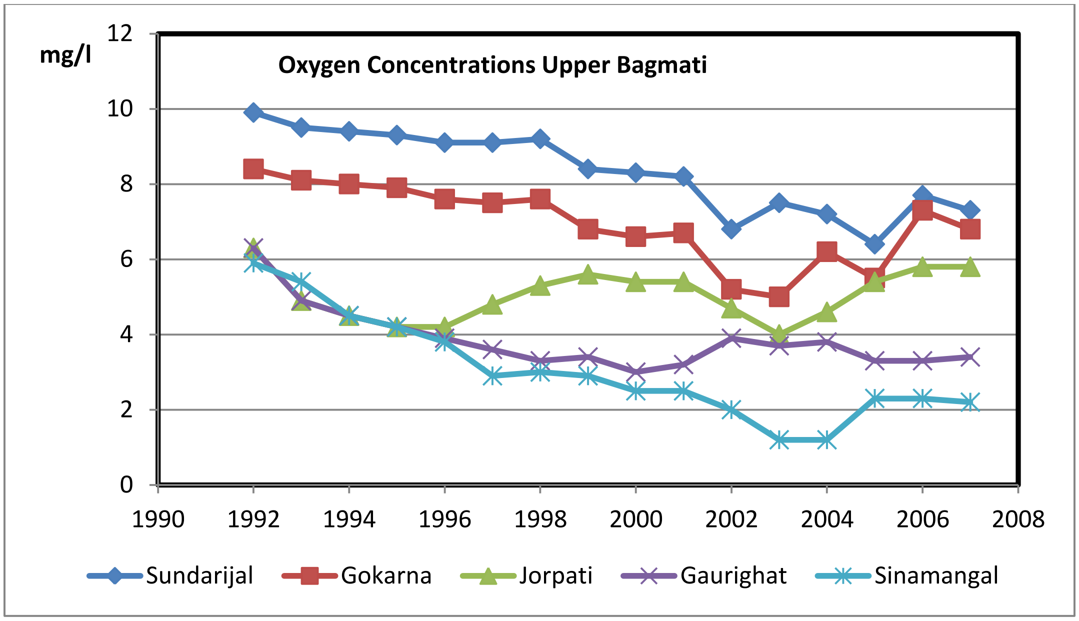
230. The DO concentrations measured under the DHM monitoring programme have been analysed for any trends over the monitoring period for the stations from Sundarijal to Sinamangal Bridge, within the Project Area of the BRBIP PPTA in the Upper Bagmati.

231. Only data outside the monsoon period has been considered. During the monsoon period the dilution factor of the high river flows is high and DO concentration levels are relatively high. It is during the dry season with low river flows that DO concentrations levels are critically affected. In order to account for variation from year to year in the river flows during the dry season, the DO concentrations levels are presented as a moving average over 4 years, see Figure IV-9.

[32] WECS, 2006, Multidimensional Study of the Bagmati River Basin.

[33] Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring – 2end Edition. 1992, 1996 UNESCO/WHO/UNEP.

Figure IV-9: Trends in DO concentrations from 1993 to 2006 for the DHM monitoring stations from Sundarijal to Gokarna Bridge. (Source: Analyses of DHM Monitoring data, represented as 4 year moving average).



Source: Data from DHM analysed by PPTA.

232. The results in Figure IV-9 show a considerable deterioration in the water quality in the Upper Bagmati from 1993 until 2006. The trend is significant for all stations, expect for the station at Jorpati Bridge. The monitoring frequency at the Jorpati Bridge is considerable less than for the other stations, making a trend analysis for this station less reliable and representative of the actual DO levels during the dry season.

233. The results in Figure IV-9 also depicts the deteriorating water quality from Sundarijal with a DO concentration level around 7 mg/l down to Sinamangal Bridge with a DO concentration level around 1-2 mg/l in the mid-2000s.

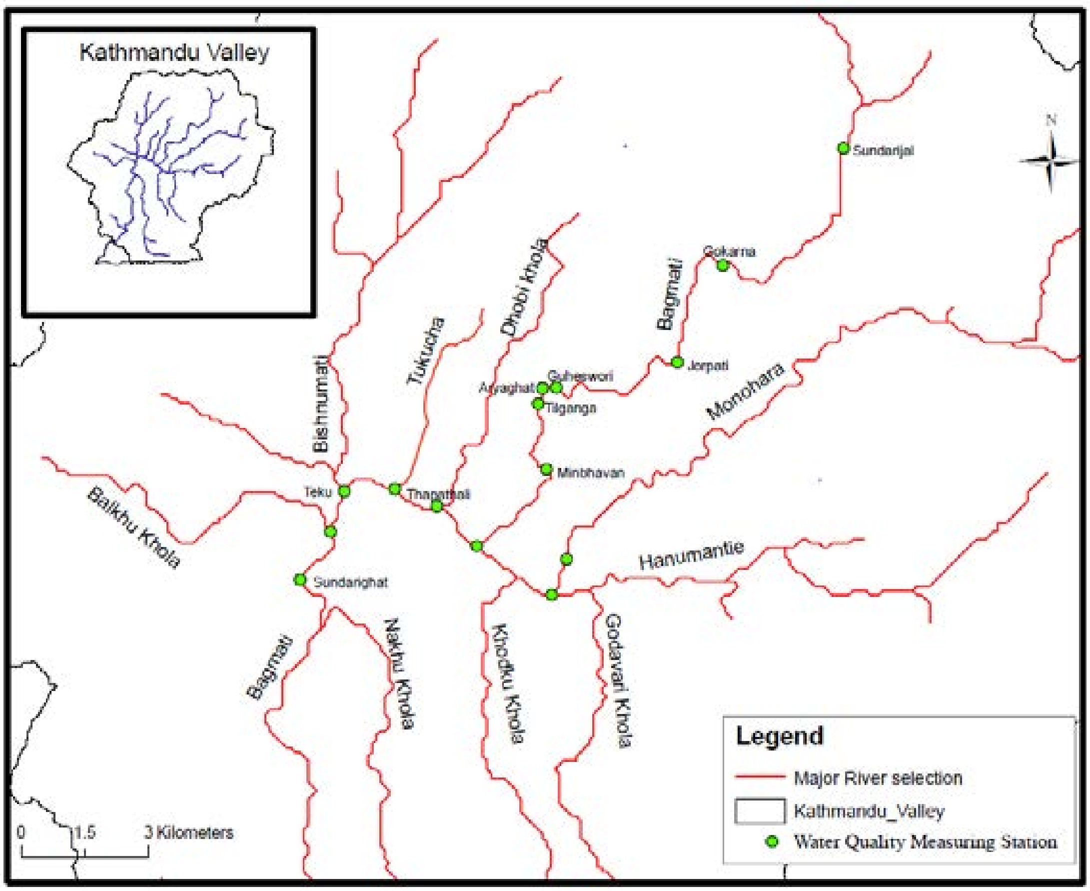
ii. HPCIDBC Water Quality Monitoring Results

234. HPCIDBC has regularly monitored the influent and effluent of the Guheshwori Wastewater Treatment Plant. In 2011 HPCIDBC started monitoring the water quality in the Upper Bagmati River and its tributaries. Monthly samples are taken from the Upper Bagmati River at 10 stations and at 5 stations at the confluence of the Bagmati River with Manohara, Bishnumati, Dhobikola, Balkhu and Tukucha, see Figure IV-10. The parameters measured regularly are shown in Table IV-14.

Table IV-14: List of parameters monitored by DHM

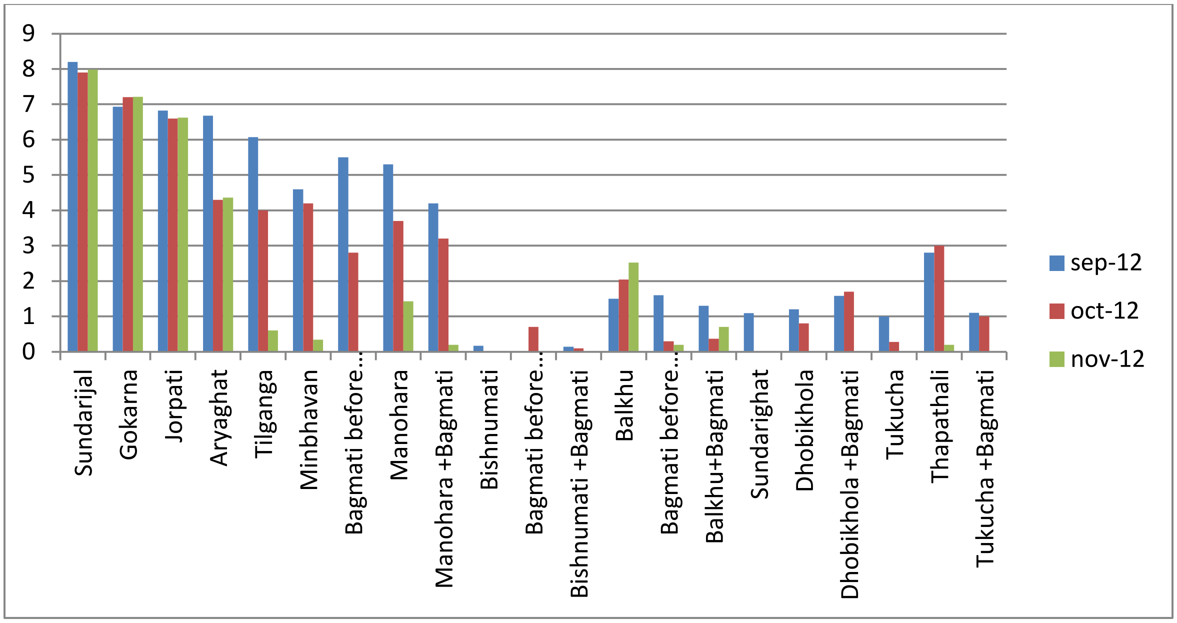
	Parameters Monitored														
	Colour	Temp.	Conduct	pH	O_2	DO	Hard	COD	NH_4	NO_3	NO_2	PO_4	Cl	Fe	Al
Units		(°C)	(µS/cm)		(%sat)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)

Figure IV-10: Water Quality sampling stations covered by HPCIDBC"s monitoring program. Source: Positions provided by HPCIDBC, map produced by PPTA.



235. As a sample of the results of the HPCIDBC water quality monitoring programme the results for DO in the autumn of 2012 are shown in Figure IV-11.

Figure IV-11: DO measurements (mg/l) from HPCIDBC WQ monitoring programme September to November 2012 from the stations shown in Figure IV-10.



Source: Data from HPCIDBC

236. The DO measurements carried out by the HPCIDBC laboratory in the autumn of 2012 reflects the same pattern as seen for the DHM monitoring results with respect to DO concentrations levels reducing from Sundarijal down to Sinamangal Bridge (Minbhavan), especially during the dry season.

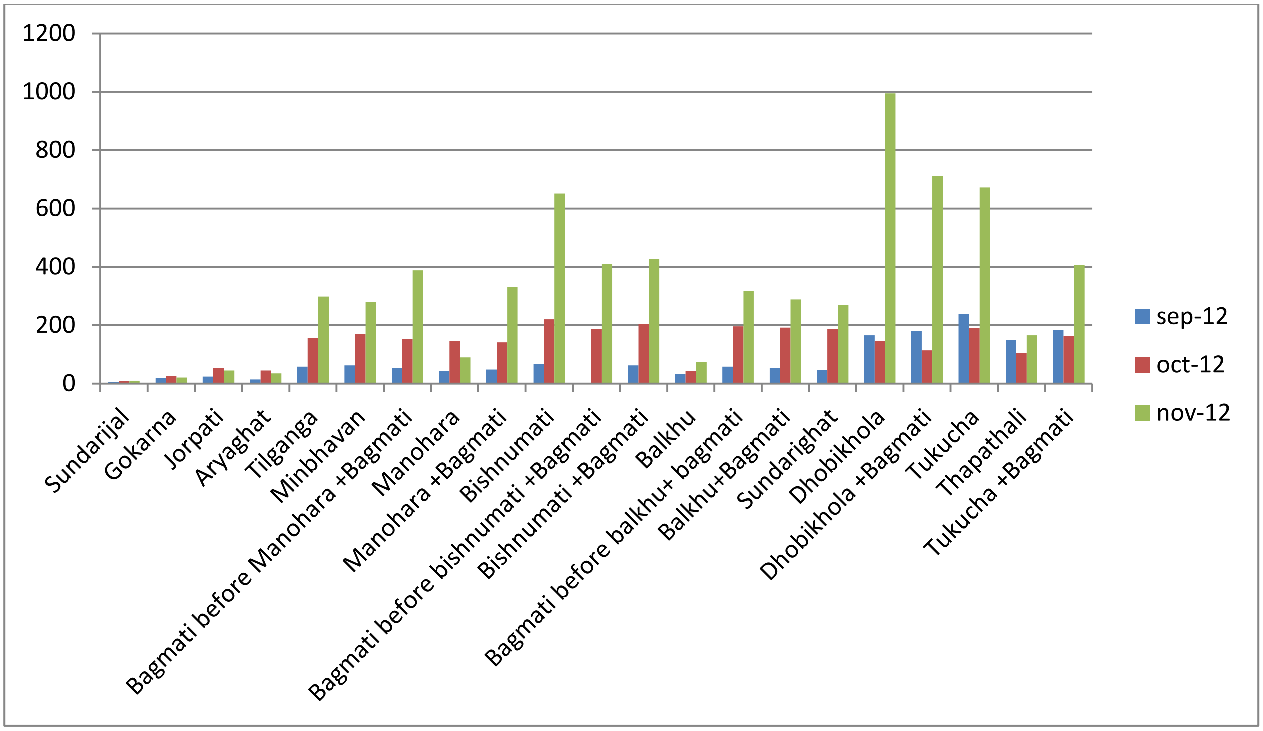
237. The DO measurement also reflects the influence of the high flows during the wet season being able to maintain relatively high DO levels down to the confluence with Manohara. However, downstream the confluence with Manohara the DO concentration levels are very low in the Bagmati, indicating the high pollution loads of domestic sewerage being discharged directly and reaching the Bagmati from the highly polluted tributaries Dhobi Khola, Tukucha, Bishnumati and Balku Khola.

238. Chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant, such as dichromate. The COD is widely used as a measure of the susceptibility to oxidation of the organic and inorganic materials present in water bodies and in the effluents from sewage and industrial plants[34].

239. The HPCIDBC laboratory measurements of COD mirror the DO measurements, as expected. Stations and months with high DO concentration levels have similarly low COD concentration levels, and vice versa, see Figure IV-12.

[34] Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring – 2end Edition. 1992, 1996 UNESCO/WHO/UNEP

Figure IV-12: COD measurements (mg/l) from HPCIDBC WQ monitoring programme September to November 2012 from the stations shown in Figure IV-10.



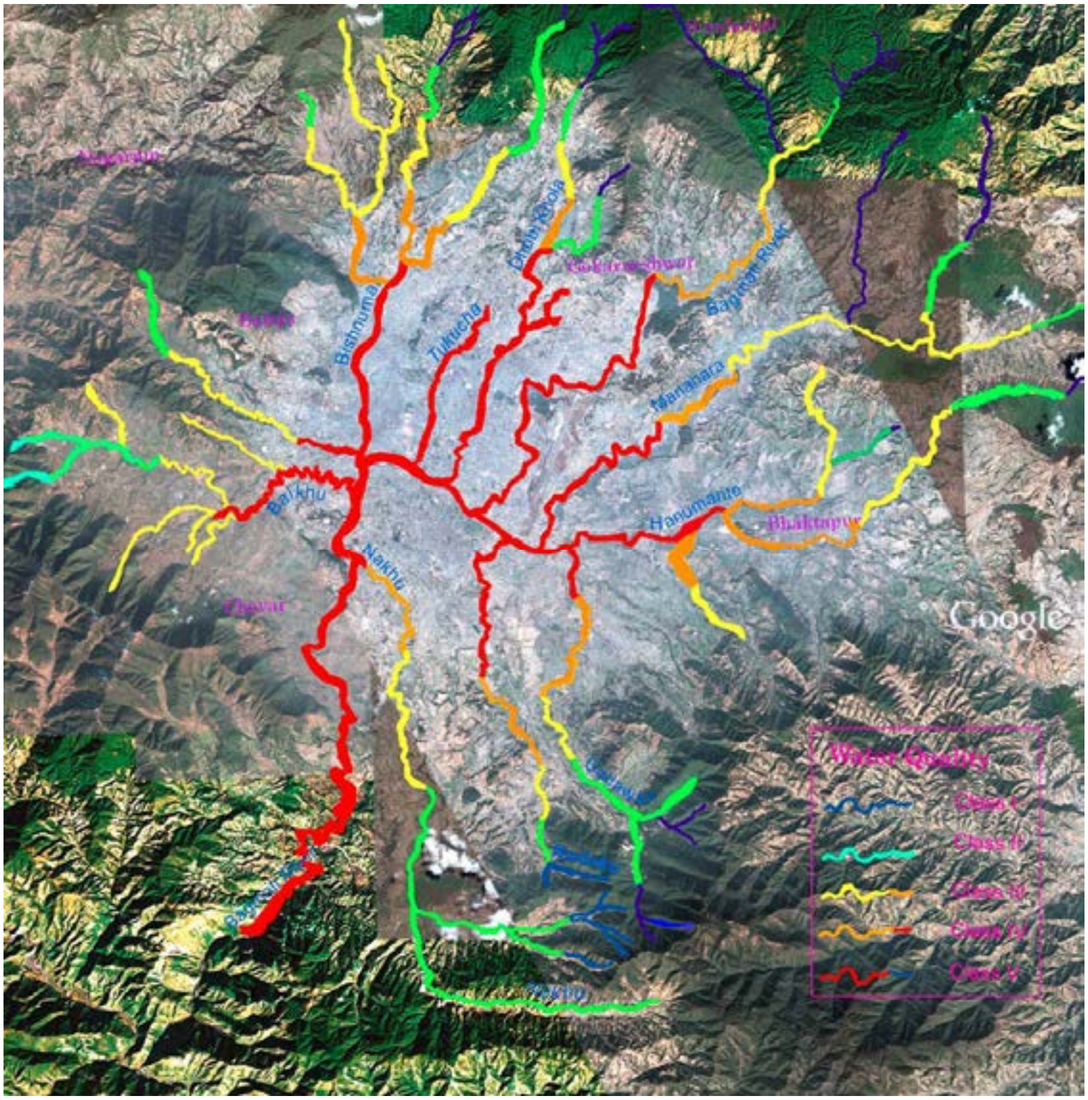
Source: Data from HPCIDBC

240. The COD parameter reflects the pollution level in the Bagmati River from domestic and industrial sources. The most severely polluted tributaries are Bishnumati and Dhobi Khola with 2 to three times higher COD levels than the highest level measured in the Bagmati itself at the confluence with Manohara.

241. The Total Suspended Solid (TSS) concentrations reflecting the level of eroded material coming out of the SNNP at the Sundarijal station by HPCIDBC are low, between 10-30 mg TSS/l.

242. The monitoring results corresponds to the river Water Quality classification carried out by the Kathmandu Participatory River Monitoring Project (KAPRIMO) study based on measurements from 2007, see Figure IV-13.

Figure IV-13: River Quality Classes of the Bagmati River Basin. Blue: Highest Class I. Red: Lowest Class V.



Source: KAPRIMO study, 2007[35].

B. Ecological Resources

1. Forests and Wildlife Reserves – Shivapuri Nagarjun National Park

243. The Dhap and the proposed dam site in Nagmati are located within the Shivapuri Nagarjun National Park (SNNP). The Park area experienced problems of soil erosion owing to deforestation, overgrazing, and cultivation on steep slopes in the past. The quality and quantity of water supplied from this area was also reduced. To overcome these problems, a program was initiated to protect Shivapuri as a watershed and wildlife reserve in 1975. It was declared as Nepal‟s 9th National Park in 2002.

[35] According to the European Framework Directive, on which the Kaprimo study was based, water bodies are graded into one of five quality classes (high, good, moderate, poor or bad)

244. The office of SNNP forwarded a draft Management Plan in 2004 with the support from Nepal Trust for Nature Conservation to the Ministry of Forest and Soil Conservation for approval. However, the plan is not yet approved. The draft Plan and other documents set the objectives of the initiative to maintain a proper balance between the natural environment and the basic needs of local people. The vision is to develop Shivapuri and Nagarjun areas as demonstration sites for multiple uses by restoring and maintaining the ecological integrity. The draft SNNP Management Plan includes, quote: "The construction of a new dam in the Dhap so that it can retain water and function as a waterhole for wildlife and recharge water to the Nagmati". This extension of the Dhap and other elements in the SNNP Management Plan was taken up and included in the Bagmati Action Plan prepared in 2008 and approved by the GoN Cabinet. The SNNP authorities are currently working on the preparation of a new Management Plan, including the declaration of a buffer zone also covering the settlements in the SNNP. The BRBIP provides support to the SNNP authorities for this work.

245. The vegetation of the park represents midhill flora, fauna, and ecosystems in the transition zone between sub-tropical and temperate climate, where the variations is primarily a function of the altitude. SNNP supports rich floral and faunal diversity with a number of protected species of mammals, birds, and plants.

246. The floral diversity is quite high in the park due to its location, altitude, and climatic variations. There are more than 2,122 species of flora and 16 of them are endemic flowering plants. About 129 species of mushroom including Lactarius pleusitides have been identified in the park. Table IV-15 presents the forest habitats and altitudinal distribution of flora and fauna in the park area.

Table IV-15: Forest Habitats and Latitudinal distribution of Flora and associated Fauna

Forest type or Habitat	**Altitude (m)**	**Flora**	**Fauna**
Ever green mixed broad-leaved forest	1000-1500	Schima wallichii Castonopsis indica Alnus nepalensis Anthosaphalus cadamba Prunus cerasoides	Wild boar (Sus scrofa) Barking deer (Muntiacus muntijak) Rhesus monkey (Macaca mulatta) Langur (Semnopithecus entellus) Indian hare (Lepus nigricollis)
Chir pine forest	1000-1600	Pinus roxburghii Castonopsis indica Myrica esculenta Pyrus pashia	Same as above.
Upper mixed hardwood forest	1500-2700	Acer. Aesculus Juglans regia. Betula, Fraxinus sp. Alnus nepalensis Salix sp. Quercus sp. Celtis sp.	Himalayan goral (Nemorhaedus goral) Himalayan black bear (Ursus thibetanus) Yello-throated marten (Martes flavigula) Wild boar (Sus scrofa)

Oak-Rhododendron forest	2300-2700	Quescus semacarpifolia Eurya acuminata Ilex dipyrens Michelia champaca Rhododendron arboreum Symplocos sp.	Wild boar (Sus scrofa) Barking deer (Muntiacus muntijak) Porpucine (Hystrix indica)

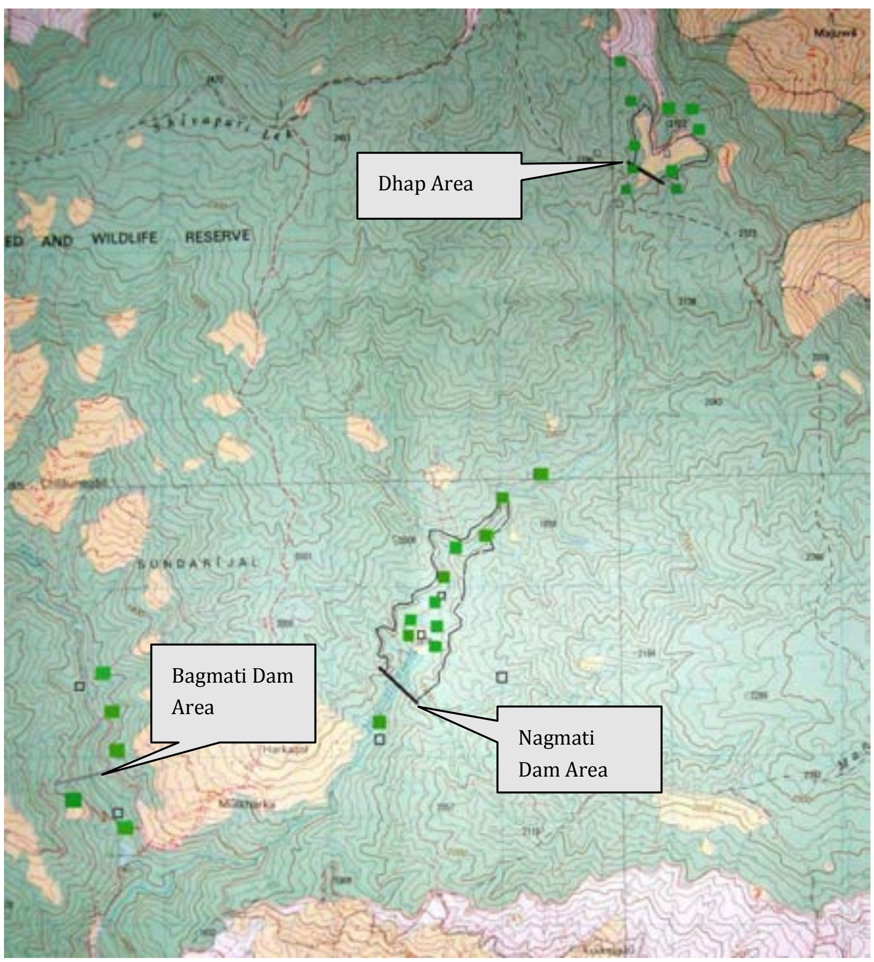
Source: Shivapuri National Park Management Plan, 2004 (draft).

247. Forests are one of the major natural resources of the National Park covering more than 70% of the park area. As detailed in the table, the Park has four types of forests which are distributed along the altitudinal gradients.

2. **Vegetation at Project Sites**

248. Field sampling was undertaken in September 2012 at the proposed dam sites to establish the presence of flora and vegetation, see Figure IV-14.

Figure IV-14: Sites for vegetation surveys.



Source: PPTA

i. Vegetation at Dhap Area

249. The Dhap area potentially hosts a wide range of aquatic plants such as *Ilex* species, *Acorus calamus, Colacasia* sp., *Caltha palustris* etc. *Acorus calamus* (Sweet Flag) is an important medicinal plant that has ecological as well as economic value. Its rhizome (modified root) consists of Calamus oil that can be used against cold, cough and other various ailments.

250. Park authorities regularly clear the weeds inside and around the Dhap area. During the process, Sweet Flag is also removed along with other weeds. The Dhap area was surveyed twice in the span of four months (first in September 2012 and Second in January 2013) but not a single Sweet Flag was recorded. Despite being an indigenous species of Dhap area, it is virtually disappeared from the Dhap area. Removal of Sweet Flag by the park authorities to maintain the Dhap aquatic ecosystem could be a matter of debate but it reduces the accumulation of organic matters in the Dhap.

251. The vegetation in the Dhap area consists of bushes and shrubs of *Berberis asiatica* (Chutro), *Pyracanta crenulata* (Ghangaru), *Edgeworthia gardneri* (Argeli), *Rubus acuminatus* (Bhalu ainselu) etc. with relatively few trees. *Symplocos sumuntia* (*Lodh*).

252. *Lyonia ovalifolia* (Angeri) and *Daphniphyllum himalense* (Rachan) are the dominant tree species in the forest surrounding the Dhap area with a density of 100, 62 and 55 trees per hectare respectively. *Pyrus pashia* (Mayal), *Camellia kissi* (Chiapate, Hingua) and *Betula alnoides* (Saur) are other major associated species in the Dhap area. Among the listed species, *Symplocos sumuntia* is the most common and uniformly distributed plant species in Dhap area (Table IV-16).

Table IV-16: Population parameters of major trees in forest surrounding the Dhap area

SN	Scientific name	Density, No tree per ha
1	*Symplocos sumuntia*	100
2	*Lyonia ovalifolia*	62.5
3	*Daphniphyllum himalense*	55
4	*Pyrus pashia*	45
5	*Camellia kissi*	42.5
6	*Betula alnoides*	42.5
7	*Quercus glauca*	22.5
8	*Rhododendron arboretum*	15
	Total density	**385**

Source: PPTA

253. Different species of terrestrial and epiphytic orchids (Nep: Sungava, Sunakhari, Chandigava, Bandar kera) were recorded. Orchids are considered threatened by IUCN and falls under CITES Appendix II. They are protected mainly because of the excessive collection for trade. Most common among them are *Coelogyne critsata, C. ovalifolia, Calanthe tricarinata, Spiranthes sinensis, Satyrium nepalense* etc. Aerial species are succulent in nature hence they absorbs moisture from environment and food from the host tree, whether the host tree is living or dead. Epiphytic orchids were recorded as well.

ii. Vegetation at Nagmati Dam Area

254. In general, most of the forest in the survey area is in secondary stage of succession. Cutting of trees for fire wood happens regularly. As a result there are very few large/mature size trees in the area.

255. Regarding **vegetation** *Symplocos pyrifolia* (*Kharane/Kholme*), *Quercus glauca* (Phalant) and *Rhododendron arboreum* (Guras/Lali guras) were the dominant tree species found in the proposed Nagmati dam area with an average density of 152, 102 and 91 trees per hectare, respectively. *Pinus roxburghii* (Khote salla), *Lyonia ovalifolia* (Bakal pate, Phalame) and *Camellia kissi* (Chiapate, Hingua) are other species found in relative large numbers. Among the listed plant species, *Symplocos pyrifolia* is the most common and uniformly distributed plant species, see Table IV-17.

Table IV-17: Population parameters of major trees in proposed Nagmati dam site

SN	Scientific name	Density. No trees per ha
1	*Symplocos pyrifolia*	152.3
2	*Quercus glauca*	102.4
3	*Rhododendron arboreum*	90.9
4	*Pinus roxburghii*	84.1
5	*Lyonia ovalifolia*	70.4
6	*Camellia kissi*	56.8
7	*Cleyera japonica*	45.4
8	*Quercus lamellose*	25.0
9	*Persea odoratissima*	22.7
10	*Pyrus pashia*	20.4
	Total density	670.4

Source: PPTA

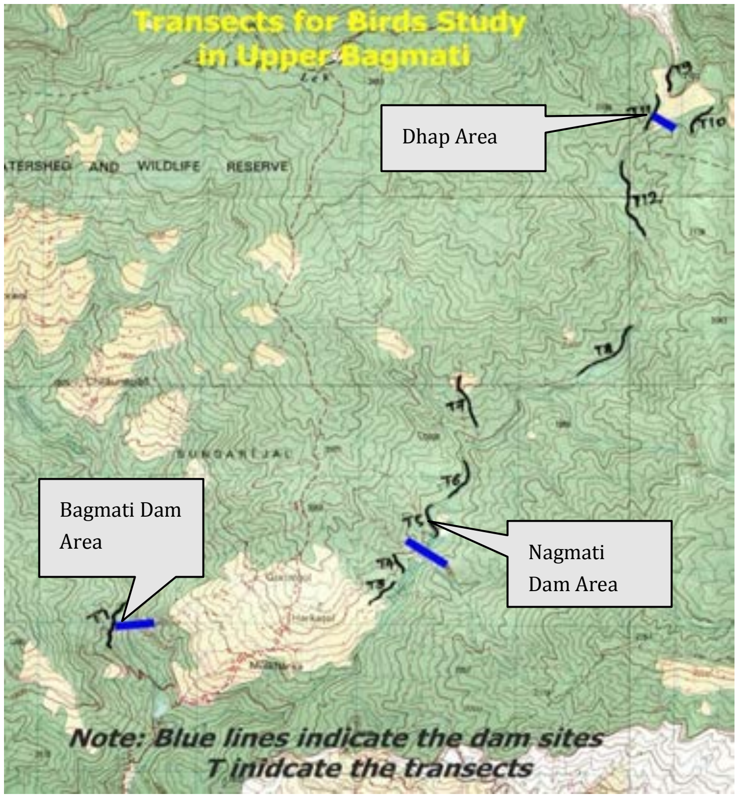
256. A few scattered saplings of Taxus wallichiana (Lauth salla) were recorded along the Nagmati River about 2 km upstream of the dam site. This species falls under CITES appendix II and the Government of Nepal protected list[36].

3. Birds at Project Sites

257. Field surveys were undertaken in September 2012 at the proposed dam sites to establish the presence of birds, see Figure IV-5.

[36] Protected Species under the National parks and Wildlife Conservation Act, 1973.

Figure IV-15 Transects for bird surveys.



Source: PPTA.

i. Birds in the Dhap Area

258. Altogether 20 species of birds were recorded at the Dhap site during the survey in September 2012 (Table IV-18). Warblers and Barbets were the most commonly observed.

259. The 12 protected bird species recorded in the SNNP are listed in Appendix A. None of these were recorded during the bird survey at the Dhap site. Out of the 12 protected species, it cannot be excluded that the Saker Falcon, Grey-sided Laughing thrush and Blue-winged Laughing thrush may occur in the forest and open areas in the Dhap area. The Saker Falcon occupies open country, while the Grey-sided Laughing thrush and Blue-winged Laughing thrush occupy forest and bush, feeding on insects and fruits.

ii. Birds at the Nagmati Dam site

260. The Nagmati Dam site supports a relatively high diversity of birds with 16 species recorded during the bird survey (Table IV-18). Warblers and Barbets were the most commonly observed at the Nagmati Dam site. Only one vulnerable species listed as a nationally threatened bird, the White-tailed Stonechat was recorded at the Nagmati Dam site.

Table IV-18: List of Birds Recorded at the Nagmati Dam Site

S.N.	Common Name	Scientific Name
1	Black Bulbul	*Hypsipetes leucocephalus*
2	Chestnut-bellied Nuthatch	*Sitta castanea*
3	Common Hoopoe	*Upupa epops*
4	Grey Treepie	*Dendrocitta formosae*
5	Grey-hooded Warbler	*Seicercus xanthoschistos*
6	Himalayan Bulbul	*Pycnonotus leucogenys*
7	Hoary-throated Barwing	*Actinodura nipalensis*
8	Mountain Bulbul	*Hypsipetes mcclellandii*
9	Oriental Turtle Dove	*Streptopilia orientalis*
10	Rufous-bellied Niltava	*Niltava sundara*
11	Shikra	*Accipter badius*
12	Striated Laughingthrush	*Garrulax striatus*
13	White Wagtail	*Motacilla alba*
14	White-tailed Nuthatch	*Sitta himalayensis*
15	White-tailed Stonechat	*Saxicola leucura*
16	Yellow-breasted Greenfinch	*Carduelis spinoides*

Source: PPTA

4. Wildlife at Project Sites

a. Wildlife in the Dhap Area

261. The survey results for the wildlife in the Dhap area are given in Table IV-19. The Dhap area provides a diverse habitat which supports a variety of mammals. Large Civet (*Viverra zibetha)* was confirmed by scat and scent, Wild Boar (*Sus scrofa)* by digging, Barking Deer (*Munitacus muntjak)* by pellets, Leopard Cat (*Prionailurus bengalensis)* by scat and Yellow-throated Marten *Martes flavigula* by pugmark. Large Hare (*Lepus nigricolli)s,* Barking Deer *(Muntiacus muntjak)* and Yellow-throated Marten (*Martes flavigula)* were also sighted directly in the vicinity of *Dhap* area. Additionally, relic scats of Common Leopard (*Panthera pardus)* found outside transect confirmed the presence of the carnivore.

Table IV-19: Wildlife of the Dhap Area

Mammal	**Sign**	**Crown Cover**	**Dominant Trees**	**Distance from Water**
Viverra zibetha (Large Civet)	Scat	1%	*Lyonia ovalifolia, Pyrus pashia, Berberis aristata, Daphniphyllum sps*	25 m
	Scent	73%	do	5 m
Sus scrofa (Wild Boar)	Digging	47%	do	35 m
	Digging	48%	do	35 m
	Digging	81%	Do	1 m

Munitacus muntjak (Barking Deer)	Pellet	25%	Do	5 m
	Sight	-	-	-
Martes flavigula (Yellow-throated Marten)	Pug mark	25%	Do	5 m
	Sight	25%	Do	5 m
P.bengalensis (Leopard Cat)	Scat	2%	*Alnus nepalensis, Rhododendron arboreum, Lyonia ovalifolia, Berberis aristata,* etc.	< 1 m
Panthera pardus (Common Leopard)	Scat	8%	*Daphniphyllum sp, Pyrus pashia, Alnus nepalensis*	100 m
Lepus nigricollis (Large hare)	Sight	20%	*Daphniphyllum sp, Pyrus pashia*	5 m

Source: PPTA

b. **Wildlife at the Nagmati Dam site**

262. The survey results for wildlife at the Nagmati Dam site are given in Table IV-20. Scats of Bengal Cat and Jungle Cat (*Felis bengalensis* and *Felis chaus)* and scent of Large Civet (*Viverra zibetha)* were recorded in the area confirming the presence of these three carnivores. However, none of the animals were sighted directly in the area. The Nagmati dam area is part of the important SNNP wildlife habitat and the area hosts corridors for wildlife movement.

Table IV-20: Wildlife of Nagmati Dam site area

Mammal	Sign	Crown Cover	Dominant Trees	Distance from Water
Felis chaus (Jungle Cat)	Scat	Open	*Pinus roxburghii, Rhododendron arboreum, Myrica esculenta*, etc.	100 m from Nagmati
Felis bengalensis (Bengal Cat)	Scat	4%	*Pinus roxburghii, Pyrus pashia, Quercus sp., Gultheria fragrantissima,* etc.	20 m
	Scat	28%	*Rhododendron arboreum, Quercus sps, Thea sps, Myrica esculenta,* etc.	20 m
	Scat with worms	64%	*Rhododendron arboreum, Lyonia ovalifolia, Daphniphyllum himalayensis*	20 m
Viverra zibetha (Large Civet)	Scent	85%	*Pyrus pashia, Thea sps, Myrica esculenta,* etc.	50 m

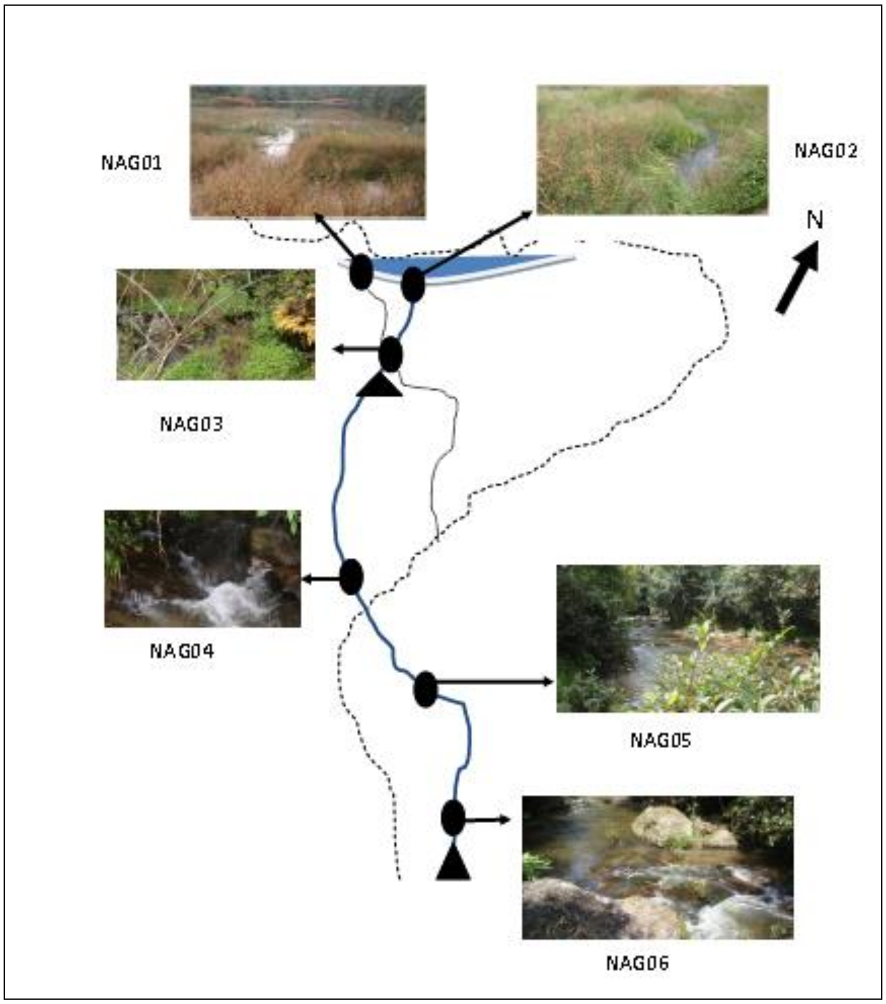
Source: PPTA

5. **Aquatic Fauna at Project Sites**

a. Macro-invertebrates

263. A macro-invertebrate survey was carried out in the Nagmati River in October 2012. Macroinvertebrate families vary in their sensitivity to changes in the substrate they live on and the water quality. Some members will respond to pollution and some have long life histories, allowing the observation of temporal changes in pollution parameters over a longer time-span. The sites studied are shown in Figure IV-16.

Figure IV-16: Location of PPTA macro-invertebrate investigation sites from NAG 01 to NAG 06, with dark pyramid shaped points indicating proposed dam sites (drawn not to the scale). Broken line indicates the motorable way and solid line indicate short trail.



Source: PPTA.

Table IV-21: Macro invertebrates identified at the location shown in Figure IV-16 and the associated Environmental Quality Class.

Order	Family	Genus/Species	Relative Abundance*	Environmental quality class
NAG 01				
Hemiptera	Gerridae	Metrobates spp.	10	II
Odonata	Gomphidae	Agrigomphus sp.	5	
Trichoptera	Glossosomatidae		2	
Ephemeroptera	Baetidae	Baetis spp.	15	
	Caenidae	Caenis sp.	5	
Diptera	Simuliidae		10	
NAG 02				
Diptera	Simuliidae	Simulium	10	II
Trichoptera	Philopotamidae	Philopotamus	1	
Diptera	Athericidae		1	
Coleoptera	Hydraenidae		1	
Diptera	Limoniidae		1	
Coleoptera	Heteroceridae		1	
Diptera	Chironomidae		2	
NAG 03				
Plecoptera	Perlodidae		3	II
Plecoptera	Nemouridae	Podomosta sp.	6	
Diptera	Simulidae	Simulium sp.	11	
Coleoptera	Hydraenidae		1	
Trichoptera	Philopotamidae		1	
NAG 04				
Trichoptera	Hydropsychiidae	Hydropsyche sp.	13	I-II
Plecoptera	Perlidae	Perla sp.	3	
Ephemeroptera	Baetidae	Baetis sp.	3	
Ephemeroptera	Heptageniidae	Heptagenia sp.	1	
Diptera	Tipulidae	Tipula sp.	1	
Coleoptera	Hydraenidae		1	
Coleoptera	Elmidae	Microcylloepus sp.	1	
Diptera	Limoniidae		1	
Coleoptera	Elminthidae		1	

Coleoptera	Psephenidae		1	
Plecoptera	Perlidae (Adult)		1	
Oligochaeta			1	
NAG 5				
Odonata	Gomphidae	Gomphus sp.	2	II
Ephemeroptera	Caenidae		2	
Trichoptera	Hydropsychidae		5	
Ephemeroptera	Baetidae	Baetis sp.	5	
Ephemeroptera	Heptageniidae		4	
Diptera	Simuliidae	Simulium sp.	1	
Coleoptera	Elmidae		2	
Coleoptera	Psephenidae		1	
NAG 06				
Ephemeroptera	Heptageniidae		7	I-II
Diptera	Simuliidae		2	
Coleoptera	Hydraenidae		1	
Trichoptera	Hydropsychiidae		4	
Plecoptera	Perlidae		1	
Ephemeroptera	Baetidae		1	
Coleoptera	Psephenidae		1	

Source: PPTA

264. The survey classified the various stretched of the Nagmati to belong to the Environmental Class I-II (Oligosaprobic to Beta-mesosprobic) with a degree of pollution as „slightly polluted" and Class II (beta-mesosaprobic) with a degree of pollution as „moderately polluted"[37].

265. Class I-II: "This transitional water quality class describes river reaches with little inorganic and organic nutrient content and, with the exception of glacier-fed brooks, clear water. The oxygen content is high. The concentration of suspended organic matter is very low. Fine substrates are of a brownish or light colour throughout; the undersides of stones have no visible black reduction spots. Primarily, these reaches are in salmonid rivers, which are densely and diversely colonized by algae, mosses, Turbellaria, Plecoptera, Ephemeroptera and Trichoptera larvae as well as Coleoptera (Elmidae, Hydraenidae) and dipteran larvae. Worms are generally represented by planarians, and sensitive oligochaets. Of the leeches (Hirudinea), at most Dina

[37] **Sharma, S.** 1999. Nepalese Biotic score and its use in water quality assessment. Water Resources Journal, June 1999, United Nations, pp. 51-59. Moog, O. and **Sharma, S.** 2001. Nepalese Biotic Score for water quality assessment. In Environment and Agriculture as Proceedings of the International Conference on Environment and Agriculture (Nov. 1-3, 1998), published by Ecological Society (ECOS), P.O. Box 6132, Kathmandu, Nepal, pp. 503-506.

punctata and Erpobdella vilnensis exist in considerable quantities; net-spinning trichopterans appear only sporadically. The chironomids (predominantly, Orthocladiinae and Diamesinae) are slightly more numerous than in water quality class I".

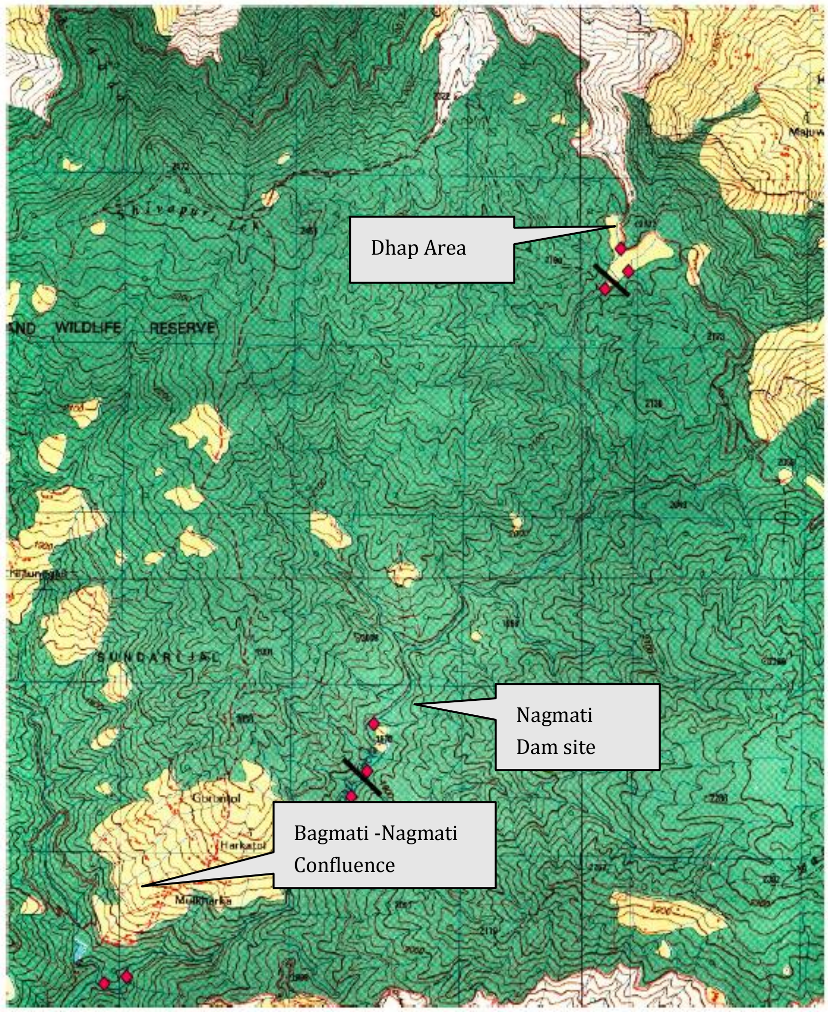
266. Class II: "This water quality class is found in river reaches with moderate organic pollution, increased nutrient content and still a good oxygen supply (despite possible oxygen supersaturation or depletion). The water is usually clear and at most contains a low amount of suspended organic particles. The sediment is light or dark, but not black, and is often slippery due to algal growth; the undersides of stones are not coloured with black reduction-spots. Processes of biodegradation take place in aerobic areas. Reduction phenomena occur only occasionally, here and there, in lentic sites of potamal waters (e.g. backwaters). Species diversity and abundances are very high for nearly all animal groups in addition to algae (all groups) and other aquatic plants. The percentage of individuals and the taxon diversity of Chironomidae further increase (predominantly Orthocladiinae, in quietly flowing reaches Tanytarsini and Chironomini). The net-spinning trichopterans are usually numerous only where suitable current velocities are available; whereby Polycentropodidae can appear in large quantities in potamal regions. Macrophytes can cover areas but usually green algae (Chlorophyceae) do not yet appear in large quantities. These rivers yield high numbers of fish of various species".

267. The classification II at both the Dhap site and the Nagmati Dam site, and the general classification do not reach Class I. This shows that the Nagmati River is not in a pristine condition. Despite having a good water quality, the aquatic ecosystem is disturbed by human activity in the catchment, that dates back to the cutting of the primary forest up the present use of the forest for grazing, cutting of trees for firewood, collection of plants and fishing.

b. Fish

268. Field surveys were undertaken in December 2012 at the Dhap and in January at the Nagmati Dam site to establish the presence of fish. The position of the sampling sites are shown in Figure IV-17.

Figure IV-17: Fish survey sampling sites at the Dhap site, Nagmati Dam site and at the confluence of the Nagmati and Bagmati rivers.



Source: PPTA.

269. The field survey at the Dhap in the impoundment and in the river downstream identified only one species which is very common and found in almost every natural water body in Nepal, the Creek Loach (*Chistura beavani*). This is a fish of minor interest and is mentioned under „Least Concern" in the IUCN list.

270. The fish survey at the Nagmati Dam site showed a poor fish assemblage as well. One single species, Snow Trout (*Schizothorax richardsonii)* was found in a very low number. The fish survey study concludes that the low numbers and existence of only 2 fish species are more due to natural causes than disturbance. This is due to the physiography, low connectivity and high elevations upstream of proposed dam site, at Nagmati. For further details of the survey, see Appendix 16.

6. Endemic, Vulnerable and Threatened and Nearly Threatened species in the Project Area

271. The SNNP supports a large number of wildlife species (Table IV-22). There are registered 21 species of mammals living in the SNNP out of which nine are threatened[38]. They include Pangolin (*Manis spp*.), leopard cat (*Prionailurus bengalensis*), and clouded leopard (*Pardofelis nebulosa*), common leopard (*Panthera pardus*), Langur (*Semnopithecus entellus*), Rhesus monkey (*Macaca mulatta*), Jungle cat *(Felis chaus*), Goral (*Naemorhedus goral*), and Himalayan black bear (*Ursus thibetanus*). Of these, the leopard cat (*Prionailurus bengalensis*) and common leopard (*Panthera pardus*) were spotted at the Dhap site while Jungle cat *(Felis chaus*) was spotted at the Nagmati site.

272. The SNNP is also one of the most popular areas for watching birds and butterflies. It harbours 323[39] species of birds of which 12 of them are considered as listed in Appendix A. None of these were recorded during the bird survey at the Dhap site. The White-tailed Stonechat (*Saxicola leucurus*) considered as vulnerable Nationally, however at Least Concern (IUCN 2012), was recorded at the Nagmati Dam site during the bird survey.

273. Herpetofauna of SNNP has not been explored. Only one species (i.e. Oligodon arnensis) of reptilia has been reported in the Park. There are more than 102 species of butterflies. SNNP is the only habitat for the relict Himalayan Dragonfly (Epiophlebia laidlawi) in Nepal. The overall status of various flora and faunal species found in the SNNP is presented in Table IV-22.

Table IV-22: Status of Species in SNNP

Group	Total Number of Species	Status
Mammals	21	Protected, Threatened (9)[1]
Birds	323	Threatened (12)[2]
Herpentofauna	1	DNA[1]
Butterflies	102	Endemic, susceptible species[1]
Plants	2122	Endemic (16) flowering[1]
Mushrooms	129	One species new to science[1]

Source: [1]Shivapuri National Park Management Plan, 2004 (Draft). [2]IUCN

C. Socio-economic Resources

1. Human Settlement and Land Use

a. Settlement in Sundarijal VDC

274. Almost 90% of the Sundarijal VDC comes under the upstream areas of the Bagmati River basin in the SNNP where the Tamang communities predominate, see

[38] Shivapuri National Park Plan, 2004 (Draft)

[39] SNP and BCN (2007). Birds of Shivapuri National Park. Shivapuri National Park and Bird Conservation Nepal, Kathmandu: Here 317 species are listed. During the PPTA Birds surveys additional 5 new species were recorded.

275. Figure IV-2. They grow millet and maize in the upstream areas. However, some vegetables and barley are also cultivated. Most of them are engaged in hoarding livestock while some are seen to be involved in small business like shops and hotels. In the downstream areas, see the extent of the Sundarijal VDC and other VDCs in Figure IV-18, wheat, barley, maze, potato, vegetables and millet are grown. The majority of the people are Chhetriyas, Brahmins, and Newars. Some of them are involved in governmental and non-governmental services while most of them are involved in agriculture and business.

Figure IV-18: VDCs in the Upper part of the Bagmati River Basin. The road from Guheshwori to Sundarijal marked in red. The Bagmati River at this stretch marked in green.

Source: PPTA.

b. **Sundarijal to Gokarna**

276. River Bagmati in the stretch between Gokarna and Sundarijal lies within Zone II of BAP and touches seven VDCs, see Figure IV-18. The river serves as the border of these VDCs viz. Gokarneshwar, Thallidanchi, Nayapati, Bhadrabas, Alapot, Sundarijal and Gagalphedi.

277. These VDCs are relatively sparsely populated. All the VDCs except Sundarijal are agriculture based area. The whole stretch of the Guheshwori-Sundarijal road passes through Gokraneshwar, Nayapati and Sundarijal VDCs. The site is a longitudinally stretched valley. River banks are all agricultural fields and any settlements are more than half a kilometre away from the banks of the Bagmati River on both sides.

c. **From Gokarna to Sinamangal Bridge**

278. The beauty of the once traditional urban development in Kathmandu Valley was its use of land based on its productive capacity. Settlements were developed in high land, while low land was specifically used for agricultural purposes. Land farther from the river banks and at higher altitude was designated for construction. This prevented the settlements from the risk of floods in the monsoon and on the other hand maintained the pristine character of the river preserving their healthy environment. With this general structure of the settlements, all the bigger urban areas developed along the rivers in the valley, honouring the basic principle of land use based on its productivity.

279. Over the last three or four decades, population growth and immigration into Kathmandu have led to an increasing urbanisation that has been so rapid that the principle of land use based on its productivity could not be continued, and created a market for land based on the demand and supply for urbanisation.

Table IV-23: Population of Kathmandu Municipality[40]

Census Year	1991	2001	Change in % 2001-1991	2011	Change in % 2011-1991
Population	421.258	671.846	59.5	1.006.656	49.9

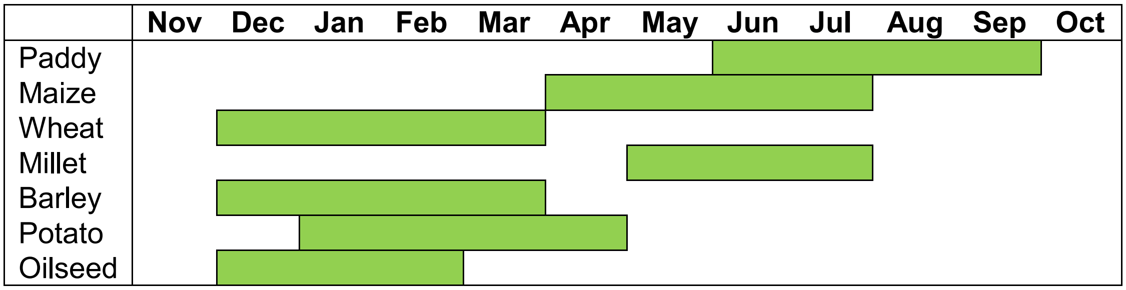
Source: Central Bureau of Statistics, GoN

2. **Agriculture**

280. The soil in the Upper Bagmati river basin along the Bagmati river from Sundarijal down to Guheshwori are mostly alluvial deposits which are fertile and suitable for agriculture, with irrigation along the river banks and rain fed agriculture in the higher lands. The crops usually grown in the low lands are paddy during the monsoon season and wheat and potato during the winter and spring seasons. In the higher lands paddy is cultivated where ever possible, otherwise cultivated with maize or millet. During the winter and spring seasons the higher lands are usually left fallow. However, in some areas mustard (oilseed) or barley is cultivated (Figure IV-19).

[40] Census, 1991, 2001 and 2011. Central Bureau of Statistics, GoN. http://cbs.gov.np/

Figure IV-19: General cropping pattern in the Upper Bagmati River basin. Source: Farm Survey for the Feasibility Study on Rehabilitation for Government Developed Irrigation Scheme in Kathmandu Valley, JICA, May 1994



281. The urban growth trend in the Upper Bagmati River stretch from Gokarna to Guheshwori along the Bagmati River corridor is quite fast in nature. The Gokarna regulator used to divert water to an irrigation scheme on the left bank. However, recent urbanization has occupied the earlier irrigated land. Roads have been developed along both sides of Bagmati River and urban development is progressing, turning whatever fragmented agricultural land remaining into housing or commercial areas. Due to urbanization the farmers have found more profit in selling their lands rather than farming.

a. **Irrigation**

282. In the Upper Bagmati River (section in between Sundarijal to Guheshwori) stretch there are three main tributaries flowing into the Bagmati River, namely the Suryamati, Kolimati and Jantare rivers on the right bank and there are few minor tributaries on the left bank. In this stretch there are about eleven formal irrigation schemes in the area in total covering about 337 ha, see Table IV-24. Four of these rely on Bagmati River flows (Sundarijal Irrigation Scheme: 20 ha; Raj Kulo Irrigation Scheme: 25 ha; Bagmati Kulo Irrigation Scheme: 7 ha; and, Gokarna Irrigation Scheme: 100 ha).

283. After the re-channeling of the Bagmati River from Sundarijal to Guheshwori the intakes to the irrigation schemes have not been maintained or re-established, except for the Sundarijal Irrigation Scheme where the old intake remains. In the other schemes farmers are using pumps when required in areas near the Bagmati River banks and in the remaining area are rainfed. Even the Sundarijal Irrigation Scheme with an intake about 300 m upstream from the existing intake for the Sundarijal water supply scheme is not operating properly due to lack of maintenance and the designed command area has been reduced. With respect to the remaining irrigation schemes in the tributary sub-catchments to the Bagmati River their remaining operation efficiency is estimated to be about 30%, only.

Table IV-24: Irrigation Schemes in the Upper Bagmati River basin.

VDC	Irrigation Project	Source	Command Area (Ha)	Crop Pattern
Sundarijal	Sundarijal	Bagmati	20	Paddy, Wheat, Potatoes
Baluwa	Baluwa	Thulo Khola	35	Paddy, Wheat, Potatoes
	Ghatre Kulo	Thulo Khola	5	Paddy, Wheat, Potatoes
	Soti Khola Muhan	Soti Khola	15	Paddy, Wheat, Potatoes
Alapot	Thado Khola	Thado Khola	50	Paddy, Wheat, Potatoes
Bradrabas	Bagmati Kulo	Bagmati	7	Paddy, Wheat, Potatoes
Nayanpati	Khahare Kulo	Khahare Khola	15	Paddy, Wheat, Potatoes
	Raj Kulo	Bagmati	25	Paddy, Wheat, Potatoes
	Dhulopuro	Suryamati	25	Paddy, Wheat, Potatoes
Gokarneshwar	Patichaur	Baibu Khola	40	Paddy, Wheat
	Gokarna	Bagmati	100	Paddy, Wheat
Total			**337**	

Source: Farm Survey for The Feasibility Study on Rehabilitation for Government Developed Irrigation Scheme in Kathmandu Valley, JICA, May 1994; WECS, Water Use Inventory Study of Kathmandu Valley, 1993; Irrigation Division Office, Department of Irrigation; and field observation

284. The urban growth trend in the Upper Bagmati River stretch from Sundarijal to Guheshwori is quite fast in nature. This has affected the irrigation schemes in this area. This trend of urban growth has no sign of containment in the present limit at Gokarna. The linkage of road from Gokarna to Sundarijal provides an ample opportunity for this development. Availability of sufficient agricultural land exposed to land market of Kathmandu Valley with comparatively cheaper rate is a lucrative attraction for land developers and individual house owners alike.

285. With the present development trend, the irrigated areas in the Upper Bagmati River are already relatively small, and disappearing at a high rate. It is considered that over the next five to ten years a major part of the irrigated agricultural land will be converted into residential area. Farmers have already stopped tending their land in anticipation opending land sales in certain areas. Given the urban development prospects over a time-span of 5-10 years and the effects it has on reduction in irrigated agricultural land, investments in re-establishing water intakes and improving the existing irrigation systems is not considered economically justified.

3. Human Resource and Pattern of Population

286. According to the 2011 population census, in Kathmandu district (noting that the project is located in Sundarijal VCD of Kathmandu district), 9 VDCs and Kathmandu metropolitan together have a total population of 1,163,785. Females constitute 47.4% and males constitute 52.6%. The average household size is 3.7 persons. Of the total population 86.5% is urban (Kathmandu metropolitan) and 13.5% rural. The household size in the urban area is slightly lower (3.6 persons).

287. The total population of the Sundarijal VDC where the proposed dam sites are situated is 2,631 in 2011. There are 621 households in the Sundarijal VDC with males constituting 53.8% and females 46.2%. The average household size is 4.2 persons. None of these households are in the vicinity of the dam sites, see Figure III-8. The settlement closest to the Nagmati Dam site is Mulkharka, approximately 300 meter away to the south from the dam site at the Mulkharka-Chisapani road passing the dam site.

288. Chisapani in the Nuwakot district is the nearest settlement to the Dhap, a small town approximately 2 km away with several hotels serving trekkers towards Helambu (Langtang Range). Besides the mountain views, one of the major attractions is the Dhap area with the lake behind the existing dam. The presence of Shivapuri Nagarjun National Park also attracts visitors. Here, international tourists as well as people of Kathmandu valley are attracted due to its pristine natural beauty with rivers, streams and small waterfalls, see Table IV-25.

Table IV-25: Number of visitors to the SNNP.

Year	2008/09	2009/10	2010/11
Foreigner	6777	10569	11957
Nepali	68641	96362	123085
Total	75418	106931	135042

Source: SNNP

4. Economic Development

289. Agriculture accounts for 35% of Nepal‟s national Gross Domestic Product (GDP), industry 15% and services (including tourism) the remaining 50%. GDP growth was 3.5% in 2011 and the economy grew by an annual average of 3.4% during the past five years which was led by growth in the service sector by 6% annually, whilst growth in the agriculture sector was only 2.6%. Per capita income was $642 in 2011 and has grown annually by 10.5% during the past five years. In 2011 the Human Development Index (HDI) of Nepal was 0.458, placing it at 157th position in the world.

D. Religious and Cultural Aspects

290. Most of the cultural sites in Kathmandu Valley are located along the banks of the rivers. Sundarimai Mandir (Temple)", Ganesh Mandir and Krishna Mandir are the main cultural sites in the Sundarijal VCD. People from Kathmandu and other places go to Sundarijal for visiting these temples. All the Hindu and Buddhist festivals are celebrated. Additionally, during the month of July, „Dashahara" fate/festival is celebrated at the spots near waterfalls and rivers near the temples.

BOX: The sacredness of Bagmati is attributed to its water.

Water of Bagmati therefore is called „*Jal*" and not simply water. Constructions of many temples at the stretch of its bank are associated with mythologies and legends. These temples have accentuated the holiness of the river.

In the past, when the water of the river used to be clean, *Jal* of Bagmati was used from drinking, bathing (including religious bathing), and offering to the God (Idols), many religious rites performed during the life cycle and also at the last rituals of every mortal. There was a belief in the society that the *Jal* of Bagmati is not only holy, it can never be polluted. The belief, that if one takes a drop of water at the time of last breath, he or she is guaranteed entry into Heaven. This belief is hard to die. The ashes of the cremated body is invariably flowed into the stream of Bagmati with a belief that by doing so the departed soul will be emancipated.

At present, Bagmati river water is not clean and so is its environment. Water pollution increases as it flows towards the municipality and intensifies in the urban area. Foul smell in the vicinity of the river in dry season, because of the river pollution and less volume of water has become an urban nuisance. This problem has the biggest impact in socio cultural terms and become more pronounced at the temple sites. *'Jal'* of Bagmati is no more used for any religious purposes and sometime for this reason, evokes political debate as well. This scenario changes to tolerable level in monsoon because of the huge quantity of flood water.

The Pashupati Area Complex, Gokarna Mahadev Temple Complex and Uttarbahini Kanti Bhairav are the three most important and prominent religious spots along the Bagmati, towards north from Sinamangal.

The river pollution at these sites evokes more effect on the dissatisfaction of the general public and more so among the devotees. The first priority in importance of water in temple areas is its use as „*Jal*" (holy water). It connotes the use of river water for religious purposes. This implies that the water at the temples has to be clean and clear. This is the basic demand and expectation of the people.

291. The major, Important Cultural Heritage sites along the Bagmati River in the Project area are:

- **Gokarna**: Gokarneshwar Mahadev Temple of Lord Shiva is the most prominent structure here. The Bagmati River passes through a narrow gorge here. People congregate here to bath in the river from the ghats (embankments) on religious ceremony of Fathers" day.

- **Guheshwori**: This Temple without roof is dedicated to the escort of Lord Shiva, Sita. This temple is a part of the Pashupati Temple Complex. Many other temples and accessory buildings surround this area. One of the most significant ghats in the complex is the „Gauri Ghat", where people take a dip in the river on the auspicious day of dark moon in January.

- **Pashupati**: The Pashupati Temple is the most important of all the temple complexes along the Bagmati River and the most important religious site in the country. It is even considered as one of the most holy religious centers for Hindus all around the world.

The Pashupati temple with many other groups of temples including Guheshwori, Dharmashalas (guest house), religious school, accessory buildings, Mrigasthali forest and the Bagmati River form the „Pashupati Religious Complex". Hindu pilgrims all around the world visit here throughout the year and especially on „Shiva Ratri" (night of the Lord Shiva).

One of the most important parts of this complex is the „Arya Ghat", where Hindus are cremated and their remaining ashes are washed out in the river. Fire wood is used for the cremation and the left over is thrown into the river. This complex is listed as a „World Heritage Site" for its religious, cultural importance, and rich architectural values.

292. Other important Cultural Heritage sites on the Bagmati River but downstream of the Project are:

- **Sankhamul**: This is the only religious cultural complex at the bank of Bagmati in Lalitpur Municipality. Temples dedicated to „Laxminarayan", accessory buildings and Ghats are the main features of this complex. People in Lalitpur Municipality use the ghats here for cremation purposes.

- **Kalmochan**: This temple complex is the latest addition to the series of cultural religious sites along the Bagmati River. This site is located at the confluence of Tukucha and Bagmati rivers and is surrounded by the urban expansion of Kathmandu Municipality.

- **Pachali**: This religious complex is dedicated to Pachali Bhairav (a form of Lord Shiva). It is situated at the confluence of Bagmati with another important and prominent river of the valley, Bishnumati. The ghat here is usually called the Southern Ghats and is also used for cremation purposes. This complex is the southernmost part of the series of such complexes in the river inside the Kathmandu Valley.

293. A detailed inventory of all smaller and larger temples in the Upper Bagmati River basin is found in Appendix 3.

V. ANTICIPATED ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

A. Beneficial Impacts from the Project

294. The overall objective the Project is to improve the water security in the Upper Bagmati. The Project implements major components from the Bagmati Action Plan and the Bagmati River Environment Management Programme planned and designed to create substantial beneficial impacts which outweigh any negative impacts after mitigation and compensation.

1. Beneficial Impacts Output 2 related

295. The anticipated beneficial impacts of Output 2 related works include:

Greenbelt and river beautification:

1) Creating respect for the river environment by communities to avoid disposal of solid waste and defecation.
2) Create amenities and recreational activity possibilities for local communities.
3) Prevent encroachment into the riparian land along the river banks.
4) Improve land values along the river corridor.

River Stone Walls with forefront protection

5) Stabilisation of river banks
6) Protection against flooding
7) Safeguarding green zones against river bank erosion
8) Improves aesthetic value by replacing existing gabion walls

Weirs/check dams

9) Increase groundwater recharge.
10) Improving river water quality by re-aeration
11) Create possibility for recreational use (e.g. boating which is not possible now).
12) Stabilise river bed and protect against river erosion

Regulator rehabilitation

13) Provide possibilities for the temples at Gokarna and Pashupatinath to regulate water levels at their ghats.
14) Improve safety of the use the regulators for river crossing.
15) Improve the aesthetics value and their value of representing their former use for irrigation as part of the local heritage.

Mobilisation:

16) VDCs and community groups mobilised and monitoring and preventing solid waste disposal into the river corridor.
17) Improved solid waste management in households.

Land Values:

18) Upon completion of the river environment improvement interventions a considerable increase in land value is anticipated in the semi-urban and urban areas around the Bagmati River from Gokarna to Sinamangal Bridge.

Cultural Heritage and Religion:

19) The Project will add to the religious use of the Bagmati River at the temples ghats used for religious purposes.

2. **Beneficial Impacts Ouput 3 related**

296. The anticipated beneficial impacts of Ouput 3 related works include:

Dams in SNNP:

1) Securing an environmental flow in the Nagmati River below the weir where water is presently diverted to the Sundarijal WTP during the dry season for water supply to Kathmandu down to the confluence with Bagmati River.
2) Securing an environmental flow in the Bagmati River during the dry season downstream the confluence with Nagmati River.
3) Increasing the assimilative capacity of the Bagmati River improving the water quality from Sundarijal to Sinamangal Bridge and further downstream.
4) Increased groundwater recharge from Sundarijal to Sinamangal Bridge and further downstream.
5) Increased water levels for cultural and religious use of the Bagmati River at temple ghats.
6) Improved hygienic quality of the water from Sundarijal to Pashupatinath reducing health risks of recreational or religious use of the Bagmati River.
7) Increased power generation providing income generation for River Basin Improvement and RBO activities.

Rainwater Harvesting:

1) Rainwater harvested from 2500 households providing 45,000 m^3 safe water supply and recharging of 135,000 m^3 annually.

2) By-laws reformulated and construction of rainwater harvesting system made mandatory in new buildings for safe guarding of the groundwater recharge capacity in new urban areas.

Watershed Management

8) Reduced erosion and silt load from the watershed in SNNP.
9) Improved livelihood for people living in the SNNP.
10) Reduced pressure from exploitation of SNNP resources.

3. Beneficial Impacts related to other Outputs

20) Improved river basin management with an RBO established and implementing an Integrated River Basin Development and Management Plan for the Bagmati basin. (Associated with Output 1 of the Project)

21) Basin wide water allocation based on improved data collection and use of a Decision Support System. (Associated with Output 1 of the Project)

22) Early warnings disseminated timely during floods providing a basis for preventive actions reducing loss of lives and flood associated costs. (Associated with Output 4 of the Project)

B. Impacts and Mitigation Measures Due to Project Location

1. General

297. The Upper Bagmati has been chosen as Project area for implementation of the water security and environment improvement interventions as it carries a strategic significance for people of Nepal in general and for the population in Kathmandu Valley in particular. The river flows through Nepal‟s capital city Kathmandu which is the central point for government institutions, commerce and Nepal‟s gateway for tourism.

298. As a resource, the Bagmati River‟s water is used for multiple purposes including: (i) Drinking water supply; (ii) Irrigation; (iii) Cultural and heritage activities; (iv) Hydropower generation; and (v) Recreational activities, such as bathing and swimming. The river flows through several prominent sites including Pashupatinath Temple, a major Hindu temple of Nepal which is enlisted as a World Heritage Site under the United Nations Educational, Scientific and Cultural Organization (UNESCO). The water within the Bagmati River is considered holy in the Hindu‟s culture and there are many temples, shrines and Ghats located along its river banks that rely on the river‟s water for their cultural and ritual ceremonies.

299. While the Project is designed to provide optimal environment improvements in the Upper Bagmati, it provides a long range of beneficial impacts, as described in Section A above. The key negative impacts are due to the dam constructions necessary to provide the needed storage capacity for release of water during the dry season, and due to the riverine works. Therefore, in the following, the description of negative impacts and the Environmental Management Plan (EMP) focus on these aspects, only.

2. Resettlement and Land Acquisition

300. No resettlement is foreseen for any of the Project components and their interventions. The Dhap and Nagmati Dam sites are located in the SNNP. The nearest settlements to the sites are Mulkharka and Chisapani, more than 500m and 2km away from the respective sites.

301. The proposed River Improvement works from Sundarijal to Sinamangal Bridge will all be carried out on GoN land under management by HPCIDBC, with the exception of the proposed

improvements of the ghats at temple sites. Any interventions at the temples will have to be carried out with approval of, and in collaboration with the temple authorities.

302. In order to establish the small powerhouse necessary on the left bank of the Bagmati River at Sundarijal, it is necessary to acquire 500m^2 of land. The suitable site is presently used for growing paddy. Compensation for acquisition of the land will have to follow the Project Resettlement Framework. However, this component is expected to be implemented only during Phase II of the project.

3. **Land value depreciation**

303. No depreciation of land values are foreseen at any Project component intervention sites, even temporarily during construction. Any potential local impacts in the semi-urban and urban stretches from Gokarna to Sinamangal Bridge will be mitigated under the Environmental Management Plan.

304. Upon completion of the river environment improvement interventions a considerable increase in land value is anticipated in the semi-urban and urban areas around the Bagmati River from Gokarna to Sinamangal Bridge.

4. **Historical / Cultural Monuments / Value**

305. The proposed Project interventions will not affect any historical or cultural monuments or religious temples or shrines negatively. In the unlikely event of encountering any finding of archaeological value, the Environmental Management Plan (EMP) has described procedures to deal with this.

306. The Project will add to the religious use of the Bagmati River at the temples ghats used for religious purposes.

5. **Encroachment into areas of ecological value**

307. The proposal for creating storage capacity in the Upper Bagmati by enlarging the Dhap and constructing a dam at the Nagmati during a subsequent phase II of the project, is dictated by the need to increase the environmental flow in the Bagmati River during the dry season.

308. All identified potential dam sites outside the SNNP have proven to be non-feasible for implementation, mainly due to a high population number in the inundation area, requiring extensive resettlement. The proposed sites in SNNP do not require resettlement.

309. However, implementation of the prosed dams in the SNNP will require extensive compensations, by replanting of 25 trees for every tree that has to be cleared in the reservoir areas behind the dams, following GoN rules and regulations.

6. **Encroachment into other valuable lands**

310. No encroachment into other valuable land is foreseen, except for the acquisition of a 500 m^2 plot of during phase II of the project for the powerhouse on the left bank of the Bagmati River at Sundarijal.

7. Compensation due to Project Location:

a. Compensation for Dams in Shivapuri Nagarjun National Park

311. The Government of Nepal in 2008 approved the Working Policy on Construction and Operation of Physical Infrastructures within Conservation Areas. Article 9 of the Working Policy says that from the view point of environment conservation, promoter will have to compulsorily plant 25 trees for every one felled or removed tree, with a diameter of more than 10cm at breast height, and take care of these trees as compensation.

312. Article 10 says that promoter, on its own cost, will have to plant trees in the land identified by the concerned office, which is equal to the government land of the national park, reserved and protected area as well as buffer zone area occupied by the physical infrastructures of the project as well as protection and conservation of the planted trees will have to be done for 5 years and after that planted area will have to be handed over to the concerned office. If the promoter is not able to do the works, money required for plantation as well as protection and conservation of the planted trees for 5 years as per the norms will have to be made available to the concerned office and the office will do plantation as well as protection and conservation of the planted trees. An estimated 15.8ha and 255 ha of open land is needed for replanting for compensation of the clearing at the Dhap and Nagmati sites, respectively.

313. The tree planting compensation has been discussed with the SNNP. Presently only a few hectares are available for replanting within the SNNP. It is therefore considered to do the replanting in the buffer zone around the SNNP, and in other areas identified by the SNNP together with the Department of National Parks and Wildlife Conservation, as advised by the MFSC.

b. Compensation for Powerhouse at Sundarijal

314. The acquisition of the 500 m^2 of land needed for the powerhouse will follow the Resettlement Framework developed for the Project (under Phase II) with respect to compensation etc.

8. Interference with utilities

315. No negative interference with utilities is foreseen under the Project. However, it is required that the power generated will enter the national grid through a power line crossing the Bagmati to the existing power station at Sundarijal (Phase II).

9. Construction of associated infrastructure

316. The construction of the new dams at the Dhap and Nagmati sites will require upgrade of existing roads and construction of access roads to the sites. The preferred road to be upgraded is east to the SNNP; see Figure III-6, referred to as the Ring Road by the SNNP authorities. The road will require upgrading with stabilisation, resurfacing and drainage. The park authorities were in favour of upgrading this road as it will also help them in their law enforcement activities.

317. Implementation of hydropower (under Phase II) will require a penstock being constructed from the Nagmati Dam site to the site of the Power House on the left bank opposite the existing powerhouse on the right bank at Sundarijal Bazaar.

C. Impacts and Mitigation Measures Due to Design and Pre-construction Activities

1. Works associated with Output 3, Dams

a. Site Investigations and Surveys

318. The pre-construction activities related to geological and other site investigation surveys: topographical surveys, environmental and engineering studies carried out under the PPTA, have been covered by EMPs prepared as part of the IEEs for the Dhap and the Nagmati Dam and implemented by the PPTA consultant on behalf of the Project Proponent[41]. Any subsequent investigative surveys, if needed, will be covered by updates of the IEEs, including the EMPs

b. Access Roads

319. Roadside drainage should receive particular attention by the detailed design team to assure that the surface of rehabilitated access roads does not concentrate rainfall and cause erosion. Engineering and hydrological criteria should be applied to the design of drainage structures[42]. Where longitudinal roadside drainage is undersized, water is diverted insufficiently, and flooding undercuts the roadway surface over time, causing breakup of the road, a safety hazard and eventual failure of the road surface. In order to avoid this condition, the design engineer should incorporate appropriate roadside drainage structures into the design construction drawings and project cost estimates.

320. The road eastern of SNNP from Sundarijal to be used for the access to the Dhap (18.8km) has only one bridge at Sundarijal (China Bridge) and this is adequate to take the traffic load expected.

c. Shifting the Mulkharka-Chisapani Road in Nagmati Reservoir Area

321. During detailed design of the shifting of the Mulkharka-Chisapani road, identification of appropriate methods of excavation or cutting to minimize landslides and enable slope stability are needed

322. As for the access roads, adequate road engineering[43] and hydrological criteria should be applied to the design of drainage structures.

323. A number of bioengineering techniques can be used to stabilize soils both during construction and for finishing slopes for long range operational integrity. These techniques consist of benching, grading and seeding slopes, and tree planting.

d. Deposit of Spoils

To prevent disposal of spoil materials on the lower slope below the access roads and hence destruction of forests and vegetation preliminary locations for any deposit of any spoil materials must be identified by the detailed design team to be confirmed by the construction supervision consultant. For the shifting of the roads to be inundated in the footprint of the reservoirs, deposits of any surplus material are

[41] Initial Environmental Examination. Pre-Investigative Works for Feasibility Study. PPTA Study. Final Report. November 2012.
[42] Nepal Roads Standards. Department of Roads
[43] Nepal Roads Standards. Department of Roads.

foreseen to be within the footprint, see Figure III-9, Figure III-5. For the existing access roads, only small quantities of deposits will be needed.

e. Land and Forest Clearing

324. No forest clearing will be needed to prepare for setting up the worker"s camp at the Dhap Dam site. Ample areas of grassland exist around the Dhap within the footprint of the extended inundation area, see Figure V-4. The worker"s camp will occupy an area approximately 500 m^2, with the worker"s camp accommodating on average 70 skilled workers/professionals and support staff. Work site clearing for the saddle dam will cover an area of with a length of 66m and height of 9 m above reservoir level. Clearing of about 2,000 m^2 of land is required of which about 1,300 m^2 is covered by forest. Clearing vegetation from the dam footprint area (approx. 7000 m^2 of which about 5000m^2 is covered by forest and remaining by grass land). Clearing for the Dhap is expected to be completed within 2-3 months.

325. Site clearing at the Nagmati dam site and the proposed area for the ancillary facilities will expose an area of 38 ha of land to rainfall and runoff, which may result in erosion and loss of topsoil thereby contributing to an increased load of suspended solids in the river and associated sedimentation. A sediment retention facility shall be installed to prevent any discharge of sediment into the Nagmati River. Clearing for the Nagmati dam is expected to take 6 months.

326. Site clearing and earthworks should not be carried out during excessively wet and rainy periods. Wood is considered recovered by the SNNP authorities as per GoN decision following the EIA, while remaining material will be composted off. Following construction of the dam, remaining cleared areas around and downstream the dam will require restoration of vegetative cover to prevent further erosion and sedimentation of the reservoir and downstream river.

f. Dam Design

327. Detailed designs for Dhap dam will be undertaken by the design build contractor. During design of the dams due attention will be given to environmental issues. A major issue during operation of a dam is water quality. When filled a reservoir of the depth foreseen at the Dhap and the Nagmati River is foreseen to have an-oxic conditions below the thermocline that will typically be formed at a depth of 10 m.

328. During conceptual dam design various release alternatives have been considered, that will ensure that water released from the reservoir is aerobic, i.e. is released from above the thermocline. A trunnion intake structure will be provided that takes water in at an prescribed depth below the surface, e.g. 2 m at the Dhap. At the Nagmati Dam a Valve tower is considered.

329. Another major issue is dam safety. The project area is situated in a high risk seismic zone, and there is an imminent risk of a major earthquake during the lifetime of the dams proposed. The type of dams selected for construction and the subsequent design takes due consideration to provide the highest safety possible based on accepted international dam design criteria[44]. The dams are designed in accordance with modern internationally accepted guidelines (including ICOLD Guidelines[45]) to withstand the effects of earthquakes. ICOLD provide guidelines for developing appropriate seismic loads that take into account the locations and frequencies of earthquakes as well as methods for analysing their effects and defining

[44] Feasibility Report for the Dhap Dam, Section 5. PPTA.
[45] International Commission on Large dams: http://www.icold-cigb.net/GB/Dams/dams_safety.asp

acceptable performance criteria. As such, the dam design proposed is engineered to withstand the design seismic event and so has an extremely low risk of failure in a seismic event. The type of dams selected (rock faced concrete fill) are known to be best to withstand earthquakes, and they are designed to withstand major earthquakes up to a probability of 1:1000 years occurrence, with a safety factor added.

2. Upper Bagmati Riparian River works.

330. The environmental river improvement interventions in the Upper Bagmati have primarily been identified with respect to their efficiency of providing water security and improved river environment.

a. Environmental Aesthetics

331. During the feasibility study of the environmental interventions in Upper Bagmati local architectural elements, design, construction materials and construction methods, especially at the temple sites, have been studied and incorporated into the design of all components in order to achieve an aesthetical beautification of the river environment.

3. Climate Change Induced Changes in the Bagmati Basin

a. Climate Change in Nepal

332. Changes in area averaged temperature and precipitation over Nepal have been assessed based upon more than a dozen general circulation models describing various spatial climate-change scenarios[46]. There is a significant and consistent increase in temperatures projected for Nepal for the years 2030, 2050 and 2100 across the various climate models. Increases in maximum temperatures are somewhat larger for the winter months than for the summer months. Climate models also project an overall increase in annual precipitation in plains and decrease in the higher altitudes. However, given the high standard deviation the results for annual precipitation should be interpreted with caution. Based on the analysis there is a reasonably high confidence that the warming trend already observed in recent decades will continue through the 21stcentury. There is also moderate confidence that the summer monsoon might intensify, thereby increasing the risk of flooding and landslides[47].

333. Nepal has ratified the UNFCCC. National Adaptation Program of Action (NAPA) was launched in 2010[48] and the national Climate Change Policy was approved by the GoN in January 2011. However, in important National Plans climate change still needs to be addressed and incorporated. Ministry of Science, Technology and Environment, (MOSTE) has the responsibility for coordinating the country's programme to fulfil its obligations under the UNFCCC. MOSTE has the mandate to be primarily responsible for formulating and implementing policies, plans and programs; preparing Acts; Regulation and Guidelines; conducting surveys, studies and research; disseminating information and carrying out publicity; monitoring and evaluating programs; developing human resources; and acting as a national and international focal point in the domain of population and environment and all climate change issues.

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[46] Development and Climate Change in Nepal: Focus on Water Resources and Hydropower. Agrawala et al. OECD Report, 2003.

[47] ICIMOD ADB-DFID Event: http://www.scribd.com/doc/34210948/Session-Climate-Change-What-the-Science-Tells-Us-About-Impacts-in-South-Asia.

[48] http://www.idsnepal.org/nseu/knowledge%20products/NAPA%20TO%20LAPA.pdf

334. Vulnerability is a subjective concept that includes three dimensions: exposure, sensitivity and adaptive capacity of the affected system[49]. The sensitivity and adaptive capacity of the affected system in particular depends on a range of socio-economic characteristics of the system. There is no universally accepted, objective means of „measuring" vulnerability. However, a subjective ranking based on the following dimensions have been attempted in Table V-1 (OECD 2003)[50]:

- *Certainty of impact.* This factor reflects the likelihood of impact. Temperatures are highly likely to rise and some impacts can be projected based on this. Changes in regional precipitation are less certain.
- *Timing.* When are impacts in a particular sector likely to become severe or critical? It is considered whether impacts are likely to emerge in the 1st or 2nd half of the 21st century.
- *Severity of Impact.* How large could climate change impacts be? Essentially, this factor considers the sensitivity of a sector to climate change.
- *Importance of the sector.* Is the sector particularly critical in terms of its size of economy, environmental, cultural or other importance, or its potential to affect other sectors.

Table V-1: Priority ranking of Climate Change impacts for Nepal (Source: OECD)

Resource/Ranking	Certainty of Impact	Timing of Impact	Severity of Impact	Importance of Sector
Water Resources and Hydropower	High	High	High	High
Agriculture	Medium-Low	Medium-Low	Medium	High
Human Health	Low	Medium	Uncertain	High
Ecosystems/ Biodiversity	Low	Uncertain	Uncertain	Medium-High

335. Water resources rank significantly higher than any other sector for several reasons. First, a number of impacts on water resources are directly related to rising temperatures that have already been observed on a national scale, and are projected (with high confidence) to increase further over the coming decades. Climate induced risks to water resources facilities in the Bagmati River Basin include: flooding, landslides and sedimentation as well as greater unreliability to dry season flows that poses potentially serious risks to water supplies and irrigation during the lean season.

4. Climate Change Induced Changes in the Bagmati Basin

a. Change in Upper Bagmati Temperature Due to Climate Change

336. In a recent study by Babel et al. (2011) the average Bagmati Basin average annual mean of maximum temperature is considered to increase by 1.5 to 2.1oC under climate change scenarios A2 and B2, in the period from 2070 to 2099 compared to the period from 1970 to 1999 (Table V-2). The A2 scenario describes a world with a continuously increasing population with regional orientation in terms of economy and culture, while B2 represents a world in which

[49] Smit B, Pilifosova O (eds.) (2001) Adaptation to climate change in the context of sustainable development and equity. Cambridge University Press, Cambridge

[50] Development and Climate Change in Nepal: Focus on Water Resources and Hydropower. Agrawala et al. OECD Report, 2003.

the emphasis is on local solutions to economic, social, and environmental sustainability with a continuously increasing population (lower than A2) and intermediate economic development[51].

Table V-2: Future changes in maximum temperature. Source: Babel et al.

Future Changes in maximum temperature (^{0}C)						
	Winter		Summer		Annual	
	Scenario		Scenario		Scenario	
Year	A2	B2	A2	B2	A2	B2
2020s	0.4	0.4	0.6	0.5	0.5	0.5
2050s	1.1	0.9	1.2	0.9	1.1	0.9
2080s	1.8	1.4	2.3	1.6	2.1	1.5

337. Precipitation may decrease in the dry season (October to May) but increase during the wet season (June-September) for the A2 Scenario. For the B2 Scenario, precipitation may increase during both wet and dry seasons. Under the A2 scenario, pre-monsoon (March-May) water availability (rainfall) may decrease more in the upper part than the lower part of the basin. During the monsoon (June-September). Both upper and lower parts of the basin show increased water availability (rainfall). During the post-monsoon season, water availability may decrease in the upper part, while the lower part shows a mixed trend. Under the B2 SRES scenario, rainfall (water availability) will increase in the entire basin (see Table V-2).

Table V-3: Future predicted changes in water availability in the Upper Bagmati Basin under climate scenarios A2 and B2. Source: Babel et al.

	Water availability at base period	Future Changes in Water Availability Scenario A2/B2					
		2020s		2050s		2080s	
SEASON	mm	mm	%	mm	%	mm	%
Pre-monsoon	229/218	-20/-4	-8.9/-1.8	-23/-10	-9.9/-47	-39/2	16.9/1.1
Monsoon	929/885	16/30	1.7/3.4	12//66	1.3/7.5	61/40	6.6/4.5
Post-monsoon	152/154	-5/3	-2.1/2.0	-2/4	-1.3/2.5	-19/-18	12.5/12.0
Annual	1311/1257	-10/30	-0.7/2.4	-13/60	-0.9/4.8	4/24	0.3/1.9

b. Climate Change Induced Changes in Rainfall in the Upper Bagmati Basin

338. An analysis of precipitation pattern was carried out using the data from DHM climate portal[52]. Bias correction using the Power Transformation Method was used in the daily precipitation data for 2020 - 2060 from the PRECIS- ECHAM05 model for A1B SRES scenario (defining a balanced scenario of fossil and non-fossil energy compared to a heterogeneous world defined in A1 scenario and a convergent world defined in B2 scenario). Table V-4, Figure V-1 and Figure V-2 show the historical and projected precipitation data for different seasons (Annual, MS- Monsoon from June-September, Post MS from October-November, and winter

[51] Crater T.R et al.: General Guidelines for the use of Scenario data for Climate Impact and Adaptation Assessment (TGICA), Version 2, 2007.

[52] DHM Climate Portal data was prepared by DHM with support from ADB. The PPTA team had access to only the A1B scenario data from Precis model for the hind-cast period of 1970-2000 and for projection for 2020-2060 and the results presented here are based on them.

from December-February and Pre-MS from March-May) in the upper catchment areas in Sundarijal. Annual and monsoon rainfall are projected to decrease by 2% and 8%, respectively, in 2020-2040 but projected to increase by 11% and 6%, respectively, in 2041-2060 compared to the period of 1994-2000. Rainfall in other seasons is projected to increase from 2020-2060 (see Table V-4). It can be seen that the variation of rainfall from one year to another is projected to increase with more extremes (high and low rainfall years). These findings mean that flow regulation through storage reservoirs will be beneficial in maintaining a constant required flows in the rivers in the dry seasons, especially up to 2040 when rainfall are projected to decrease.

Table V-4: Comparison of Historical and CC Projected Rainfall at Sundarijal

	Annual		Monsoon (Jun-Sep)		Pre-Monsoon (Mar-May)		Post-Monsoon (Oct-Nov)		Winter (Dec-Feb)	
Period	mm	% change from 1994-2000	mm	% change from 1994-2000	mm	% change from 1994-2000	mm	% change from 1994-2000	mm	% change from 1994-2000
1994-2000	2865		2450		299		70		46	
1994-2010	2187		1790		290		56		51	
2020-2040	2821	-2%	2254	-8%	370	24%	142	104%	55	18%
2041-2060	3170	11%	2587	6%	386	29%	142	104%	56	20%

Note: The rainfall during 2000 - 2010 is relatively lower than 1994-2000 giving a lower long-term average rainfall for the period 1994-2000. Hence, the comparison of CC projected rainfall is made with the period of 1994-2000 which was also the period for bias correction used.

Figure V-1: Predictions of climate change induced changes in Annual and Monsoon (MS) rainfall. (Source: Babel et al)

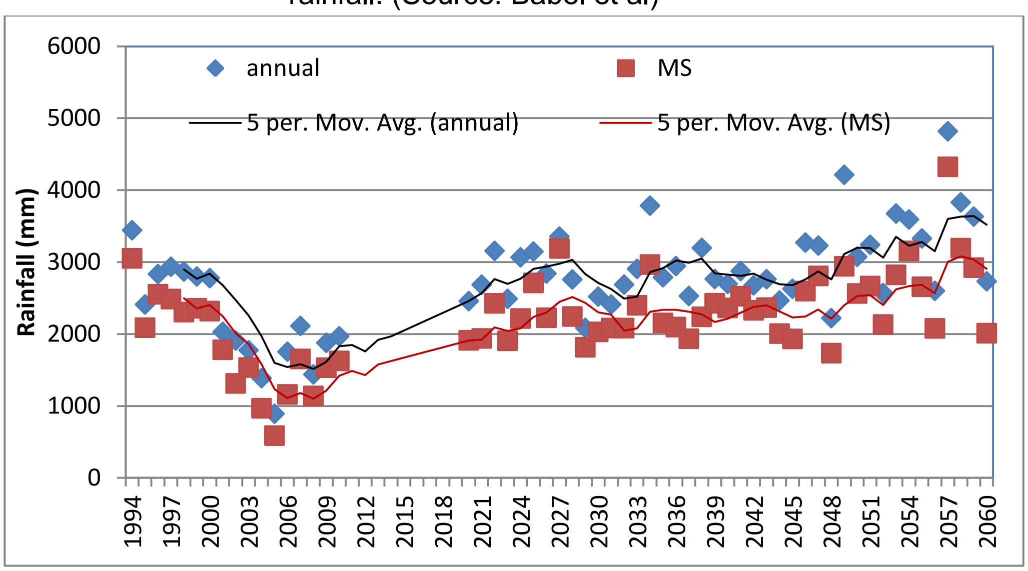
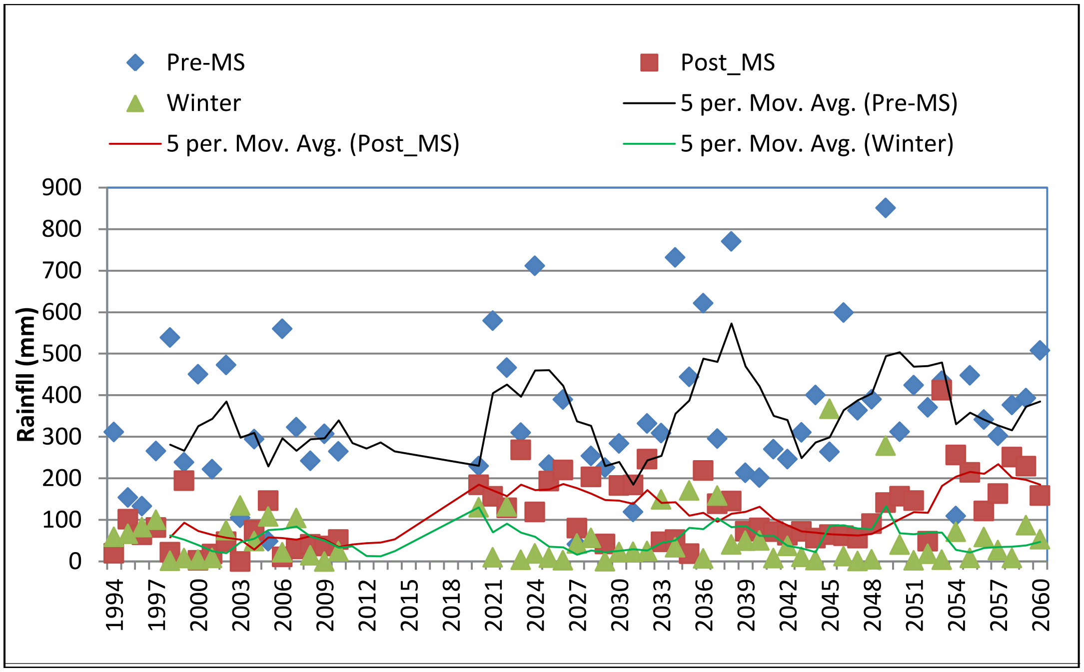


Figure V-2: Predictions of climate change induced changes in Pre-Monsoon (Pre_MS), Winter and Post Monsoon (Post_MS).



Source: Babel et.al.

339. The impacts of climate change on rainfall and consequently on the hydrology and the river hydraulics were used in catchment rain-fall run-off simulations and river hydraulic model calculations to ensure that dam designs and river works designs are climate change safe.

D. Impacts and Mitigation Measures Due to Construction Activities

1. Physical Environment

a. Air Quality

340. Air emissions during construction arise from the operation of construction vehicles, blasting and clearing of rubble, operation of quarry pits and hauling of materials. Emissions from rock crushing operations, aggregate drying and hot mix plants also degrade air quality.

341. The problem is present wherever construction is taking place in varying degrees, but it is generally local and do not affect regional air quality; However, potential impacts are considered to be most severe in the semi urban and urban areas from Sundarijal to Sinamangal Bridge where there are communities, homes, businesses and institutional buildings in the vicinity of construction activities.

342. Mitigation measures are aimed at dampening dust emissions from disturbed soil and access road surfaces and removing operations that contribute to point source emissions from the vicinity of communities. The contractor will be required to regularly water roadway surfaces wherever there are communities (homes, businesses, schools) nearby. The site access road segments near settlements will need spraying of water to lessen the dust pollution during construction. Spraying may be done twice daily or at such frequency as is needed to minimize impacts.

343. A rock crushing plant will be operated at the borrow/quarry within the footprint of the reservoir at the Dhap Dam site. Similarly, a rock crushing plant will be operated at the quarry in the foot-print of the Nagmati Dam during Phase II. Areas where dust accumulates should be watered regularly. Any changes in location of crushing plant must be approved by the SNNP authorities.

344. All equipment, machinery and vehicles used for the project must be well maintained in order for proper functioning as well as reduction in air pollution.

345. No impact on air quality is considered for the implementation of rainwater harvesting facilities.

b. **Noise**

346. Noise impacts on human settlements and wildlife in the SNNP will originate from the operation of construction equipment and from rock blasting and rock crushing to provide rock-fill for the dams.

347. Noise impacts at the Sundarijal Bazaar, the housing along the Gokarna-Sundarijal main road, and in the increasingly urbanised areas from Gokarna down to Sinamangal Bridge will originate from the operation of construction equipment and transport of construction material to the construction sites.

348. Noise impacts are an unavoidable consequence of construction that should be mitigated by limiting the times of transport of material and construction to daylight hours in the vicinity of sensitive locations such as schools, health clinics etc. Appendix 8 provides a list of noise sensitive locations within 200 m from the Bagmati River potentially affected by noise.

349. The blasting activities in the SNNP should be carried out during the daytime to prevent disturbance to wildlife during the night, dawn and dusk.

350. The settlement of Mulkharka in the SNNP is more than 300m from the quarry site in the Nagmati reservoir area. Therefore, any noise impact on human settlement as a result of blasting would be minimal.

351. The contractor will prepare a blasting procedure requiring area restrictions; prior warning of workers and others passing through the SNNP; restrictions on the timing of blasts; and worker safety procedures. In consideration of its impacts to surrounding environment, the quarry operation shall utilise an environmental friendly blast initiation system in its blasting operation. This will enable a multi-row blast pattern to be implemented in order to achieve a desired shot volume. The initiation system recommended for primary blasting is Non-el or electrical system with minimal holes per delay design. The use of millisecond delay intervals between adjacent holes in a single row will minimise ground vibrations, air blast, fly-rock and increase fragmentation. However, there is no housing or other sensible structures in the vicinity of the dam sites that is considered to be affected by vibration from the blasting.

352. The contractor shall employ competent personnel handling the blasting operation are an important factor to ensure that the operation is conducted in a professional manner. The person in charge which is the shotfirer shall have experience in blasting operation at sensitive areas and possess good knowledge in the latest technology in blasting operations.

353. Noise emission caused by construction and construction related activities and transport of materials to and from the construction sites near and within settlements and urbanised areas from Sundarijal down to Sinamangal Bridge will be restricted to the daytime. For trucks speed limitations should be strictly adhered to and use of horns banned.

354. No impact on noise is considered for the implementation of rainwater harvesting facilities.

c. **Soil, Erosion and Sediment Transport.**

355. The access to the dam site at the Dhap will be by the existing road east of the SNNP from Sundarijal to Chisapani (a distance of 18.8km). The access to the Nagmati Dam site will be at the existing road from Sundarijal to the Nagmati Dam site via Mulkharka (a distance of 6.6 km). The roads will be upgraded and gravel surfaced, both to serve as a safe access road, but also to reduce the present high erosion rate of the un-surfaced road cut into soft soils and heavily weathered rock. Further, the upgrading of the road will include proper drainage and provision of culverts where needed. Where the reservoir will inundate the existing track at the right (west) side of the Dhap, the track will be shifted further west to the future edge of the reservoir in consultation with the users of the track,

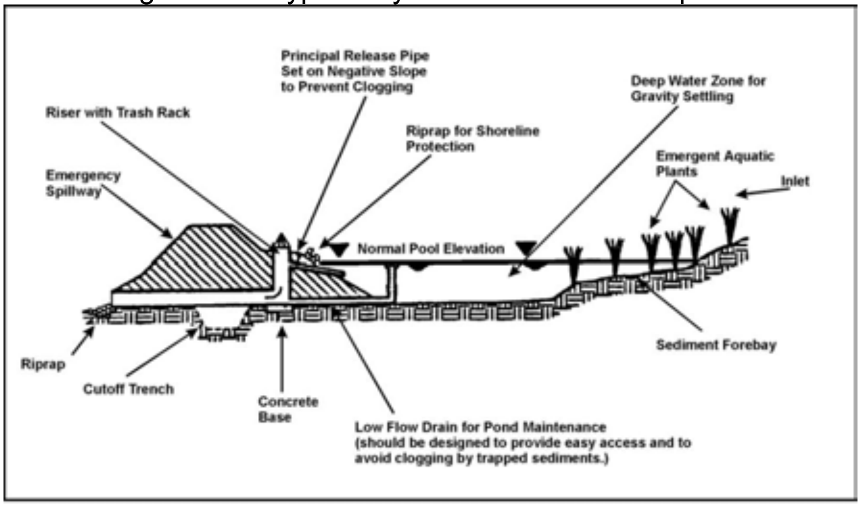
356. Where the reservoir in Nagmati will inundate the existing road, the road will be shifted to a higher, non-inundated level. It will mostly be cut into the side slopes ranging from 35 to 70 degrees. The shifting of the road will include proper drainage, provision of culverts and slope protection to avoid any soil erosion and damage to the road, where needed. The shifting of the road will be carried out before the filling of the reservoir, to avoid any disruption to the traffic

357. Impacts in the form of landslides and erosion may occur due to cutting and excavation of the roadbed, on the upslope from barren rock or loosely held conglomerate materials that are variably stable during construction and must be removed sufficiently to provide clear space for the roadbed and working shoulders and to assure stability over the long term period of use. Down slopes must also be stabilized but to a lesser extent; here the greater problem is with rubble loosed from above that is lost down the mountainside and may be mobilized by rainfall or from earth movements.

358. Though erosion, rock falls, are unavoidable during cutting works, appropriate methods of excavation and benching recommended during the detailed design must be followed to minimize these impacts. Use of borrow areas where necessary will result in formation of open pits. This can lead to issues of erosion. Hence, after use all borrow areas must be properly restored by filling with unwanted material generated from the construction works. The top soil of the borrow area must be kept aside and reused to seal the borrow areas at the end of its use.

359. The operation of the quarry at the Nagmati site, and at the Dhap site particularly during clearing, drilling and preparation of benches may cause entry of suspended particulates consisting primarily of eroded soils from denuded area of the quarry and fine rock particles from the drilling of the blast face into the Nagmati River leading to deterioration in the river water quality. Hence, the quarry must maintain a buffer zone of 20 meter to the Nagmati River and all clearing of the quarry site should be restricted to the necessary area of rock extraction. A sedimentation pond for retention of eroded particles should be put in place. A typical sedimentation pond design is provided in Figure V-3. Proper drainage shall be established to channel the runoff to the sedimentation ponds before final discharge into the Nagmati River.

Figure V-3: Typical layout of sedimentation pond



360. Areas of steep slopes and unstable terrain should be terraced, stabilized, strengthened and re-vegetated to avoid risk of erosion and slope failure during and after the construction stage. Soil erosion at construction sites shall be minimized using soil protection such as terracing, plastic sheeting and installing silt traps at strategic locations.

361. The river improvement works from Gokarna down to Sinamangal Bridge will be carried out during the dry season, and are not foreseen to result in any significant impact with respect to erosion and sediment transport. Dredged material will not be permitted to be stored at the river banks and will be transported to the landfill site in covered trucks.

362. No impact on soil erosion and sediment transport is considered for the implementation of rainwater harvesting facilities.

d. **Hydrology and River Hydraulics**

363. The constructions at the Dhap site will commence at the start of dry the season to minimise the risk of flooding of the damsite. Inundation of the dam footprint is prevented through the construction of upstream and downstream cofferdams. The 0.4m stream diversion pipeline is constructed with sufficient capacity to pass the 5 year return period flood, see Section a. During the construction period the natural, low will pass the construction site. Consequently no impact on the Upper Nagmati hydraulics downstream the Dhap dam site is foreseen during the construction period.

364. The constructions at the Nagmati site will also commence at the start of dry the season to minimise the risk of flooding of the damsite. A river diversion (pipeline of approx. 1.2m in diameter even adequate during the wet season), to be released immediately downstream of the construction site. Consequently, no impact on the Nagmati River hydraulics downstream the Nagmati Dam site is foreseen during the construction period, see Section c).

365. The river improvement works from Gokarna to Sinamangal Bridge will be carried out during the dry season to ease the construction and avoid flooding of construction sites, and minimise any impact on the Bagmati River hydraulics. Any construction works affecting the river flow, such as the construction of weirs, will typically be carried out in two phases, with the construction going on in one half of the cross section, leaving the river to flow in the other half.

366. No impacts on hydrology and river hydraulics are considered for the implementation of rainwater harvesting facilities.

e. **Water Quality**

367. The river water quality will be affected by any increased total suspended solid (TSS) concentrations and turbidity due to increased erosion and sediment loads into the river system. A decrease in quality and availability of light due to increase in TSS and turbidity is expected particularly at the construction site for the dam. The contractor will provide a detailed sedimentation and erosion control plan for all sites, with the detailed activities to be carried out as part of the EMP. Mitigation measures are similar to the measures mentioned in Section c.

368. The river improvement works from Gokarna down to Sinamangal Bridge will be carried out during the dry season, and are not foreseen to result in any significant increase in TSS concentrations and associated impacts with respect to river water quality.

369. No impact on water quality is considered for the implementation of rainwater harvesting facilities.

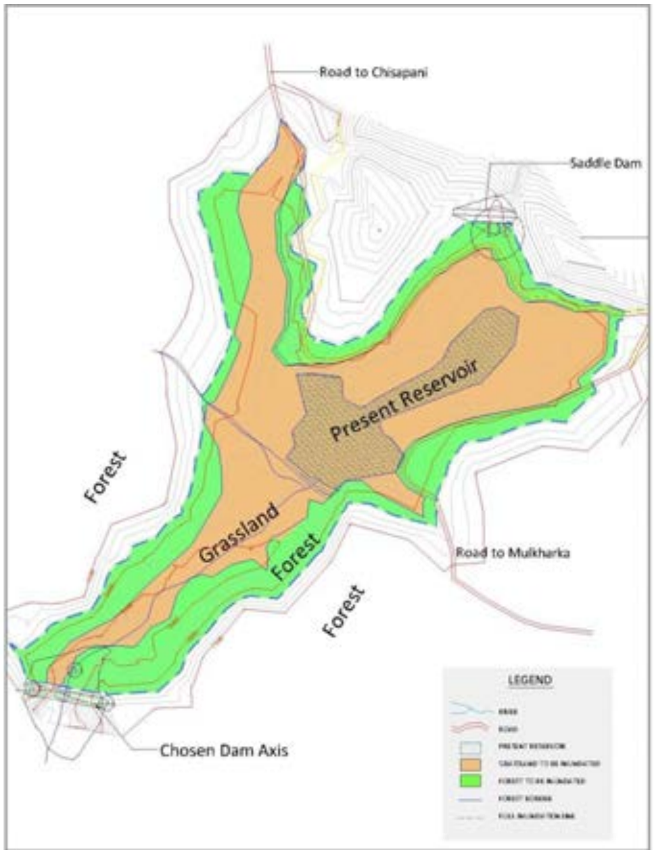
2. **Impact on the Biological/Ecological Environment**

a. **Forest and Vegetation**

Dhap Area

370. The area to be inundated by the new Dhap Dam is 12.5 ha when at full capacity (Figure V-4). The inundated area of the Dhap inundated behind the existing dam is 1.5 ha. The open area covered by grass around the existing inundated area is 5.9 ha. Consequently, 5.1 ha of forested area around the Dhap will be inundated behind the new Dhap Dam when at full capacity. The area will be cleared in the dry season at the end of the construction period, before filling the reservoir.

Figure V-4: Inundation of the Dhap Area.



Source: PPTA

371. With the given total average density of trees in the forested area surrounding the Dhap provided in Section 2 of 385 trees per ha, a total of 1964 trees are estimated to be inundated behind the new Dhap Dam when at full capacity.

372. The trees to be inundated are not expected to survive an annual inundation. The trees will be cleared during the construction period before the filling of the reservoir upon the completion of the construction. The forest density around the Dhap is relatively low and in a secondary stage of succession. There are few large/mature size trees in the area. There are no direct mitigation measures to the loss of trees, with the exception of replanting of 25 trees for each tree cleared, at sites to be determined by SNNP officials. Considering the state of the forest and the composition of species, of which none are considered endangered, the loss of biodiversity is relatively insignificant.

373. However, compensation will be provided according to the Working Policy on Construction and Operation of Physical Infrastructures within Conservation Areas. This will require that for each tree removed, 25 trees have to be planted (Section a). With 1964 trees to be cleared, planting of 49,100 trees are needed as compensation. With an estimated density of 2500 seedlings per ha this will require 19.6 ha of land for replanting. As discussed with MFSC, Department of Wildlife and SNNP, the park authorities will identify sites for replanting. Before clearing, all tree with a diameter of more than 10cm at breast height will be registered with assistance from SNNP officials. When felled, the trees are under SNNP ownership, and will be removed.

374. No trees are foreseen to be cleared for the access road to the Dhap site.

Nagmati Area

375. The area to be inundated by the Nagmati Dam is approximately 38 ha when at full capacity. With the given total average density of trees in the forested area surrounding the Nagmati Dam site provided in Section 2 of 670 trees per ha, a total of approximately 25,400 trees are estimated to be inundated behind the Nagmati Dam when at full capacity, to be cleared in the dry season at the end of the construction period, before filling the reservoir.

376. With respect to the construction of the penstock from the Nagmati Dam to the powerhouse at the left bank of the Bagmati River at Sundarijal, it is considered feasible to line this without the clearing of major trees, as they are relatively sparse. However, the line will be prepared in close consultation with SNNP staff to minimize any clearing of trees. If any trees need to be cleared they will be registered in the presence of park officials and compensation in the form of replanting of 25 trees according to the Working Policy on Construction and Operation of Physical Infrastructures within Conservation Areas will be undertaken.

377. The trees to be inundated are not expected to survive an annual inundation. The trees will be cleared during the construction period before the filling of the reservoir upon the completion of the construction. The forest density around the Nagmati is relatively low and in a secondary stage of succession. There are few large/mature size trees in the area. There are no direct mitigation measures to the loss of trees with the exception of replanting of 25 trees for each tree cleared, at sites to be determined by SNNP officials. Considering the state of the forest and the composition of species, of which none are considered endangered, the loss of biodiversity is relatively insignificant.

378. However, compensation will be provided according to the Working Policy on Construction and Operation of Physical Infrastructures within Conservation Areas. This will require that for each tree removed, 25 trees have to be planted (Section a), With 25.400 trees to be cleared, planting of 636,500 trees are needed as compensation. With an estimated density of 2500 seedlings per ha, this will require approximately 255 ha of open land for replanting. Tree replanting and felling will follow the same process as described for the Dhap Dam.

379. The access road to the Nagmati site during construction will be placed at the footprint of the reservoir. Consequently, no trees are foreseen to be cleared in addition to the estimated 25,400 trees to be cleared overall in the footprint.

From Sundarijal to Sinamangal Bridge

380. No natural forest or vegetation is considered to be affected by the proposed River Environment Improvement and rainwater harvesting interventions.

b. **Birds**

381. The SNNP is a possible habitat for 12 threatened bird species, see Appendix 6, of which four are globally threatened (Hodgson"s Bush Chat, Lesser Kestrel, Saker Falcon and White rumped Vulture) and four vulnerable nationally threatened (Grey sided Laughingthrush, Blue-winged Laughingthrush, White-tailed Stonechat and Brown Wood Owl) and one nationally endangered (Spot-bellied Eagle Owl).

Dhap Area

382. The likelihood of the 12 threatened species being present at the Dhap Dam site has been evaluated by the national bird experts as presented in Appendix 4. It cannot be excluded that the Saker Falcon, Grey-sided Laughingthrush, Blue-winged Laughingthrush may occur in the forest and open areas around the site. The Saker Falcon occupies open country, while the Grey-sided Laughingthrush and Blue-winged Laughingthrush occupy forest and bush, feeding on insects and fruits.

383. Clearing of the forest will be carried out during the dry season where nesting is less common for most species. Of the 12 species listed as threatened, it is only the White-rumped Vulture and the Spot-bellied Eagle Owl that nests during the dry season. However, they are considered as „least possible" to be found in the Dhap area, see Appendix 4, that provides the local PPTA Bird expert"s screening of protected species with respect to their possible presence in or in the vicinity of the Dhap site.

384. The branches and canopy of the trees must be checked before clearing to make sure that there are no nests with young chicks in them. This is a very important step to be taken to minimize the casualties to the bird nests and young chicks. Any nests with chicks found in the trees must be handled carefully and displaced in other area with the help of expert. It is foreseen the clearing will be done manually, section by section, each section to be checked before clearing starts.

385. The clearing of the forested area to be inundated behind the Dhap Dam will generally deprive birds from a forest habitat of 5 ha, or approximately 0.031% of the total 15,900ha of similar forested land habitats in the SNNP. The birds living in the area are envisaged to move outside the project area, and find new nesting and feeding grounds. The areas replanted as compensation will provide new habitats for forest birds.

386. With no trees foreseen cleared for the access road to the Dhap site, no impacts on birds are foreseen from the access road.

387. No major impact is considered for threatened or endangered bird species.

Nagmati Dam Area

388. Only one vulnerable species listed as a nationally threatened bird, the White-tailed Stonechat was recorded at the Nagmati Dam site (Table IV-18). Of the other 11 threatened bird species listed in Appendix 6B, the Saker Falcon, the Grey-sided Laughingthrush and Blue-winged Laughingthrush are possibly found at the dam site, while the remaining 8 threatened species are not likely to be found here.

389. Clearing of the forest will be carried out during the dry season where nesting is less common for most species. Of the 12 species listed as threatened, it is only the White-rumped Vulture and the Spot-bellied Eagle Owl that nests during the dry season. However, they are considered as „least possible" to be found in the Nagmati Dam site area, see Appendix 5.

390. The branches and canopy of the trees must be checked before clearing to make sure that there are no nests with young chicks in them. This is a very important step to be taken to minimize the casualties to the bird nests and young chicks. Any nests with chicks found in the trees must be handled carefully and displaced in other area with the help of expert. It is

foreseen the clearing will be done manually, section by section, each section to be checked before clearing starts.

391. The clearing of the forested area to be inundated behind the Bagmati Dam will generally deprive birds from a habitat of 38 ha or 0.24% of the total 15,900ha of similar forested land habitats in the SNNP. The birds living in the area are envisaged to move outside the Project area, and find new nesting and feeding grounds.

392. No major impact is considered for threatened or endangered bird species. However, the compensation for the clearing of the area by planting 25 trees elsewhere in or around the SNNP is considered to provide alternatives to nesting and feeding ground lost in the reservoir area.

393. With no additional trees foreseen cleared for the access road to the Nagmati site, no additional impacts on birds are foreseen from the access road.

Upper Bagmati from Sundarijal to Sinamangal Bridge

394. No impacts on birds are envisaged from the construction of the river improvement interventions and implementation of rainwater facilities from Sundarijal to Sinamangal Bridge.

c. **Wildlife**

395. The SNNP record shows that the park provides shelter to 21 species of mammals (Pandey, 2010)[53]. Of these the Chinese pangolin *Manis pentadactyla* and Himalayan black bear *Ursus thibetanus* are endangered, Large civet *Viverra zibetha* is near threatened, and Clouded leopard *Neofelis nebulosa*, Common leopard *Panthera pardus* and Leopard cat *Prionailurus bengalensis* are considered vulnerable.

Dhap Area Wildlife

396. Of the endangered, near threatened or vulnerable species known to live in the SNNP, the Large Civet and Common leopard were recorded during the wildlife survey. Of the other species known to live in the SNNP, the Clouded leopard is likely to be there, and the Himalayan black bear is possibly found there[54].

397. The reservoir created will inundate habitats of wildlife. However, there are no elevated sites in the reservoir area where wildlife may be trapped during the filling of the reservoir. Therefore, wildlife is considered to move to other areas outside the reservoir.

398. The pond created will inundate some of the core habitats of wildlife. Besides, permanent deep water pond creates a barrier to wildlife movement thus restricting their distribution. For example, grasslands that are being used by the free ranching animals around the *Dhap* area will be lost. They were found to support the herbivores like *Munitacus muntjak* and *Lepus nigricollis*. However, they are expected to move to other open areas at the outskirts of the SNNP, and none of the species are listed as endangered or threatened. Carnivores like *Martes flavigula, Prionailurus bengalensis* and *Panthera pardus* are expected to follow their herbivore prey.

[53] Pandey, B.P. 2010. *Presence Absence Survey of Clouded Leopard (Neofelis nebulosa) in Shivapuri Nagarjun National Park, Nepal.* Report submitted to Shivapuri-Nagarjun NationaL Park

[54] Wildlife Survey of Upper Bagmati Catchment. PPTA study, November 2012

399. Impact to Burrowing Wildlife: Wildlife that live in burrows (for e.g. Large hare, Chinese pangolin and Mongooses) will be impacted after the dams are made. Their habitat at the Dhap will be lost after the area gets submerged. However, they are expected to move to other open areas at the outskirts of the SNNP, and none of the species are listed as endangered or threatened.

400. It is unlikely that any trees will need to be felled for the access road to the Dhap site,. Therefore there will be no significant impact on wildlife from the access road.

Nagmati Dam Site Wildlife

401. None of the three wildlife animals recorded during the wildlife survey, see Table IV-20, are listed in the IUCN List of Threatened species for Nepal[55]. The species on the IUCN Red List likely to be in the area are the Chinese pangolin (internationally: endangered, nationally: endangered), Clouded leopard (globally: near threatened, nationally: endangered) and the Common leopard (globally: near threatened, national: vulnerable), see Appendix 11.

402. The Chinese Pangolin is solitary, nocturnal and largely terrestrial although it is fully capable of climbing trees and, like other pangolins, swims well (Heath and Vanderlip 1988; Chao Jung-Tai 1989). Little information is available on population levels of any species of Asian pangolins. These species are rarely observed due to their secretive, solitary, and nocturnal habits[56]. However, a 1993 survey conducted in the Royal Nagarjun Forest determined that there was a healthy population there, however, the general trend elsewhere in Nepal was dramatically declining, due to increased access to hunting areas and loss of habitat (Gurung 1996). In general pangolins, are able to adapt to modified habitats (e.g., secondary forests), provided their termite food source remains abundant and they are not unduly persecuted. The reservoir will inundate an area that may host Chinese pangolins at present, but they will be able to move to other areas. The creation of the reservoir is not considered to have any significant impact on the Chinese pangolin population in SNNP.

403. The reservoir area is not considered to constitute the main area in the SNNP for the Clouded leopard, which is strongly associated with primary, evergreen forests. A presence/absence survey was carried out by SNNP staff using camera traps, supplemented by interviews and sign surveys during April-June 2010. Four images of a Clouded leopard (sex unknown) were captured in a single event in the transition zone of the subtropical and lower temperate vegetation zone of Schima and Castanopsis forest at 1,985 m. The study was carried out to verify the status of the poorly known clouded leopard. This is the first authentic record of the species in a decade. However, there are records where they have occured in secondary forest[57]. Clouded leopard may temporarily be present in the Nagmati Dam site area. Yet, they are not considered to use the area permanently, especially as the area is already relatively disturbed by intermittent road traffic and people from the nearby settlement using the area. The creation of the reservoir is not considered to have any significant impact on the Clouded leopard population in SNNP.

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55 http://biodiversityofnepal.icimod.org/ProtectedAreas/Redbook.asp

56 Duckworth, J.W., Steinmitz, R., Pattanavibool, A., Than Zaw, Do Tuoc & Newton, P. 2008.*Manis pentadactyla*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 07 June 2013.

57 Sanderson, J., Khan, J.A., Grassman, L. & Mallon, D.P. 2008. *Neofelis nebulosa*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 06 June 2013

404. The Common leopard is an adaptable, widespread species that nonetheless has many threatened subpopulations[58]. Leopards are generalist species and therefore found in a variety of habitats, from desert to rainforest and high mountains. They are also very opportunistic animals and have an extremely flexible diet ranging from mice and hares to large deer.[59] The diet for the Common leopard in the SNNP is considered to be mainly monkeys, deers and rodents.[60] The Common leopard is not considered to use the area permanently, especially as the area is already relatively disturbed by intermittent road traffic and people from the nearby settlement using the area. The creation of the reservoir is not considered to have any significant impact on the Common leopard population in SNNP.

405. The reservoir created will inundate habitats of wildlife. However, there are no elevated sites in the reservoir area where wildlife may be trapped during the filling of the reservoir. Therefore, wildlife is considered to move to other areas outside the reservoir.

406. However, permanent deep water pond creates a barrier to wildlife movement thus restricting their distribution. The areas at the immediate banks of the Nagmati River just upstream of the proposed dam, called as *Sano Dhap* and upstream of *Dhap* dam site are found to be important wildlife corridors for e.g. barking deer. These will be permanently lost and this will have a local negative impact on wildlife population and distribution in the area.

407. On the other side, construction of reservoir will create a lake/reservoir environment that might turn into important wildlife habitat. Perennial water bodies will remove the limit on wildlife distribution related to water availability. The impact will be of limited magnitude, medium in extent and permanent in duration.

408. With no additional trees foreseen cleared for the access road to the Nagmati site, no additional impacts on wildlife are foreseen from the access road.

Upper Bagmati from Sundarijal to Sinamangal Bridge

409. No impacts on wildlife are envisaged from the construction of the river improvement interventions and rainwater harvesting implementation from Sundarijal to Sinamangal Bridge.

d. **Aquatic Flora and Fauna**

Aquatic Rooted Vegetation, Dhap

410. As mentioned in section 2 the SNNP authorities are removing all aquatic, rooted vegetation along the present reservoir pond. If this practice is abandoned, the naturally adapted rooted aquatic vegetation is considered to return in the fringes as least, with same species and densities whether the existing dam is kept, or a new is constructed, forming a larger reservoir.

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[58] Henschel, P., Hunter, L., Breitenmoser, U., Purchase, N., Packer, C., Khorozyan, I., Bauer, H., Marker, L., Sogbohossou, E. & Breitenmoser-Wursten, C. 2008. *Panthera pardus*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on **07 June 2013**.

[59] The Status of Nepal"s Mammals, The national Red List Series. IUCN 2011.

[60] Wildlife Survey of Upper Bagmati Catchment. PPTA study report, November 2012

Aquatic Rooted Vegetation, Nagmati

411. No aquatic rooted vegetation exists in the river environment at the Nagmati Dam site. It is expected that limited aquatic rooted vegetation may be established during operation of the Nagmati reservoir.

Macro Invertebrates

412. The physical characteristics, such as benthic substrate, suspended sediment concentrations and turbidity of the aquatic habitat is a prime factor influencing the composition and abundance of stream faunal communities that form one of the important components in the lotic environment as indicators of environmental quality.

Dhap Area Invertebrates

413. The construction of the Dhap Dam will commence at the start of the dry season. The site will be kept free of flooding by diverting the natural water flow through a 0.4m diameter pipeline over a length of approximately 200m to keep the construction site free of flooding. The benthic aquatic life will disappear at this river stretch during construction.

414. Downstream the aquatic faunal characteristics may be temporarily altered due to release of suspended matter and sediments from the construction activities. The mitigation measures targeted to reduce or avoid any release of suspended matter and sediments are described in Section c. No significant, permanent impact on the invertebrates are foreseen at the Dhap originating from construction.

Nagmati Dam Invertebrates

415. During construction the Nagmati River flow will be diverted through a pipeline over a length of approximately 400m to keep the construction site free of flooding. The benthic aquatic life will temporarily disappear at this stretch during construction.

416. Upstream the dam construction site no impact on the benthic aquatic life is foreseen. However, downstream the aquatic faunal characteristics may be temporarily altered due to release of suspended matter and sediments from the construction activities. The mitigation measures targeted to reduce or avoid any release of suspended matter and sediments are described in Section c. No significant, permanent impact on the invertebrates are foreseen downstream the Nagmati Dam site originating from construction

Fish in Dhap

417. Construction and operation of a new dam at the Dhap site will enlarge the existing, impounded reservoir. The future reservoir is considered to provide the same basic conditions for any aquatic fauna, including fish, as the present one.

418. During construction and operation of the Dhap Dam the diversion pipeline is sufficient to convey the natural flow during construction. Consequently there will be no impact on fish and aquatic fauna downstream the Dhap dam site.

Fish in Nagmati

419. As mentioned in section b there are very few fish at the Nagmati site at present due to the natural conditions and disturbance of the natural conditions. Several small water falls on this stretch already hinders the Snow Trout in free migration up- and downstream. The construction and operation of the Nagmati Dam will create a significant additional barrier. However, given the very limited fish population, it is not considered as a significant impact.

420. The natural flow will be maintained during construction via a 1.2m diameter diversion pipeline. band 100 l/s during operation of the Nagmati Dam, to maintain whatever limited aquatic fauna, including fish, supported by the river ecosystem. Consequently no significant impact on fish and aquatic fauna downstream is considered downstream the Nagmati Dam site originating from construction.

3. **Impact on Human and Economic Development**

a. **Land Use and Resettlement**

Dhap and Nagmati Dam Sites

421. The construction activities are not foreseen to have any impact on land-use at the Dhap and Nagmati dam sites. Informal and formal users of the open areas around the existing reservoir can continue to use these during construction. During operation visitors can use the areas around the new reservoir as before.

422. For the roads to be shifted, both at the Dhap and the Nagmati sites, the shifted road will be constructed before closure of the old road sections in order not to interrupt any road traffic.

Upper Bagmati from Sundarijal to Sinamangal Bridge

423. With respect to the implementation of green zones from Gokarna to Sinamangal Bridge, local communities are informally using about 4km of the river bank areas between the existing gabion walls and the roads along the river banks for homestead gardening.

424. The construction of the green zones with foot and bicycle paths will dis-continue the homestead gardening. Based on stakeholder‟s consultations with the local communities, they a willing to give up this informal practice in return for the establishment of the green zones.

b. **Water Supply**

425. During construction the natural flow in the Nagmati River will be maintained, No significant change in the Nagmati River flow at the confluence with the Bagmati is foreseen and adverse impact on the diversion of water from the Nagmati to the Sundarijal Water Supply system is not foreseen during construction.

c. **Workers Camps**

426. Establishment and operation of a workers camp at the dam construction sites could cause temporary adverse impacts on flora and fauna as well as on the health of the workers. The following measures will be adopted and applied for construction and removal of the camps.

(i) Permission for camp areas must be obtained in writing from the National Park authorities.
(ii) Suitable latrines and other sanitary arrangements at the camps and sites where work is in progress should be availed to the personnel.
(iii) Access tracks and the camp area as well as drilling sites should be sited to cause minimum disturbance. Only kerosene, gas or other suitable energy sources are allowed for cooking. Use of firewood is strictly forbidden. Safety rules will be applied and fire fighting equipment be provided.
(iv) Movement of personnel should be restricted within workers camps, access tracks, construction sites.
(v) Poaching and hunting of wild animals should be strictly prohibited. Contract agreements should specify heavy penalties for illegal hunting, trapping and wildlife trading. No permanent structures should be built at the camp, and the camp site to be cleared and cleaned free of all debris, waste and hydrocarbons at end of the works under inspection by the National Park authorities.
(vi) All rubbish (except for oils and other mechanical or chemical waste) should be buried or removed. Organic waste shall be buried. Non-organic waste shall be removed.
(vii) Waste oils, chemicals and mechanical waste should be stored and removed by a registered waste handling company.
(viii) Health services, first aid kits and regular health checks shall be provided.

d. **Construction Sites:**

427. Impacts from construction wastes and other wastes generated during the construction activities are anticipated. The contractor will be required to implement the following measures to control drilling sites:

(i) Each construction site should be completely cleared of all waste after use. Rubbish, waste oil and chemicals should be returned for disposal as outlined in the Workers Camp section (viii) above.
(ii) Waste material should not be disposed in the river water.
(iii) No spillage of oils or fuels should occur. In order to reduce and control any spillage, stocks of sawdust should be placed at strategic points in the working areas, to be poured immediately onto any spill. In the event, the sawdust will have to be removed and deposited by a registered waste handling company.
(iv) On completion of works the site must be left clean and free from all debris, hydrocarbons and waste.

e. **Community Impacts**

Dhap and Nagmati Dam Sites

428. During construction the communities in the SNNP and nearby will have income generating opportunities by supplying to the non-skilled work force needed for a range of activities such as serving in the workers camps, transport of materials, forest clearing etc.

429. The contractors will be encouraged to employ as large a part of his workforce from communities in the vicinity of the construction sites.

430. Local shops will opportunities for supplying goods and services to the workers and workers‟ camp.

4. Way of Life and Equity

a. Transport of Material and Disposal of Spoils

431. Transportation of material may cause dust and noise pollution. Dust blowing from various material should be prevented by coverage or by keeping the surface wet during transport. Any transport should take place during the daytime to minimise nuisance and disturbance. Various sites have been identified for delivery of aggregates, e.g. from the Indrawati 70 km away.

b. Community Impacts

432. Disruption of community life, disturbance and social and environmental problems may arise when an imported workforce is housed in work-camp accommodation at the Dhap and Nagmati Dam site. The camps are estimated to host on average 32 and 65 imported skilled workers, engineers, supervisors etc., respectively.

433. Employment of workers from the local communities will mitigate some of these effects. Besides, the contractors will need to enforce strict rules for the behaviour of the workforce hosted in the camps.

E. Impacts and Mitigation Measures from Operation

1. Physical Environment during Operation

a. Air Quality

434. No negative impacts on air quality are expected during operation of the Project

b. Noise

435. No negative impacts on noise are expected during operation of the Project

c. Soil, Erosion and Sediment Transport.

436. No negative impacts on soil, erosion and sediment transport are expected during operation of the Project.

437. The Nagmati Dam reservoir will trap suspended matter and sediments from the upstream catchment, thereby reducing the sediment transport downstream the reservoir in the Nagmati River, improving water clarity and water quality. The trapping of sediments will reduce the already human affected high sediment transport out of the SNNP. Watershed management will be introduced in the settlements downstream the reservoirs to further reduce the already human induced sediment transport, downstream and out of the SNNP.

d. **Hydrology and River Hydraulics**

Dhap and Nagmati Dams

438. The Dhap and Nagmati Dams will be operated to increase the flow in the Bagmati River during the dry season with a continuous release of 40 l/s from the Dhap Dam[61] (see Section 1 for the determination of this release). When phase II of the Project is operational a continuous environmental compensation flow of 100 l/s equal to the average dry season flow at present will be released from the Nagmati Dam and a balance of 400 l/s to be taken into the hydro intake down to the power station at Sundarijal, where it will be released back into the Bagmati River. During filling of the reservoirs in the wet season, water will be released at least at a quantity of the average natural minimum flow. No negative impacts are foreseen on hydrology and hydraulics during the operation of the Dhap and Nagmati Dams.

Sundarijal to Sinamangal Bridge

439. The river improvement interventions from Gokarna to Sinamangal will be designed to provide safety against floods, with the provision of river flood protection stone walls.

440. The provision of weirs will stabilise the river bed morphology and regulate and increase water depths during the dry season. No negative impacts on hydrology and hydraulics are considered.

e. **Water Quality**

Dhap and Nagmati Dams

441. The formation of a thermocline in the reservoirs will create a deteriorating water quality in the bottom layer after time progresses during the dry season after filling the reservoir in the wet season. If bottom water is released in an environmentally un-safe manner it will have considerable negative impact on the aquatic life including fish downstream the reservoirs.

442. The design of the dams provides options to operate and release water in an environmentally safe manner, with the provision of structures to re-aerate water released, if necessary. A trunnion intake structure will be provided that takes water in at a prescribed depth below the surface, e.g. 2 m at the Dhap. A valve structure will be implemented at the Nagmati Dam.The Reservoir Operation Manual and Plan will provide rules for safe environmental release of water

443. The retention of suspended matter in the Nagmati reservoir will decrease turbidity and thereby improve water quality downstream. However, the present levels at Sundarijal are already low, see b.

Sundarijal to Sinamangal Bridge

444. The increase in river flow during the dry season due to the releases from the Dhap reservoirs will improve the water quality from Sundarijal and down to Pashupatinath. However, an average release from the Dhap reservoir of only 40 l/s will provide only about 1/10 of the environmental flow needed to achieve targets for minimum flows at the temple sites of 200 l/s

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[61] If decided by HPCIDBC, foreseen to operate the Dhap Dam, more water can be leased during festivals. Consequently the flow during the remainder of the dry season will be lower.

and bathing water quality standards (BOD< 6 mg/l and DO> 3 mg/l), see 1. However, during festivals water can be released to achieve the water quantity and quality targets at temple sites. Upon completion of phase II, the Nagmati reservoir will provide water to reach the targets at the temple sites during the entire dry season for more than 2 out of 3 years.

445. In addition to this significant improvement, the weirs to be implemented as part of the river improvements will increase the self-cleaning capacity in the Bagmati river by re-aeration. On average, each weir, designed with a heights of 1m head will increase the dissolved oxygen concentration by at least 0.6 mg O/l. In total it is envisaged to implement 11 new weirs.

Box V-1: Estimation of re-aeration efficiencies of weirs

Re-aeration from weirs

The effectiveness of weirs for re-aeration is quantified by their Transfer Efficiency, termed E_{20} (at water temperature 20^0C). The equation providing the best correlation with field measurements undertaken for low as well as high sharp-crested weirs is the Avery and Novak equation[62]:

$$E_{20} = 1 - \left(\frac{1}{1 + 0.64 * 10^{-4} * F_j^{1.787} * R^{0.533}}\right)^{1.1149}, \text{ where}$$

F_j is the Froude‟s Number,

R is the Reynold‟s Number

With a 1 meter high weir, with water having e.g. a dissolved oxygen concentration 4 mg/l and a saturation concentration of 7,5 mg/l, the Avery and Novak equation predicts 1,65 mg O_2/l will be added. However, the Avery and Novak equation tends to over-estimate the re-aeration efficiency for lower weirs.

The Holler‟s equation provides a better correlation between measured and observed Transfer Effiencies[1]:

$$E_{20} = \frac{0,21325 * H}{(0,21325 * H + 1)}, \text{ where}$$

H is the Head in meters.

For the above example, Holler‟s equation predicts a re-aeration of 0.62 mg O_2/l for a 1m high weir. An empirical value based on observed values available[63] predicts a re-aeration efficiency of 0.24, which equals an addition of 0.82 mg O_2/l, see Figure Box 1.

[62] Steven C. Wilhelms and John D. Gullliver: "Re-aeration at Low-Head Hydraulic Structures". US Army Corps of Engineers. Technical Report W-93-2, July 1993.

[63] Thomas E. Butts et.al.: "Evaluation of re-aeration Efficiencies of Sidestream Elevated Poll Aeration (SEPA) Stations". Contract Report 653. Metropolitan Water reclamation District of Greater Chicago. Oct. 1999.

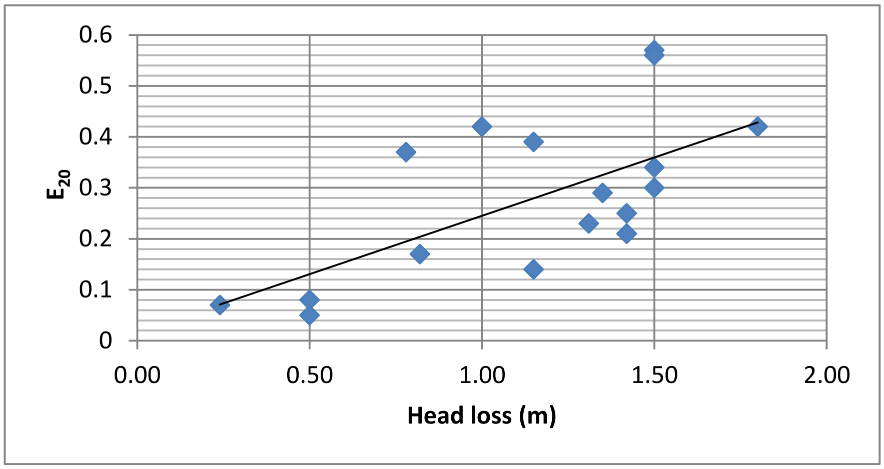

Figure Box 1: Correlation between observed transfer efficiencies and Head of the weirs. Based on analyses of observations available from Wilhelms et.al, 1993 and from Butts et.al. 1999

Source: PPTA.

2. Impact on the Biological/Ecological Environment during Operation

a. Forest and Vegetation

Dhap Reservoir

446. The seasonal filling and release of water will prevent any re-growth of trees in the reservoir area. Provision for compensation in the form of planting 25 trees for each cleared during construction is provided as part of the Project. Besides provision for re-planting, the compensation includes provisions to the SNNP for overseeing and protecting the re-planted areas for a 5 year operation period. The re-planting and protection of the trees planted are foreseen to be carried out by the SNNP under the EMP.

447. Introduction and re-planting of indigenous plants adapted to the environment will be carried out after construction, supporting the natural vegetation population of the borders of the reservoir. Such plants may include already existing semi aquatic plants in the fringes of the Dhap such as *Arisaema* sp., *Ilex* sp., *Impatiens* sp., *Cautleya* sp., *Colacasia* sp., *Caltha palustris.*

Nagmati Reservoir

448. The seasonal filling and release of water will prevent any re-growth of trees in the reservoir area. Provision for compensation in the form of planting 25 trees for each cleared during construction is provided as part of the Project. Besides provision for plant, the compensation includes provisions to the SNNP for overseeing and protecting the re-planted areas for a 5 year operation period.

449. In the relatively steep to very steep slopes around the Bagmati reservoir, only small brims of plants may adapt, and any re-planting is not considered feasible.

Sundarijal to Sinamangal Bridge

450. No negative impacts on aquatic vegetation are foreseen from the river improvement interventions proposed from Sundarijal to Guheshwori.

451. The river improvement interventions from Tilganga to Sinamangal Bridge includes enhancement of the aquatic, semi-aquatic vegetation by introducing species well adapted to the urban river environment, such as *Phragmites karka* (Narkat, the most common plant at the banks of the Bagmati and Bishnumati). *Phragmites karka* is capable of purifying water and at the same time it can spread up to five meters by root suckers under favourable condition thus stabilizing the soil and to withstand high water flow pressure. (favourable for phyto-remediation.

452. Other beautiful plants that thrive well in such habitat include *Hedychium* sp., *Pandanus nepalensis*, *Typha angustifolia*, *Nymphaea esculenta, Nelumbo nucifera, Ipomoea aquatica, Colocasia esculenta* etc.

453. Similarly, Bamboos and Sambucus adnata (kanike phul) can grow well just above the submerged area. Other plants that grow well in the fringes (above the submerged area) are *Prunus cerasoides* (Paiyun), *Riccinus communis* (castor/ander) etc.

b. **Birds**

454. The major impact on birds occur during clearing of the reservoir areas. During operation with the seasonal filling of the reservoirs during the wet season and release of water only limited negative impacts on birds are considered.

Dhap Reservoir

455. The local habitat at the Dhap will change during operation. The increased reservoir which will fragment the habitat for birds like White-breasted Water Hen.

456. However, the extended Dhap reservoir might increase the habitat of certain water birds.

Nagmati Reservoir

457. The Nagmati reservoir will inundate a stretch of 2.8 km of the Nagmati itself and other stretches of smaller tributaries, which will decrease the habitat of birds like Forktails and Dipper which prefer to forage near fast flowing rivers and rivulets.

458. However, the construction of the water reservoir might increase the habitat of certain water birds.

Sundarijal to Sinamangal Bridge

459. No impacts on birds are considered in the area from Sundarijal to Sinamangal Bridge by the project.

c. **Macro-invertebrates**

Dhap Reservoir

460. When extended, the Dhap reservoir will when filled annually, have depths up to 20m. The bottom waters below the thermocline expected to be at a depth of approximately 10m will be anaerobic wherefore no macro-benthos will be expected at the bottom of the reservoir. However, the new reservoir will provide similar living conditions for macro-invertebrates as the present reservoir in a bottom area similar to or larger than the present reservoir.

Nagmati Reservoir

461. A stretch of approximately 2.8 km of the Bagmati River and its tributaries, will when the reservoir is filled annually, be converted from a fast-flowing river to a reservoir with depths up to more than 70m. The bottom waters below the thermocline expected to be at a depth of approximately 10m will be anaerobic therefore no macro-invertebrates will be expected at the bottom of the reservoir.

462. However, there will be a new benthic environment created around the edges of the reservoir where conditions are more favourable for macro-invertebrates[64]. The shore area is suitable for macro-invertebrates with a high food diversity and favourable oxygen conditions.in the water column. Species diversity is expected to be highest at the rim of the reservoir and decrease with depth where there will be less taxa but abundance in species such as oligochaetes that tolerate harsh environmental conditions.

d. **Fish**

Dhap Reservoir

463. The extended Dhap Reservoir is expected to have the same fish fauna as in the present Dhap Reservoir during operation. No negative impacts are considered for fish in the Dhap reservoir or downstream during operation.

Nagmati Reservoir

464. The formation of a lacustrine habitat after the reservoir is created will initiate a period of stabilization of the fish population. Certain species of fish that are well adapted to a lacustrine habitat will flourish while other species that have specialized adaptations for living in fast flowing rivers will either move to other suitable areas upstream or perish. Therefore, the species composition and relative abundance of fish species will change.

465. The reduced water velocity in the reservoir will encourage the deposition of suspended solids especially around the areas of the inflowing water supply. The water will be more transparent, thus encouraging the growth of phytoplankton in the newly developed lacustrine environment. Enhanced primary productivity in the lacustrine environment will lead to increase in selected fish species, particularly planktivorous and herbivorous species. These species will be preyed upon by carnivorous species.

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[64] Pamplin, P.A.Z., Almeida, T.C.M., & Rocha, O. 2006. Composition and distribution of benthic macroinvertebrates in Americana Reservoir (SP, Brazil). Acta Limnol. Bras., 18(2):121-132.

466. Movement of fish from the reservoir to the downstream areas or the other way will in practice be blocked. However, already at present the fish population is very small and diversity very low with only one species recorded during the fish survey. One of the main reasons is due to the low connectivity in the Nagmati due to several natural water falls. Implementation of the Nagmati Dam is not considered to have any significant impact on the fish population in the Nagmati River.

Downstream Area (between the Nagmati Dam/outlet of powerhouse)

467. In the downstream area between the dam and the power house an environmental flow of 100 l/s will be maintained during the dry season. During the annual filling stage, fish in the river between the dam and powerhouse will experience less of the natural flow variability However, as mentioned, the fish numbers and diversity is very low downstream of the proposed Nagmati dam site, and no significant adverse impacts are foreseen on the fish population due to the changes in water flow.

Downstream Area below the Main Powerhouse

468. In the downstream area below the power house, there will also be an increase in water flow during the dry season.

469. During the annual filling stage, fish in the river between the dam and powerhouse will experience less of the natural flow variability.

470. However, the fish numbers and diversity is low downstream of the proposed Nagmati dam site, and no significant adverse impacts are foreseen on the fish population due to the changes in water flow.

3. Impact on Human and Economic Development

a. Tourism in SNNP

471. The extension of the Dhap and the new Nagmati Dam is considered to increase the tourist potential for hotels and restaurants in Chisapani near the Dhap, and in Mulkharka near the Nagmati Dam site. Large wetlands and reservoirs are not found elsewhere in the Kathmandu Valley and is expected attract day and weekend visitors.

472. In order to accommodate the expected increasing number of visitors to the Dhap, viewing sites will be created at the saddle dam with toilet and garbage collection facilities.

4. Way of Life and Equity

473. All strata of the population living in the SNNP and living along the Bagmati River downstream to Sinamangal Bridge will have extensive positive benefits to the River Environment Improvement along the Upper Bagmati by:

(i) Securing an increased flow in the Nagmati River below the weir where water is presently diverted to the Sundarijal WTP

(ii) Increasing the assimilative capacity of the Bagmati River improving the water quality from Sundarijal to Sinamangal Bridge and further downstream.

(iii) Increasing groundwater recharge from Sundarijal to Sinamangal Bridge and further downstream.

(iv) Increasing water levels for cultural and religious use of the Bagmati River at temple ghats during festivals

(v) Improving hygienic quality of the water from Sundarijal to Pashupatinath reducing health risks of general recreational or religious use during festivals.

(vi) Reducing erosion and silt load from the watershed in SNNP

474. The creation of greenbelts and providing river beautification, from Gokarna to Sinamangal Bridge and training and community awareness raising on proper solid waste management will:

(i) Create respect for the river environment by communities to avoid disposal of solid waste and defecation.

(ii) Create amenities and recreational activity possibilities for local communities.

(iii) Prevent encroachment into the riparian land along the river banks.

(iv) Improve land values along the river corridor

Provision of stone walls with forefront river protection will:

(i) Stabilise river banks

(ii) Protect against flooding

(iii) Safeguard green zones against river bank erosion

(iv) Improve aesthetic value by replacing existing, old gabion walls

475. No permanent negative impacts on Life and Equity from the project are identified, except for the risk of dam failure. The dams are designed using the safest technology. In the very unlike event of a dam failure, an Emergency Action Plan will be enacted to protect against any loss of life.

476. Temporary negative impacts during construction will be reduced or fully mitigated through the implementation of the Environmental Management Plan.

a. **Dam Breach / Failure**

477. The most likely form of dam failure (although still unlikely) is one where a specific feature of the structure fails, while the overall integrity of the dam is maintained. Either due to earthquakes, excessive rain above design levels, sabotage, etc. The consequences upon downstream flooding in such instances are generally not severe and are considered to be an aspect of structural design. These include:

(i) Underestimation of Probable Maximum Precipitation and Probable Maximum Design Flood.

(ii) Erosion and leakage through foundations.

(iii) Capacity of spillways.

(iv) Gated spillways, and their appropriate operation and sensitivity to debris blockage.

(v) Damage to spillway.

478. The timing of the flood wave from a dam failure is initially dependent upon the nature and timing of the dam failure mechanism. The propagation speed would be relatively uniform down to Sundarijal, but would slow as it reaches the flatter, wider floodplain areas downstream Sundarijal due to the change in gradient and the storage effects of floodplain inundation.

479. There is a risk that the right river bank at Sundarijal Bazaar may be eroded with a collapse of the bank side on which the Sundarijal Bazaar is situated. By inspection, the river bank is considered stable even during a 1:100 year flood. However, in order to prevent any collapse should a Nagmati Dam failure occur, the river bank will be protected at a 1.2 km long stretch.

480. Inundation of the floodplains may continue for several days following arrival of the flood wave front. At present, where the flood plain is used mainly for growing paddy, the impact will be relatively modest. However, people working or travelling through the flood plain may be in danger. An emergency response organisation will be created based on an emergency response plan. An outline of such a plan, to be developed as part of the detailed design for the dams, is provided in Appendix 10.

481. During construction it will be the responsibility of the owner, to monitor and detect any possible failure and determine the emergency level. Subsequently to provide warnings. During operation it will be the responsibility of the HPCIDBC. The regular staff at the dam site will observe the state of the dam and any water level fluctuations indicating a risk of dam failure from earthquakes. In case of observing any risk indications, they will notify the authorities downstream according to the Emergency Action Plan. For the Dhap Dam, the emergency action plan will primarily target warnings to people at Sundarijal Bazaar, who are down at Bagmati River, where they may be washed away of the relatively small flood wave expected here. The dam constructor/operator will have to warn immediately and directly the VDC Secretary, or his staff in office, the police, the local Nepal Army, and the National Park Office, for these to take the actions necessary, such as evacuating people from the immediate danger zone. It is considered that a siren be installed at Sundarijal Bazaar to warn people.

482. A more comprehensive Emergency Action Plan may be needed for Phase II for the combined Dhap and Nagmati reservoirs.

F. **Cumulative Impacts**

1. **Cumulative Impacts Shivapuri Nagarjun National Park**

483. The protection of the current National Park started from as early as 1976 when His Majesty's Government of Nepal (HMG) realized that further degradation of the Shivapuri watersheds would be detrimental to protection of vital water sources. To overcome these problems, HMG constituted the Shivapuri Watershed Area Development Board and launched various rehabilitative and preventive measures to protect Shivapuri in 1976. In 1982 the "Shivapuri Protected Watershed Area" was declared under the Soil and Watershed Conservation Act, and in 1984 it was declared as the Shivapuri Watershed and Wildlife

Reserve. At the same time the Shivapuri Watershed Area Development Board was converted to Shivapuri Watershed and Wildlife Reserve Development Board, which was abolished from the decision of Council of Ministers of HMG dated 2057/6/13 (September 2000) and later on followed with the declaration of the National Park on 2058/11/6 (18 February 2002).

484. The SNNP helps to protect the variety of flora and fauna, protects endangered species and leads to improvements in the general environment, promoting tourism. However, conservation also leads to conflicts. People living inside the SNNP or in the buffer zone around the Park have problems related to cooperation with the government and the Park authorities, with most problems arising out of :

- Buffer zone management, e.g. wild boars and monkeys destroying crops.
- Inadequate guidance from government and lack of compensation for crops losses
- Least concern from outside except from environmentalists and the students
- No strict plans and policies for those who violate the rule of the wildlife reserve.
- People have few alternatives than to use the forest resources for fuel, fodder etc.

485. On the other hand, the general condition of the SNNP is considered to be improving and conservation objectives are expected to be achieved in the long-term. However, sustainable harvesting practices and regeneration programs take years to materialize with any observable outcomes. At the same time the SNNP staff lacks resources to address the issues, with poor equipment for communication and lack of transport facilities for fulfilling their duties in the SNNP

486. The present Project would potentially contribute to three types of cumulative impacts in relation to the present development in the SNNP: (i) Reduction in forest cover; (ii) Alteration in flora and fauna; and (iii) Alteration in road access.

487. There are no on-going or immediate upcoming projects that are expected to significantly affect forest cover, flora and fauna or the Nagmati/Bagmati River flow in the SNNP, However, there is a proposed project for upgrading the existing (non-formalised) road from Sundarijal via Mulkharka, that passes the Nagmati Dam site, continue further north of the Dhap to Chisapani, see Figure III-6. If upgraded, the road will increase the access to the Nagmati Dam site and the Dhap site.

488. In the following the cumulative impact of the regeneration and improved succession of the SNNP and the Project on the natural resources are assessed, along with the expected impact of road upgrading.

a. Cumulative Impact on Forest Cover in SNNP

489. At present the forest cover is stable in the SNNP, see Table IV-1. In the Nagmati watershed the forest is generally in a secondary stage of succession. Cutting of trees for firewood happens regularly. As a result there are very few large/mature trees. However, the forest cover has improved substantially since the formation of the SNNP and is considered to continue regeneration, overall.

490. While the present project will imply clearance of an estimated 1964 and 25,400 trees at the Dhap and Nagmati Dam sites, respectively, the project provides compensation for replanting of 25 trees for each tree cleared. To be done in the SNNP by the Park authorities, where an estimated 2 ha of free space for replanting is available. The rest of the replanting to be done in

the Kathmandu Valley by Department of Forest. In effect, the forest cover in the SNNP may be reduced by 0.33%; the forest cover in in the buffer zone and around the SNNP in Kathamndu Valley will increase overall.

491. Further, the project will have beneficial impacts on the forest succession by providing logistic support to the SNNP staff related to necessary communication and transport equipment for their improved patrolling and protection of the Park. Overall the cumulative impact on forest cover is considered to be insignificant.

b. **Cumulative Impact on Flora and Fauna in SNNP**

492. The flora and fauna diversity in the SNNP is considered to have improved overall since the formation of the SNNP. The formation of the extended reservoir behind the Dhap Dam in Project Phase I, and the larger reservoir behind the Nagmati Dam during Phase II, will change the environment from open grassland, forest at the Dhap and forest at the Nagmati from a terrestrial to a semi-aquatic system.

493. While the reservoirs will replace certain flora and fauna depending on the existing terrestrial environment, the semi-aquatic environment will establish living conditions for flora and fauna adapted to a semi-aquatic environment. Overall the cumulative impact of the development in flora and fauna diversity in the SNNP and the Project is not considered to result in a loss of bio-diversity.

c. **Cumulative Impact on Road Access**

494. The planned project for upgrading the road from Sundarijal via Mulkharka to Chisapani will have a cumulative impact on the access to the SNNP in general, the Nagmati Dam site specifically and the Dhap Dam in particular in combination with the upgrade of the Ring Road east of the SNNP as access road for the construction of the extended Dam at the Dhap site under the Project.

495. With the improved access to the Dhap site, more visitors can be expected, with an increased need for tourist facilities. The Project includes the provision of walking treks around the extended Dhap, viewpoints and toilet as well as waste handling facilities, as mitigation.

2. **Cumulative Impacts Upper Bagmati**

496. Kathmandu Valley is characterized by high urban population growth and high population density. During the last three decades, the growth in population has been significantly driven by in-migration. The rapid unplanned urbanization of the Kathmandu Valley has brought negative impact to its overall development. Water has become scarce as demand exceeds supply. The lack of operational wastewater system facilities has converted the holy Bagmati River into a highly polluted river. Congested and crowded roads have brought hardship to travellers and road junctions as well as river banks have become solid waste dumping sites. Despite these negative impacts, the urbanization of the valley has still continued at a similar rate to the past 10 years.

497. Urbanisation is expected to continue with an estimated population of 2.72 million in 2011[65] and 3.8 million in 2016[66]. Rapid and largely unplanned urban growth, high population

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[65] Bagmati River Basin Profile. Supporting Investments in Water Security in River Basins. River Basin Profile. ADB TA 7547-REG. JWA May 2012

density, lack of sustainable water resources, and inadequate past investments in water supply, electricity and other infrastructure have resulted in abysmally poor availability and quality of drinking water etc. Moreover, poor access to sanitation facilities, improper solid waste management system, and ground water and surface water pollution from untreated domestic sewage have caused increased disease incidence, health risks, and associated economic burdens disproportionately impacting the poor and vulnerable.

498. The Project will contribute to the following types of cumulative impacts in the Upper Bagmati: (i) Alteration in river water flow; (ii) Alteration in river water quality; (iii) Alteration in the aesthetic value of the riparian river environment. The following developments are impacting cumulative impacts on the river environment, Table V-5:

Table V-5: Developments impacting future cumulative impacts.

Development	Status	Impact on the River Environment	Comments
Melamchi Project	Ongoing	Increase in overall wastewater discharges as water usage increases.	-
Population Growth and Urbanisation.	Ongoing	The urbanisation will increase storm water runoff and wastewater discharges upstream of Guheshwori. Wastewater is expected to be connected to the treatment plants in Gokarna and Guheshwori.	-
Sundarijal Water Treatment Plant	Operational	Because water scarcity within Kathmandu will persist after Melamchi becomes operational the likely scenario is that the WTP will continue operating with current capacity.	-
Irrigation upstream of Gokarna	Decreasing	As urbanisation continues in this area, owing to rising land values and the urbanisation pressure, farmers are reducing their activities and selling their land for urban development. In some cases, the farmers have already stopped farming in expectation of land sales. This reduces the water demand for irrigation. It is expected that in the future scenario, all irrigation is stopped.	-
Upgrade and expansion of Guheshwori WWTP	Expected	The KVWMP will upgrade and expand the Guheshwori WWTP as a high priority.	Modern WWTP with BOD effluent standards with 100% entering the river: 15 mg BOD/l.
Treatment of Gokarna	Expected	As the Gokarna area urbanises, the population will significantly increase. This	Modern WWTP with

[66] Bagmati Action Plan, 2008.

wastewater		is unlikely to support on-site wastewater treatment and therefore four scenarios are possible: (i) on-site treatment; (ii) DEWATS; and, (iii) collection to a local centralised Gokarna WWTP. The scenarios impact the quantity and quality of river flows in Segments II to IV.	BOD effluent standards with 100% entering the river: 15 mg BOD/l.
Wastewater system from Tilganga to be diverted away from project area.	Expected	HPCIDBC is currently constructing interceptors along both sides of the river in Zone IV and ultimately it is planned that they will discharge to a new WWTP at Chovar. In the future this will reduce the flow in this segment but also reduce pollution considerably.	Yes and 50% storm water

Source: Adapted from BREMP, 2012.

a. Cumulative Impacts on Water Quantity

499. The Melamchi project will increase the water supply in the Project area in the Upper Bagmati. However, as the growing number of households in this area is considered to be connected to the Guheshwori WWTP, and the discharge of the treated water are to be diverted from Tilganga and downstream of the Project area below the Sinamangal Bridge. Consequently, no cumulative impact on the river flow with the Melamchi project is foreseen.

500. Increase in urbanisation will increase stormwater run-off. Increased stormwater run-off will have a minor positive, cumulative impact on the river flow, as this will occur during heavy rain, and the present Project is primarily targeting to increase the river flow during dry periods/season. However, increased stormwater run-off has a negative impact reducing groundwater recharge. The Project provides mitigation with incentives for installation of rainwater harvesting and groundwater recharge through soak-away pits for 2500 households.

501. The Sundarijal Water Treatment presently contributes to reducing the low flow in the Bagmati River during the dry season. The continued water scarcity expected over the next many years in the Kathmandu Valley, see Figure VI-3, may trigger attempts to capture the water supplied by the Project during the dry season from the water retention dams in SNNP. Potentially this is a negative cumulative impact. To mitigate the potential cumulative impact Project delivers legal support for the revision of the Water Resources Act (WRA) to fix the current use/abstractions to the current level. In addition to frame a new regulation utilizing the authority to frame rules under the WRA 1992 (Section 24) to secure the legal background for maintaining environmental flows in a stream or a river.

502. Any future reduction in irrigation in the Upper Bagmati will have a positive cumulative impact on the river flow.

b. Cumulative Impact on River Water Quality

503. The Melamchi project will increase the water supply and thereby the waste water load in the Project area in the Upper Bagmati. However, as the growing number of households in this area are considered to be connected to the Guheshwori WWTP, and the discharge of the

treated water are to be diverted from Tilganga and downstream of the Project area below the Sinamangal Bridge, no negative cumulative impact with the Melamchi project is foreseen.

504. Increase in urbanisation will increase stormwater run-off. Increased stormwater run-off will have a negative, cumulative impact on the river water quality, as the stormwater overflow will be polluted. At the same time, the basic river flow will increase during the same event, increasing the dilution capacity of the river. Besides, as this will occur during heavy rain, and the present Project is primarily targeting to increase the river flow during dry periods/season, the cumulative impact is considered to be minor.

505. The upgrading and expansion of the waste water treatment plants at Gokarna and Guheshwori, with the diversion of the outlet from Guheshwori WWTP downstream of the Project area will have a high, positive cumulative impact with the Project.

c. Cumulative Impact on Riparian River Environment

506. Population growth and urbanisation will increase the pressure on the riparian river environment, and if not curtailed, river banks will increasingly be used as a dumping ground for solid waste. The Project mitigates the potential cumulative impact by providing a riparian river environment with green zones, walking and bicycle paths, beautification and amenities in the entire stretch from Gokarna to Sinamangal Bridge. In parallel mobilising and raising awareness of local stakeholders and communities to adopt and protect the improved river environment.

507. However, the present lack of proper solid waste management infrastructure constitutes a substantial risk for a cumulative negative impact on the riparian environment. No other projects or initiatives to provide solid waste management infrastructure has been identified. There is a medium risk of a negative cumulative impact if solid waste management infrastructure is not provided in Kathmandu as a whole. The Project provides mitigation in the most urbanised areas downstream in the project area, by training households in solid waste collection and handling on household basis.

VI. ANALYSIS OF ALTERNATIVES

A. Introduction

508. The “Regional Capacity Development Technical Assistance (R-CDTA) 7547: Supporting Investment in Water Security in River Basins” has prepared a conceptual Bagmati River Environment Management Programme (BREMP) for the upper section of the Bagmati River in Kathmandu Valley. The BREMP identifies key issues affecting the river environment in terms of its flow, water quality, and riparian environment under future scenarios that include the impact of: (i) future population growth and urbanization; (ii) the Melamchi Water Supply Project generating additional waste water; (iii) planned development of wastewater treatment facilities; and (iv) ongoing river training works being carried out by local authorities.

509. With stakeholders, the BREMP proposes a phased set of target objectives along the river which include increasing the flow rate and improving the river‟s water quality to bathing standard at the main temple sites of Gokarna and Pashupatinath which are considered representative and key locations for the river environment. Depending on the level of available investment the phased targets focus on (i) improving the river water‟s clarity, odour, and visual cleanliness; (ii) achieving the flow and quality targets for the dry season as needed for cultural

festivals and for all of the wet season; (iii) achieving the flow and quality targets all year; and (iv) achieving a healthy ecological environmental flow.

B. With and Without Project Scenario

1. With Project Scenario

510. The poor water quality conditions in the Bagmati River and its tributaries, as described in Section b is caused by the discharge of untreated or poorly treated domestic sewage, discharge of untreated industrial wastewater, and dumping of solid waste then undergoing degradation in the river system. Adding to the water quality problems are the diversion of the flow in the Upper Bagmati for water supply to Kathmandu and water use for irrigation, reducing the water flow and thereby the assimilative capacity of the Bagmati River critically during the dry season,

511. In addition sand mining takes place in the Bagmati River and its tributaries in the rural sections upstream of Kathmandu and there is settlement encroachment of the river banks in the densely urbanised sections, downstream. In the Upper Bagmati itself, sand mining is continuing above Gokarna. There are existing regulations preventing sand mining however these are poorly enforced and mining in the other reaches of the Bagmati cause significant degradation of the river channel

512. The results of a 2007 study[67] that used a calibrated Qual2Kw river water quality model of the Bagmati River concluded there were three required measures to achieve acceptable water quality standards: (i) reducing pollutant loads from point sources (wastewater outlets to the river at Jorpati, Pashupatinath and Minbhavan) to a maximum of 30mg/l; (ii) augmenting river flow at Sundarijal by $1m^3/s$; and, (iii) strategic placement of check dams below Pashupatinath to increase aeration of river flow at critical locations.

513. The conceptual Bagmati River Environment Management Programme (BREMP) [68] identified the low dry season river flows and the poor water quality is affecting (i) the utility of the river for cultural, religious and recreational activities; and, (ii) the river‟s natural ecosystem and habitat. Based on stakeholders consultations and problem tree analysis, the BREMP focus on the following improvements:

(i) **Riverbank restoration:** to enhance the river environment by preventing solid, animal and human waste while improving their design and layout. This would be achieved by: (i) restoring the natural environmental amenity of the river; (ii) providing a natural stepped channel profile that conveys each component of the modified hydrological regime (for example: dry season base flow, wet season base flow, regular and extreme floods); (iii) providing terraces for each stage in the hydrological regime to support associated habitats; (iv) providing weirs, pools and ripples to physically support natural ecosystems and aerate the river flow; (v) providing a consistent flood capacity that is known to the neighbouring communities; and, (vi) improve the public amenity of the rivers by providing safe entry and exit to the river, cultural and recreational features.

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[67] Kannel, P.R., et al, 2007, Application of automated Qual2Kw for water quality modelling and management in the Bagmati River Nepal, Ecological Modelling 202.

[68] Regional Capacity Development Technical Assistance (R-CDTA) 7547: Supporting Investment in Water Security in River Basins. 2012.

(ii) **Increasing discharge:** to provide a suitable depth of water to allow bathing at the Gokarna and Pashupatinath Temples. In the dry season this may mean that the water level rises only to people"s knees and water levels can be controlled either by the inflow or downstream weirs. People also expect that the water is moving and therefore do not want to rely solely on downstream weirs. Historically, when the temples were constructed, the minimum monthly average flow would have been about $0.5m^3/s$ which is difficult to achieve now considering the Sundarijal Water Treatment Plant withdrawals and urbanisation of the catchment. Rather, the dry season flow could be augmented to achieve about $0.2m^3/s$ which would still meet the above requirements with some additional channel works at the temples to concentrate the flow in the bathing area and adjust water levels using a downstream weir.

(iii) **Improving water quality:** to provide safe bathing minimum water quality standards for bathing should be targeted. As an interim target the river water should at least be visually clean (clear and free of debris) and not smell.

514. The BREMP envisages these targets to be achieved in a phased approach addressing flow and water quality initially focusing on the social requirements to the use of the Upper Bagmati river and then move towards enhancing the natural habitat as follows:

- **Target I & II:** Improve the river water"s: (i) clarity; (ii) odour; and, (iii) visual cleanliness. (iv) achieve for one month of the dry season during temple festivals (as needed) and all wet season with a minimum flow of $0.2m^3/s$ at Gokarna and Pashupatinath; and, water quality at temple sites exceeding bathing standard.

- **Target III:** achieve all year round: (i) a minimum flow of $0.2m^3/s$ at Gokarna and Pashupatinath; and, (ii) water quality in Segments I to IV exceeding bathing standard.

- **Phased Target IV:** achieve all year round a minimum flow based on the ecological environmental flow requirements of the river.

515. The project adopts the needs for improvement identified under the BREMP and targets the inter-connected issues of dry season flows and the increasingly poor river water quality from upstream Gokarna down to Sinamangal Bridge. Increasing the low flow by increasing the storage capacity upstream at the Dhap by implementing a minor dam and further increase the storage capacity by constructing a medium sized dam in the Nagmati River will have a direct positive impact on cultural and heritage activities at the temple areas, providing more water for religious dipping, bathing in this holy river, especially during festivals.

516. By increasing the dry season low flow the assimilative capacity of the Bagmati River will be increased and thereby improve the water quality of the river, reaching bathing water quality standards at the temple ghats at Gokarna and Pashupatinath.

517. Further, by introducing a number of weirs that will function to not only stabilise the river bed and prevent and erosion, they will help to increase the assimilative capacity of the river through re-aeration. In addition to this, the weirs will at strategic cultural sites help to ensure the desired water level for cultural and religious uses of the Bagmati River.

518. The provision of greenbelts and parks will improve the re-creational use of the Bagmati River corridor and help to secure a cleaner environment.

2. **Without Project Scenario**

519. The first alternative considered has been the “do nothing” option. Examination of this option indicates that continued inaction would lead to further deterioration of the river environment. This in turn would lead to noxious conditions in the river during each dry season with increased risk to public health. For a responsible government, some positive action is clearly required.

520. The next option considered was whether the Upper Bagmati River could be made self-cleaning and sustainable simply by concerted action among the population to minimise the pollutants entering the river which - in theory - should be feasible, requiring no physical intervention.

- In theory, the population could be helped to end all dumping of solid waste in the vicinity of the river. This would however require 100% effective recycling or collection and disposal elsewhere of solid waste.

- In theory, the population could be helped to compost all human and animal waste and to recycle all domestic and commercial/industrial wastewater. This would however require major effort by sanitation and local authorities to make the schemes 100% effective and reliable.

521. Regrettably, it is most unlikely that both of the above could be made to work in the present social and economic climate, although some moves in this direction would be most welcome.

522. The next option considered was to eliminate the most significant source of pollution to the Upper Bagmati River, namely domestic wastewater entering the river from collection and treatment facilities in Gokarna and from smaller untreated facilities elsewhere. In fact, these sources are already being dealt with by:

(i) the parallel ADB-funded Kathmandu Valley Wastewater Management Project[69] which will upgrade and set to efficient working the collection and treatment facilities in Gokarna, and

(ii) The on-going work by HPCIDBC to construct interceptor sewers along each side of the Upper Bagmati to minimise ingress of untreated wastewater.

523. The final requirement is restoration of the base environmental flow in the Upper Bagmati, throughout the year, dilute any remaining pollutants and to achieve the stated target of bathing water quality at the entrance to Pashupatinath Temple Complex.

524. Without the Project the water flow and water levels will remain at the present low level that prevents the recreational, cultural and religious use of the Upper Bagmati River.

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[69] Kathmandu Valley Wastewater Management (Formerly Kathmandu Valley Urban Environment Improvement Project). Proposed Loan. ADB Proj.no. 43524. Loan Fact-Finding Mission. Aide Memoire. December 2012

525. The ADB financed Kathmandu Valley Wastewater Management Project will improve the water quality in the Bagmati River by collection of waste water and expanding the waste water treatment capacity in Gokarna and Guheshwori within the project area of the Upper Bagmati, expected to be completed within a 5-year period. However, if the river flow during the dry season remains at the present level, the targets of reaching a water quality acceptable for the recreational, cultural and religious use of the Upper Bagmati River during the dry season will not be reached.

526. While the water quality will be improved the full benefits of the Kathmandu Valley Wastewater Management Project will not be reached if the River Improvement works under the Present Project are not implemented.

527. The river stretch from Tilganga to Sinamangal Bridge will remain in an entirely un-aesthetic condition preventing any recreational use of the river environment. And the river stretch upstream Guheshwori will remain un-attractive and cannot be used to the benefit of the increasing population in this area.

C. Location Alternatives

1. Alternatives Storage Locations outside SNNP

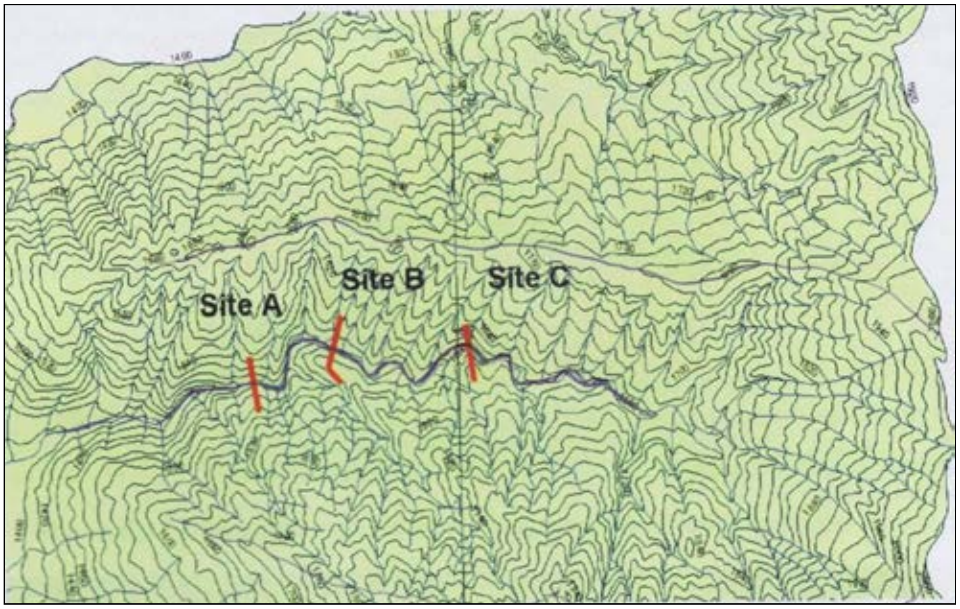
528. The Terms of Reference for the Project PPTA pointed at the possibility of having up to 4 dams in series located at the Mahadev Khola in the Bageshwari Reserved Forest, near Bhaktapur. The heights of the dams could range from 5 to 40 meters and the types of dams to be chosen would dependent on the guidance of the stakeholders and advice of the Dam Specialist. Another alternative dam site outside the SNNP at the Thosne Khola has been identified[70].

a. Alternative Reservoirs Located at Mahadev Khola

529. Review of the technical feasibility of the proposal for a 50 m high dam at Mahadev Khola found no particular problems (Figure VI-1). This aside, the JWA 50 m dam proposal would give a safe yield of only 9.5 MLD from a catchment of 4.3 km^2, and a storage of 2.6 MCM. The estimated cost of the JWA proposal is US$29m (i.e. equivalent to US$3.0 m per MLD) and for a smaller dam US$$20 m (i.e. equivalent to US$2.9 m per MLD).

[70] JWA, 2012

Figure VI-1Alternative Dams sites located in Mahadev Khola.



Source JWA 2012.

530. In relation to the economic justification of the proposed Mahadev Khola dam, a „yardstick cost" is available from the Stage 1 Melamchi Diversion, the cost of which is approximately US$1.2 m per MLD, excluding the water treatment and non-infrastructural components. For comparison, the estimated unit cost per MLD delivered by the Mahadev Khola dam would be nearly three times that of Melamchi. Consequently, reservoirs at Mahadev Khola have been found to be economically non-feasible, compared to the cost of water from inter-basin transfer, as for the Melamchi[71].

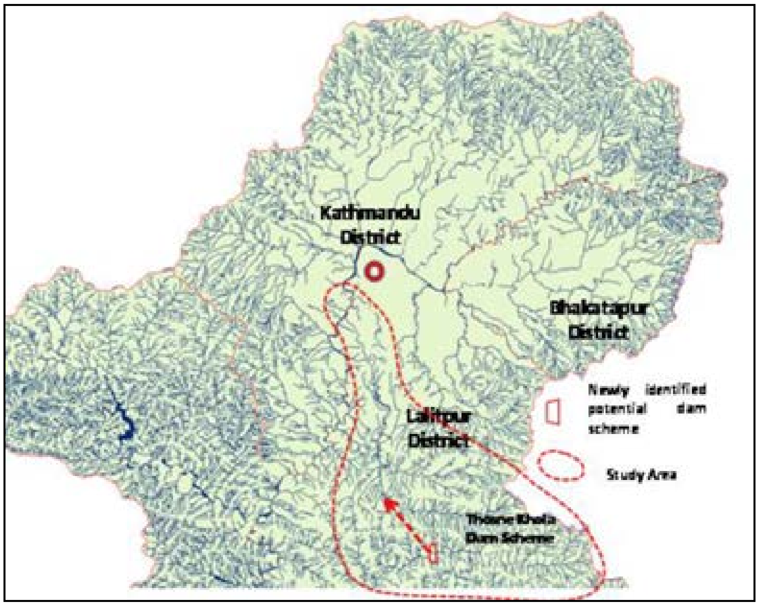
b. **Alternative reservoir located at Thosne Khola.**

531. The Thosne Khola is a river to the south of Kathmandu. It flows west initially and then turns south to join the Bagmati River. The project concept formulated by JWA involved constructing a 120 m high dam on Thosne Khola with stored water fed north by a 3.9 km long tunnel to the Nakhu Khola (refer Figure VI-2).

532. The Nakhu Kola runs in a predominantly northerly direction to reach the Bagmati River at Chobar, 4 km south of central Kathmandu, meaning that water from the Thosne Khola dam could be released into the Nakhu Khola and abstracted to public water supply (i.e. most likely near its confluence with the Bagmati River, albeit needing to be upstream of any significant pollution sources). The manner in which it could substitute for the Nagmati dam is through a „water swap" in which Melamchi water would be taken to boost the dry season flow in the upper Bagmati and „replaced" by an equal amount of water from Thosne Khola joining the water supply system from the south.

[71] BRBIP PPTA Inception Report.

Figure VI-2: The Thosne Khola Project Concept.



Source: PPTA.

533. No re-evaluation has been done of the JWA cost estimate, given that their cost is equivalent to $1.89 m per MLD of yield, or 89% higher than the estimated cost-per-MLD of water from Melamchi (i.e. had the Thosne Khola cost been closer to that of Melamchi, a review would have been justifiable, but in practice the cost margin is so high that Thosne Khola would not be economic even if it were possible to identify substantial cost savings).

2. Location Alternatives to Dam Sites inside SNNP

a. Alternative Location to Dhap Site

534. The Bagmati Action Plan identifies the increase of the recharging capacity of the Dhap in the SNNP by constructing dam/embankments. No other suitable Dhap areas of the required size are available in the SNNP.

b. Alternative Location to Nagmati Dam

535. During the Inception Phase of the BRBIP PPTA considered two locations for larger dams (one each on the Bagmati and Nagmati). However, these were found to be non-feasible for geotechnical and technical, as well as economic reasons[72], see Section a.

3. Alternative Location to River Environment Improvement

536. The Bagmati River has been selected as a priority location for initiating River Environment Improvement interventions under the Project due to its historic and religious importance.

[72] Feasibility Study for Improving the Upper Bagmati River Environment. PPTA. February 2013.

537. Other locations for river environment improvement in the Bagmati River Basin are the tributaries Bishnumati, Hanumante, Dhobi Khola and Manohara.

D. Project Alternatives

1. Alternatives to increase storage capacity to achieve Output 3

538. Using a water balance and quality model to account for future developments, the BREMP identifies the following alternative measures for flow augmentation in the river to improve its assimilative capacity:

(i) Constructing new reservoirs in the Shivapuri Nagarjun National Park.

(ii) Interbasin transfer, using water from the Melamchi tunnel;

(iii) Reducing the withdrawals to the Sundarijal Water Supply Treatment Plant by replacing with other sources such as sustainable, new groundwater sources.

539. Further, during stakeholder"s consultations the alternative of building a series „cascade" of smaller dams instead of the higher Nagmati Dam was suggested. The feasibility of these alternatives is discussed in the following.

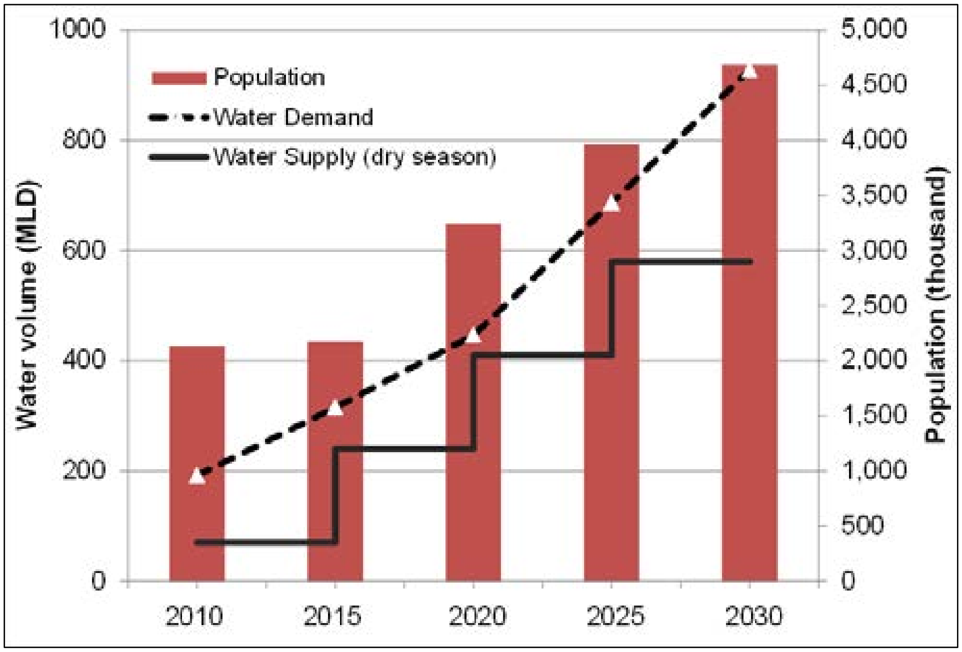
a. Construction of other New Reservoirs in SNNP

540. During the feasibility study, only three dam sites on the Bagmati and Nagmati Rivers were considered to be feasible, namely the Dhap Dam, Nagmati Dam and Bagmati Dam, see Figure III-8. Of these, a 60 m high dam at the Bagmati would provide 2.5 Mm^3 of storage (i.e. about 30% of the storage capacity of 8 Mm^3 needed to meet the downstream flow enhancement target) and its unit cost ($\$/m^3$) would be about twice that for Dhap and Nagmati dams. On this basis a dam at the Bagmati was eliminated from consideration in favour of the Dhap and Nagmati dams.

b. Interbasin Transfer – Using water from the Melamchi Tunnel

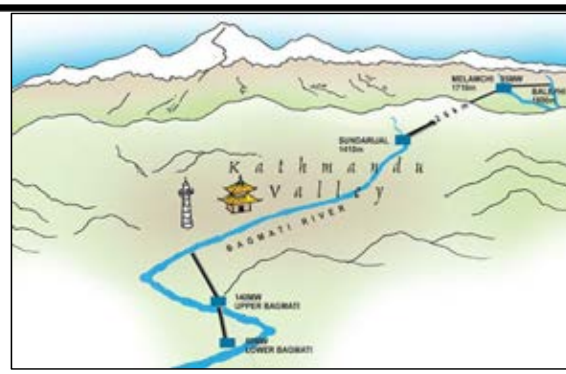
541. Considering the time needed for planning, design and implementation of an interbasin transfer the most favourable would be to use of water from the Melamchi Tunnel, if possible. However, a major issue that have been identified by the BREMP when developing the basin profile with the stakeholders in terms of water resources management in the Upper Watershed is related to the huge gap between the water demand growth and the decreasing water availability in the Kathmandu Valley. This situation is particularly sharp during the dry season. Figure VI-3 below illustrates this issue. It should be noted that the graphic refers only to the KUKL area which covers approximately 70% of the population of the Kathmandu Valley. If considering the entire Kathmandu Valley the gap between water demand and water supply is likely to be even worse.

Figure VI-3 Water Demand & Supply Balance Projection (KUKL service area, Dry Season)[73]



542. Even considering that the 3 phases of Melamchi Project is completed on time, an important gap will remain. Because the water scarcity within the Kathmandu Valley will persist after Melamchi becomes operational the likely scenario is that no water will be made available for augmenting the low flow in the Bagmati River during the dry season. Therefore, the alternative of interbasin transfer was not considered to be feasible in any foreseen future.

The Melamchi Project



The major work under this scheme is the construction of Diversion tunnel approximately 26.3 km long excavated by drill and blast method in order to divert 170 MLD of raw water from Melamchi River to Sundarijal outlet where the raw water is treated before sending it to Bulk Distribution System (BDS).

The water treatment plant will treat raw water coming through 26.5 Km tunnel from Melamchi River for the Melamchi water supply project. As the first phase of WTP project, the detailed design of the WTP capacity will be done for 170 mld with provision of the future expansion. The ultimate capacity of the water treatment plant will be 510 mld. The plant will be developed in three phases, each of 170 Ml/d. The second stage will be accomplished by duplicating the major facilities of the initial phase, and the third phase will comprise mainly performance enhancements and increased design loading on the facilities constructed under phases 1 and 2.

[73] BREMP. River Basin Profile. 2012.

c. **Reducing withdrawal of water for the Sundarijal WTP**

543. Even considering that the 3 phases of Melamchi Project is completed on time, an important gap will remain in the supply of drinking water in the Kathmandu Valley. Because the water scarcity within the Kathmandu Valley will persist even after Melamchi becomes operational the likely scenario is that the Sundarijal Water Treatment Plant will continue operating with its current capacity. Therefore, stopping the water diversion from the Bagmati for drinking water is not considered a feasible option in any foreseen future.

d. **Series of Smaller Dams**

544. In theory, instead of one large dam at Nagmati, a series of smaller-scale dams, forming a cascade, could be constructed on the Bagmati and Nagmati Rivers within the National Park. However, in practice this is not a feasible proposition, for the following reasons:

545. There are relatively few sections of the two rivers where the river valley narrows sufficiently to provide the topography suited dam construction (that is, where the river is wide, damming would require an exorbitantly large dam).

546. With respect to topography, the local geological characteristics determine whether a dam is feasible at a given site (e.g. a dam will not be feasible where the sides of the valley that form the dam abutments are comprised of highly permeable strata, deeply weathered rock, deep soils, etc. – and where the valley slopes in the dam or reservoir area are unstable) – in this context, five prospective damsites were identified on the Bagmati River. However, geological reconnaissance[74] ruled out three of these damsites due to the sorts of geological constraints referred to above.

547. With respect to overall environment issues, a cascade of dams would require more access roads to be built, disturbance in larger areas of the SNNP, effects on the Bagmati and Nagmati at more sites, etc."

e. **Conclusion, alternatives to increase storage capacity in the Upper Bagmati**

548. Having considered any identified options for increasing the storage capacity and increase the water availability in the Upper Bagmati to achieve the water quantity target of 200 l/s and water quality target of bathing water standards at the temple sites at Gokarna and Pashupatinath (BOD< 6mg/l and DO> 3 mg/l, see Appendix 3) set forth in the BREMP, it is concluded there are no feasible alternatives than to establish this storage capacity in the SNNP.

2. **Alternatives to achieve an improved riparian river environment under Output 2.**

549. The BREMP identifies the following structural interventions for improving the river environment and water quality in the Bagmati River:

(i) Low check dams that aerate the flow and provide bio-filtration;

[74] Refer „Engineering Geological Reconnaissance of Damsites", DHI, September 2012.

(ii) Reshaping the riverbed at temple areas to achieve desired water levels and velocities;

(iii) Screening of ashes and debris from cultural ceremonies at Pashupatinath Temple

(iv) Improving the riverbanks and riparian areas including their management.

550. Alternatives identified to the intervention (i) substituting the re-aeration provided by weirs thereby improving the water quality by in-river BOD reduction include:

(i) Increase the river assimilation capacity by increasing the river flow further by installing a storage capacity in the SNNP larger than proposed in Project Sub-components.

(ii) Provide in-river mechanical re-aeration.

(iii) Increase the WWTP capacity to lower the BOD effluent standards.

551. Except for the Dhap and Nagmati Dam sites identified, no other dam sites have been identified that are economically feasible for installing additional storage capacity in the Bagmati River basin in SNNP. In-river mechanical re-aeration is not considered feasible due to costs, un-reliable power supply, and high requirements for maintenance and protection against theft and vandalism. The increase of waste water treatment capacity expected to be carried out under the KVWMP, with effluent standards of 15 mg BOD at Gokarna and Guheshwori WWTPs reflects the lowest, feasible standards, identified under the newly competed KVUEIP PPTA.

552. The alternative identified to intervention (ii) is:

- Increase the river assimilation capacity by increasing the river flow further by installing a storage capacity in the SNNP larger than proposed for the Dhap and Nagmati sites.

553. No dam sites have been identified that are economically feasible for installing additional storage capacity in the SNNP. As mentioned in section 6.4.11, the dam site at the Bagmati River in SNNP was not considered feasible.

554. In consultations with the Pashupati Trust intervention (iii) is considered not feasible for religious concerns.

555. No alternative use of the riparian riverbanks than for green zoning, foot and cycle paths and amenities (iv) has been identified.

a. Conclusion, alternatives to increase storage capacity in the Upper Bagmati

556. Having considered many options for improving the riparian environment along the Upper Bagmati alternatives (i), (ii) and (IV) are considered to be the most feasible to achieve an improved riparian river environment along the Upper Bagmati.

VII. INFORMATION DISCLOSURE, CONSULTATION AND PARTICIPATION

A. Pre-EIA Public Consultations

557. As part of the EIA, stakeholder and community consultations were carried out during field visits. The consultations included discussions with stakeholders and village level authorities. The details of such consultations carried out during field visits are presented in Table VII-1.

558. Field visits were jointly undertaken with a Range Officer from the Shivapuri Nagarjun National Park to identify the extent of physical activities and likely impacts to forest/vegetation, if any.

559. Also, a number of officials from various agencies, i.e., the Ministry of Forests and Soil Conservation, Department of National Parks and Wildlife Conservation, Ministry of Environment, Science and Technology, Village Development Committee members etc., have been consulted.

Table VII-1: List of Stakeholders / Communities Consulted

Name and Designation	Organization and Date	Issues Discussed	Comments on the issue
Mr.Gopal Prakash Shivakoti, Chief Warden SNNP	Shivapuri and Nagarjun National Park (SNNP), August 09, 2012.	• Survey permission and procedure essential to carry out activities in the park • Secondary Information regarding the park is e.g. included in their Draft Management Plan from 2004.	• As per the Rules, necessary actions are included in EMP • The information collected are included in EIA reports
Mr.Gopal Prakash Shivakoti, Chief Warden (CW) SNNP Laxman Paudyal, Ass. Conservation Offficer Major Bhesh Raj Ichttri	Shivapuri and Nagarjun National Park (SNNP), May 13, 2013.	• Ring Road the preferred access road to the Dhap • Paths, view points and toilets at Dhap	• The CW confirmed that the Ring Road is the preferred access road by the SNNP. Upgrade at least with gravel surface and proper drainage. Further improvements welcome if budget allows. • The CW expressed that the SNNP would like a walk route established all way round the extended Dhap, with certain viewpoints, and toilet facilities at the road north

		• Quarry/borrow for fill material for the Dam and Saddle Dam at the Dhap • Operation of crushing plant at the Dhap • Workers camp • Re-planting as compensation for trees cleared	of the Dhap. • The CW confirmed it is acceptable to quarry/excavate material within the footprint of the Dhap. • The CW confirmed it is acceptable to operate a crushing plant next to the quarry in the footprint of the reservoir • The CW confirmed it is acceptable to have the workers camp in the open grassland area around the Dhap. • The CW informed the existing rules of re-planting of 25 trees as compensation for any tree of more than 10 cm diameter is generally followed. Final decision on compensation, and who will be responsible for clearing and compensation re-planting will be taken by GoN in their approval of the EIA. Re-planting will be within Kathmandu Valley to the extent free areas are not available in the SNNP. Only native species must be used. Preferred flowering and fruit-bearing trees to support bio-diversity. •
Mr. Ram Chandra Khatiwada, Asst. Conservation Officer Mr.Nawa Raj Baral, Engineer	Shivapuri and Nagarjun National Park (SNNP), September 13, 2012	• Is the Dams construction activity a national priority project? • Chances of habitat fragmentation • Procedure to be followed while clearing trees in	• When ADB financing is approved by GoN the project is considered a national priority • Environmental issues are covered inthe EMP, including habitat fragmentation and clearing of trees with compensating replanting

		the park • Compensatory plantation at the ratio of 1:25 is needed as per GoN rules • Large scale infrastructure is not a priority of the National Park • Mitigation measures may take a big share of the project • Payment of Environmental Services (PES) could be considered in estimation of benefits of services provided by SNNP • Department of Roads have planned to improve the road passing through the Park from Mulkharka to Chisapani.	• Mitigation measures including replanting are included in the EMP for the project • Prioritisation of improved water rentention capacity in SNNP has been confirmed with Chief Warden • The issues of PES is not directly relevant to BRBIP • The access road to the Dhap Dam will be via the existing road east of SNNP. • Access road to the Nagmati Dam site will be via the ring road and not the road that DOS plans to improve .
Ms. Madhu Devi Ghimire, Head	EIA Section, Ministry of Forest and Soil Conservation, Sept 14, 2012	• Mandatory Provision of getting approval from MOFSC for EIA study for any intervention in the Park • Govt. of Nepal (Minister or Cabinet level) approval essential for cutting the trees in the park • In the past, the Govt. has permitted to cut the trees in the park for national	• Request for EIA study as per the Government rules has been sent to MOFSC • When ADB financing is approved by GoN the project is considered a national priority

		priority projects only after EIA approval • Is the Dam construction activity a national priority project?	
Mr. Shiva Lal Gaire, Ranger	Shivapuri Nagarjun National Park, September 15, 2012	• Possibilities of lowering the rig in the river without cutting the trees • Possibilities of carrying out the topographic survey without cutting the trees.	• The issues were addressed in EMP of for the drilling surveys, and no trees were cut.
Mr.Nima Sherpa, Ex. Chairperson	Sundarijal VDC, September 15, 2012	• Employment of the locals during survey, construction and operation of the dams • Upgrading of the existing road for the purpose of serving the project as an access road • Benefits to the local communities as of the construction of the project	• The issues raised are covered in EIA study and in the EMP • Access road (Ring Road) will be upgraded as part of the project • Contractors will be encouraged to employ local labour.
About 60 participants	Mulkharka Village, Sundarijal VDC, Sept 22, 2012	• Resettlement of the Households currently living inside the Park • Employment to the locals if Govt. decides to not relocate them • Contamination of drinking water supplied to Kathmandu due to the settlements in the park • Open defecation in the Park	• The households which are inside the Park are not impacted by the project and therefore any resettlement is beyond the scope of the project. • Contractors will be encouraged to employ local labour. • The Project includes a comprehensive watershed improvement sub-component addressing income generation for settlements

		• Household wastewater treatment of the communities in the park • Employment to the locals during project construction and operation • Consideration of alternatives (several low height dams vs. a single tall dam) • Disclosure of risk mitigation plan in case of dam failure • Rehabilitation and upgrading of the local road • Technical team must discuss the alternatives and technical details with the public prior finalising the design • On what basis the projects components particularly in the Sundarijal-Tilganga stretch were selected? • Payment of environmental Services • Misleading information in the media regarding the project • Little or no communication to the public regarding the preparation of the project	• The Project will provide improved water treatment and sanitation facilities • Alternatives to high dam considered in FS. • A dam-break emergency action plan in considered. • Access roads will be rehabilitated and road shifted when inundated. • Alternatives have been discussed at workshops. Components selection discussed with stakeholders and Technical details with HPCIDBC. • The issue of PES is not directly related to BRBIP. . However, Willingness to Pay for a Clean River Environment by the urban population has been considered. • During preparation the contents of the Project has been communicated via the news media. • Public consultations have been held. Present meeting early in the Project preparation an example the project has a communications strategy and .

Source: PPTA.

1. **Pre-EIA Information Disclosure**

560. The findings of the Draft EIA report were presented to Government Agencies, local NGOs, local representatives and other stakeholders at a workshop on the 23rd of April 2012. The Project was presented along with the impacts identified and the proposed measures to mitigate or reduce any adverse impacts, and where this is not possible, provide compensation.

561. The comments and suggestions received during the EIA workshop were recorded, and responses given, see Table VII-2.

Table VII-2: Records of EIA Workshop, April 23rd, 2013.

Name and Designation	**Organization and Date**	**Issues Discussed**	**Comments on the issue**
About 30 participants (See list of participants in Annex	Indreni Hotel, Kathmandu, April 23, 2013	• Strengthening of park management required to handle anthropogenic pressure from the Dhap dam • Quarry site for the dam to be identified and approved by concerned ministry where required • Needs clarification on compensation mechanism of trees cut for the project (for e.g. alternative location of tree plantation if there is no plantation space in SNNP) • The minimum, moderate and maximum flow for Bagmati needs to be specified • Ensure that national and international rules and regulations are strictly followed to minimize any damage to biodiversity • Discarding ritual materials into the river from temple	• Based on consultation with Chief Warden about possible initiatives to be supported by BRBIP project initiatives have been included • Necessary permission will be acquired from concerned ministry for using quarry sites • The compensation planting as clarified with MOFSC will be done in consultation with SNNP and the Department. • BRBIP project has done water quality modelling to determine desired flow • The EIA presents a review all national and international regulations • Solid waste management along river banks/greenbelt parks shall be carried out by

		areas a key source of water pollution • Municipality has to be consulted to implement solid waste management component along river banks • The financial information about the project needs to be disclosed to public to ensure transparency	involving local communities. However, the BRBIP will only carry out any activities at temple sites with temple authority consent. • Concerned agencies are consulted for greenbelt park and solid waste management sub-component • Transparency is insured as per the rules and regulations of GON and ADB.

Source: PPTA

562. The EIA findings will be disclosed at ADB‟s website for the BRBIP, and key information will be provided in the local language at strategic locations including the SNNP office. In addition parallel procedures to obtain GON‟s approval under the local laws have been initiated.

B. Future Consultation and Disclosure

563. The consultation and disclosure process will expand significantly during implementation of BRBIP following the Communication Strategy and Plan[75]. An experienced NGO will be engaged to support the Project Coordination and Management Unit in handling this key aspect of the programme. A wide range of activities will be conducted in all areas covered by the project, to ensure that the needs and concerns of stakeholders are registered, and are addressed in the project design, construction or operation where appropriate. The consultation activities will start in 2nd quarter of 2014 an estimated 3 months before the start of detailed designs. The detailed program of activities will be developed during the detailed design stage, and will include the following:

1. Consultation during detailed design:

564. Focus-group discussions with affected persons and other stakeholders (including women‟s groups, NGOs and CBOs) to hear their views and concerns, so that these can be addressed in subproject design where necessary will continue to be held during the detailed design to be conducted by the design and supervision consultants;

565. Structured consultation meetings with the institutional stakeholders (government bodies and NGOs) to discuss and approve key aspects of the project.

[75] Communication Strategy and Plan. Linked document to the Draft Final Report. PPTA Consultants 2013.

2. Consultation during construction:

566. Public meetings with affected communities to discuss and plan work programmes and allow issues to be raised and addressed once construction has started;

567. Smaller-scale meetings to discuss and plan construction work with individual communities to reduce disturbance and other impacts. Besides, as the Project progresses, the smaller-scale meetings will provide a forum for stakeholder‟s participation in subproject monitoring and evaluation.

3. Project disclosure:

568. During project implementation public information campaigns will be carried out (via newspapers, posters, etc.) to explain the project to the population in the project area and prepare them for disruption they may experience once the construction programme is underway;

569. During project implementation public disclosure meetings will be arranged at key project stages to inform the public of progress and future plans, and to provide copies of summary documents in Nepalese and English;

570. Formal disclosure of summaries of EIA findings and EMP reports by making copies available at the HPCIDBC office, and SNNP office informing the public of their availability, and providing a mechanism through which comments can be made.

571. It is proposed to provide 3-4 pages hand-outs in local language at public accessible places like VDC, SNNP and municipality offices.

VIII. GRIEVANCE REDRESS MECHANISM

572. The process for resolving complaints that may arise in the project will be handled by a grievance redress mechanism (GRM) to be established by the Safeguard and Monitoring & Evaluation Unit under the Project Coordination and Management Unit (PCMU) (see Figure IX-1) within 12 months from start of the project and before construction works begin. While the Project does not entail any land acquisition except for a smaller plot of land for the powerhouse at Sundarijal and there are no resettlement issues, the types of grievances expected to be handled are generally construction-related grievances brought up during construction by households who lives relatively close to construction sites.

573. Any household/local stakeholder, feeling that adverse and material harm is caused by the Project, may contact village community development leaders from the VDC or Municipalities, that would then forward the complaint to the Unit Leader of the Safeguard and Monitoring & Evaluation Unit in the PCMU hosted in HPCIDBC (see Figure IX-1), or the stakeholder may contact the worksite directly or the Safeguard and M&E Unit in the PCMU in HPCIDBC or SNNP staff, directly. The VDCs and SNNP staff are ready to receive a complaint and forward.

574. Local households and stakeholders will be informed about the setting up of the Grievance mechanism by the PCMU before start of any construction as part of the community mobilisation process under the Communication Strategy Plan implementation. Besides, at the construction sites and at the Chief Warden and the PCMU offices boards will be set up will give

the contact details of persons to be contacted in case of any grievances. The information will be specific related to the construction works and provided in local language describing the Project, the grievance mechanism and where and to whom stakeholders can deliver their complaints, and in what form, verbal or written.

575. When obtaining the information from the complainant, either in verbal or written form, directly or from the VDC and Community offices, Chief Warden"s office or the work sites the Safeguard and M&E Unit within the PCMU will complete a Grievance Action Form (GAF) to record all grievances and actions taken in a Grievance log. At a minimum, the information to be recorded in this form will include (i) basic information about the affected person (name, address, contact number); (ii) category of grievance filed (legal, social, environmental, technical/engineering, financial, etc.); (iii) detailed description of grievance; and (iv) type of action taken. The GAF will be filled out by the person receiving a grievance and signed by the affected party and the receiver of the complaint. The affected party will receive a copy signed by both.

576. Grievances received and related to works on the dam will be handled by the Safeguard and M&E Unit in collaboration with the DOI PIU and the dam contractor. Grievances received and related to riparian river works will be handled by the Safeguard and M&E Unit in collaboration with the River Works Planning Unit and the river works contractor. In each case the Safeguard and M&E Unit will be supported by the PM&SC and in cooperation with the respective IA and contractor clarify if the complaint is caused by the construction works,. The PCMU will inform and update the complainant about the progress of grievance mitigation within 24 hours for urgent issues and 7 days for non-urgent issues.

577. Once verified that the problem/complaint is well founded and due to the construction works, the IA will together with the Safeguard and M&E Unit, the PMSC and the Contractor take the necessary corrective actions and try to resolve the grievance informally, directly with the complainant. If not possible or at the choice of the complainant, a formal redress can be forwarded to the Grievance Redress Committee (GRC).

578. The GRC will be formed to review complaints that cannot be resolved immediately. The members of the committee would be the Project Director of the PCMU as chair, the Unit Leader from the Safeguard and M&E Unit, members of local stakeholders or VDC involved, community members, NGOs etc. The GRC has the right to request the leaders of the River Works Planning Unit and the Dam Design and Supervision unit, other project technical staff, and officers from relevant governmental or non-governmental institutions to attend the meetings and provide information. A complainant has the right to appear in person, to be accompanied by a family member, and/or to request to be represented b senior village/community member.

579. In the event that a grievance is not addressed by the contractor, PCMU, IA or AE, the affected person can seek legal redress of the grievance in the appropriate courts under the formal legal court system.

580. Depending on the complaints and the mitigation measures decided and implemented, if necessary, the EMP will be updated in order to avoid similar problems, afterwards.

581. The PCMU Safeguard and M&E unit will provide monthly reports of any complaint registered, and how it has been dealt with to the SNNP Authorities, the IAs and the EA, to the GRC. The PCMU Safeguard and M&E unit will regularly provide information to the local stakeholders and communities of any grievances received and how they have been resolved,

through the community mobilisation process under the Communication Strategy Plan implementation. Progress reports and environmental monitoring reports to be submitted to ADB will include details of grievances received during the reporting period and how they were dealt with.

IX. ENVIRONMENTAL MANAGEMENT PLAN

582. The Environmental Management Plan (EMP) outlines the environmental management system that will be implemented during the detailed design and construction works of the project to manage minimisation of deleterious effects and implementation of enhancement measures. The primary focus of the EMP is mitigation of environmental impacts occurring in the natural and social environment. The EMP consists of the following parts: (i) implementation arrangements, (ii) roles and responsibilities for environmental management, (iii) acquisition of prior clearances and no-objection certificates, (iv) general guidelines, (v) a listing of environmental impacts and mitigation measures; (vi) the environmental monitoring and reporting program for construction and operation periods; (vii) recording, auditing and corrective actions; and (viii) the environmental management budget and resources.

583. The EMP is based on the anticipated environmental impacts and mitigation measures identified and described in chapter V, but it would be developed and updated when the detailed design is completed.

584. The objective of the EMP is to provide a framework for the monitoring and management. The EMP monitors and manages environmental aspects and issues of the Project during detailed design, implementation of the works and Operation and Management (O&M) by following:

- Provision of an organisational IWRM framework that assigns roles and responsibilities for environmental monitoring and management;
- Identification of potential environmental impacts;
- Recommendation of mitigation measures for the negative impacts;
- Identification of opportunities for enhancement measures;

A. Implementation Arrangements

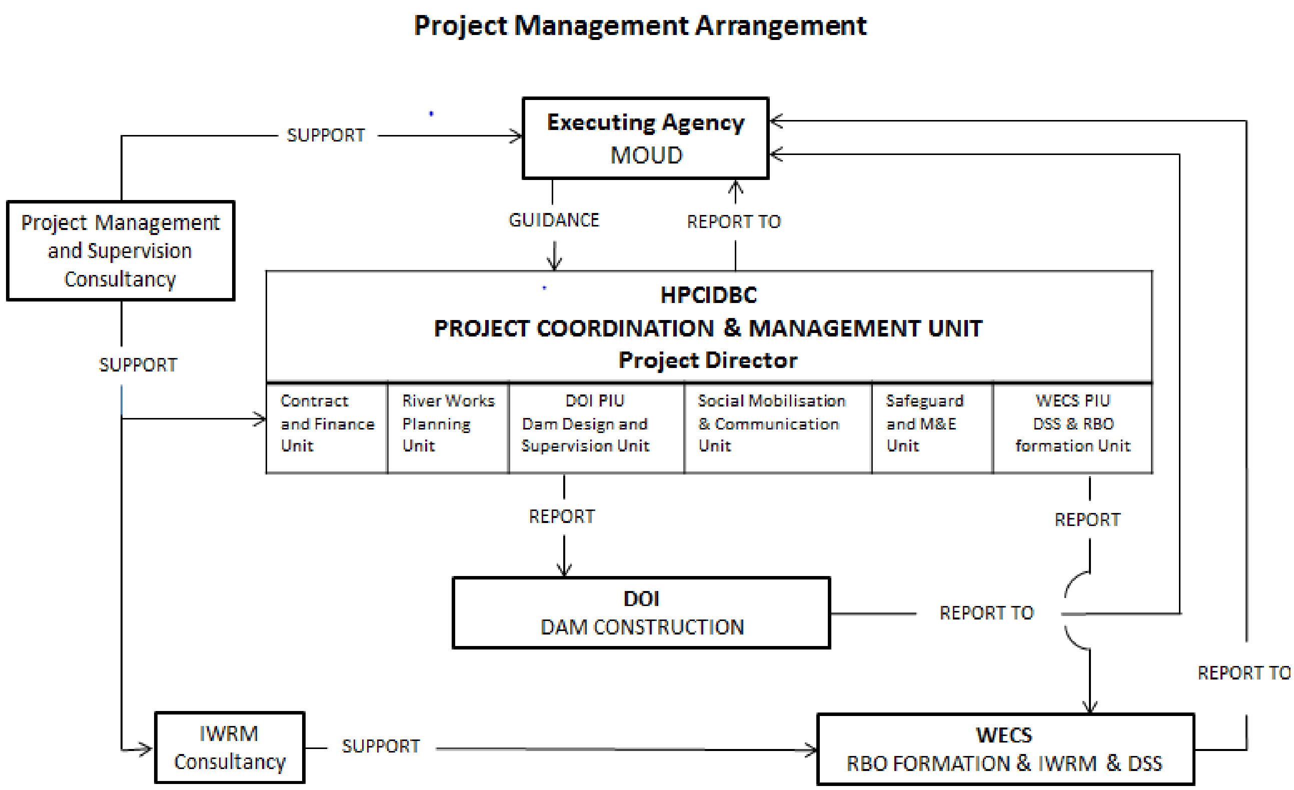
585. The environmental management framework during construction is based on and integral with the overall project management framework for the Project, see Figure IX-1. The Project will be implemented by the Ministry of Urban Development as Executing Agency. Department of Irrigation (DOI) is the Implementing Agency for the Dams in the SNNP, while HPCIDBC is IA for the Upper Bagmati River works. Upon completion of the dams, DOI will hand these over to HPCIDBC for operation, management and maintenance. Besides, HPCIDBC will be responsible for the management and maintenance of the Upper Bagmati River Improvement works. Overall management will be under a Project Coordination and Management Unit (PCMU) which will be established in HPCIDBC under a project Director who will be a seconded Government staff, see Figure IX-2.

586. A Project Management and Supervision Consultancy (PMSC) will support the Project Director and the PCMU and provide training to the Government staff in the PCMU. Construction activities will be overlooked by the PCMU supported by the PMSC. The PMSC will engage an

environment specialist to support the PCMU environmentalist in the implementation of the EMP. The PMSC environmentalist will provide training in environmental monitoring, evaluation and assessment to the PCMU staff. This will consist of on-the-job-training to the Safeguard and M&E Unit staff. Specific and technical short term courses will be given to PCMU staff, other relevant staff in HPCIDBC and DOI in: (i) EIA and IEE including GoN rules and regulations and ADB Guidelines; (ii) Development and implementation of Environmental Monitoring Programmes; (iii) Analyses of monitoring results and assessment of impacts; and (iv) Evaluation and Reporting of Environment Monitoring results and Impacts. Besides, the PMSC environmentalists will give short lectures in EIA and IEE, monitoring, evaluation and reporting to senior level staff, to make them familiar with the EIA and IEE requirements and their importance. In addition an independent environmental consultant will be appointed to monitor environmental compliance by both consultants and contractors.

587. Under Phase 1 – the Dhap Dam will be built under a design and build contract. The environment specialist of the PCMU will update the EMP based on updated detailed designs and ensure that it will be adhered to during construction. The implementation of the EMP will be the responsibility of the Design and Build contractors supervised and overseen by the PCMU. DOI will place a Project Implementation Unit with their own staff, in the PCMU to supervise the implementation of the construction of the Dhap Dam.

Figure IX-1: Project Management Organisation.



Source: PPTA.

Figure IX-2: Project Coordination and Management Unit staffing. Staffing of the Dam Design & Supervision Unit is from DOI.

STAFFING
PROJECT COORDINATION and MANAGEMENT UNIT
Project Director

Contract and Finance Unit	River Works Planning Unit	Dam Design & Supervision Unit	Social Mobilisation & Communication Unit	Safeguard and M&E Unit	DSS & RBO formation Unit
1: Senior Accountant 1: Procurement & contracting specialist 2: Accountant	1: Senior Engineer (Unit Chief) 2: Design engineer 2: River engineer	1: Senior Engineer (Unit Chief) 1: Dam Construction Supervision Eng. (Dhap Dam) 2: Supervision River Eng. (Upper Bagmati)	1: Senior Sociologist (Unit Chief) 1: Sociologist 1: Gender specialist 1: Communication specialist	1: Senior Safeguard Specialist (Unit Chief) 1: Environmentalist 1: Socio-economist 1: M & E Specialist 1: Gender Specialist	1. Senior Engineer (Unit Chief) 1: Hydrologist 1: Water quality specialist 1: Database specialist

588. The Design & Build Contractors will be responsible for implementing mitigation requirements in the construction specifications. The roles and responsibilities for environmental management of the Project are listed in Table IX-1.

Table IX-1: Environmental Management Responsibilities

Organizations	Responsibilities	Schedule
Executing Agency (Ministry of Urban Development)	-Review of the project design, construction and operation activities against approved EIA and EMP measures and national environmental standards	At least once a year during construction
	-Auditing of project general performance during operation phases	Every two years in the operation phase.
Ministry of Science, technology and Environment	-Approving EIA and EMP measures, following national environmental standards and license conditions.	Aproval will be a one time event and they may monitor at least twice a year during construction and once during operation
Svivapuri Nagarjun National Park authorities	-Approval of permits for pre-construction activities and permit for staff to enter the SNNP -Approval of permits for construction activities and works in the SNNP	
Implementing Agencies: (Department of Irrigation for the dam design and construction, High Powered Commission for Integrated Development for Bagmati Civilization for the Upper	-Ensure that the EIA and EMP measures are incorporated in the final project design.	Prior to contract award.
	-Assist contractors to acquire necessary permits and approval for project construction and operation.	Before construction.
	-Ensure that the Project construction activities are in accordance with the EMP and other GON legislative requirements and submit bi-annual monitoring reports.	During construction.
	-Implementation of repair and maintenance of project components including environmental safeguards	During Operation.

Organizations	Responsibilities	Schedule
Bagmati river works and operation and maintenance of the dams.	-Monitoring and record keeping and report regarding environmental measures and impacts	During operation
	-Ensure public consultation, participation and involvement in all phase of project implementation	Project period
Ministry of Forestry and Soil Conservation	-Provide permits for admission and the construction works, including operation of quarry/borrow sites and watershed activities in the SNNP	Prior to, and during construction
Project Coordination and Management Unit (PCMU) with assistance of the Project Management and Supervision Consultant (PMSC)	-Oversee environmental mitigation measures as per EIA and EMP are incorporated into the final design. Update the EMP as required during detailed design.	During final design
	-Supervision and impact and compliance monitoring of the construction contractor‟s activities and environmental mitigation measures as per EMP and provisions of inspection reports. Determine corrective measures is new impacts not identified in the EMP are encountered during construction.	As per EMP
	Conduct environmental monitoring and prepare bi-annual monitoring reports for submission to ADB and MOSTE.	As per EMP
	-Assist IA in the implementation and supervision of environmental enhancement programs and their monitoring and auditing.	As per EMP
	-Ensure public participation and involvement in project construction	Construction period
	-Ensure construction contractors follow worker‟s safety rules and regulations	Construction period
Design & Build Contractor (D&BC)	-Acquire necessary permits and approval for project construction, entrance to SNNP, and operation.	Before construction.
	-Prepare a detailed Construction EMP (CEMP) before construction and get it approved by PCMU. -Implement mitigation measures as specified in the CEMP/EMP updated by the PCMU as necessary during detailed design. Provide necessary plans such as erosion control plans, health and safety plans and obtain approval from the EA and IA.	As per EMP
	-Monitoring and record keeping of environmental mitigation measures	As per EMP
	-Implementation of the corrective actions as recommended by the supervising	As per EMP

Organizations	Responsibilities	Schedule
	consultants	
	-Ensure public participation and involvement in project construction	Construction phase
Independent Environment Monitoring Consultant	- Review safeguards documents including EIA and EMP and request changes if and when required	Project Period
	- Oversee and periodically monitor Contractor‟s implementation of the EMP and review control procedures carried out by PCMU and PIUs.	Project Period
	-Review environmental impacts of project interventions and monitor progress with regard to environmental targets and indicators	Project Period
	Review reports and report to EA through the PCMU/Project Director on EMP efficiency, contractors performance and identify corrections needed	Project Period
NGOs, CBOs, VDCs, and DDCs	-Monitor that the environmental mitigation measures and enhancement measures are implemented in all stages of the project as per EMP	Project Period

Source: PPTA.

589. The primary responsibility for environmental management lies with the PCMU. However, all responsible parties involved have their important role for the effective implementation of the EMP in order to minimise any environmental impact and maximise enhancements. Mitigation measures that are the responsibility of the Design & Build contractors will have to be included in the construction tender documents. The EMP will be updated to reflect any changes to Project design that may occur during implementation.

B. Acquisition of Permits and Clearances

590. Table IX-2 summarizes the status of clearances and no-objection certificates that are already obtained or are likely necessary for implementation of the construction works.

Table IX-2: Status of Permits and Clearances

Agency or Group	**Purpose and Status**	**Responsible Party**	**Timeframe**
Government of Nepal	Construction of the dams in SNNP has to be accepted as National Priority Projects.	GoN/ADB	Signing of loan agreement
Ministry of Forestry and Soil Conservation (MoFSC)	Approval of application for initiating an EIA. Status: Application Letter sent by MOUD to MoFSC. Issue permission letter to Department of National Parks and	EA MoFSC/IA	Prior to forward Scoping Report to MOSTE.

	Wildlife Conservation for initiating construction works upon approval of EIA. To be issued		
Ministry of Science, Technology and Environment (MOSTE)	1. Approval of Scoping Report including ToR for EIA. To be obtained. 2. Approval of EIA. To be obtained.	MOSTE/IA MOSTE/IA	1.Prior to GoN EIA Process 2. Prior to construction
Department of National Parks and Wildlife Conservation (DNPWC)	Issue permission letter to SNNP for initiating construction works upon approval of EIA. To be issued.	DNPWC/IA	
Shivapuri Nagarjun National Park (SNNP) authorities	1. Permits for any pre-construction survey, design and construction staff to enter SNNP. Status: To be obtained. 2. Permits for any construction, including establishing workers camp, operation of borrows and/or quarries within SNNP. Status: To be obtained.	Contractor/IA Contractor/IA	Prior to any pre-construction activities. Prior to construction
Nepal Electricity Authority	Permission to implement Hydropower and connect to national grid. Status: To be obtained. If Phase II of Project proceeds.	IA/EA	Prior to construction
Department of Culture	Clearance for works close to and at cultural and religious sites Status: To be obtained.	IA/EA	Prior to construction
Private property and Land owners	Acquisition of land for power house. Status: To be obtained	IA/EA	Prior to construction
Department of Irrigation	Obtain clearance for upgrade of regulators. To be obtained.	IA/EA	Prior to construction

EA: Executing Agency, IA: implementing Agency.
Source: PPTA.

591. Table IX-3 and Table IX-4 summarize the environmental impacts and proposed mitigation measures, along with their locations, that were identified in Chapter V. The tables also prescribe the responsibilities for: The PCMU, with the support of the PMSC, the Project Implementation Unit (PIU), DOI within the PCMU for the Dhap Dam (Phase I) and the Nagmati Dam (Phase II), HPCIDBC for Upper Bagmati River Improvement works, the Design & Build Contractors (D&BC), and the SNNP. Responsibilities for a particular mitigation may be shared among these units.

C. General Environmental Guidelines during Detailed Design and Planning

592. Referencing to the potential negative impacts of the project as described in chapter V, the identified compensation, mitigation and enhancement measures during design are explained in the following.

1. Compensation

a. Acquisition of Land

593. Under Phase II of the project- for which funding has not yet been ear marked, a relatively small plot of land will be required for the power house at the left bank of the Nagmati River at Sundarijal. The executing agency for the project will determine the registered land ownership and value of the land to be affected as part of the pre-construction phase, if no suitable government land is available. Values will be based on land capability for agriculture, location, recent land transactions and other parameters normally used for calculating land values. Any land acquisition and compensation determination will be based in the resettlement framework prepared for the project.

b. Re-planting of trees

594. The seasonal filling and release of water will prevent any re-growth of trees in the reservoir areas. Provision for compensation in the form of planting 25 trees for each cleared during construction is provided as part of the Project. Besides provision for re-planting, the compensation includes provisions to the SNNP authorities for overseeing and protecting the re-planted areas within the SNNP and provision to Department of Forest for any replanting outside the SNNP in Kathmandu Valley for a 5 year operation period. The re-planting and protection of the trees planted are foreseen to be carried out by the SNNP authorities as well as by Department of Forest outside the SNNP under the EMP, with payment for the compensation services by contractors under the Design & Build contract for the Dhap Dam, and for a coming Build contract for the Nagmati Dam.

c. Resettlement

595. No resettlement is foreseen under the project. In the un-likely event resettlement would be needed, any compensation should be done according to the Resettlement Framework prepared by the project.

2. Mitigation

a. Local employment

596. The contractor shall, to the maximum possible extent, employ local labour for the works;

597. No children under the age of 14 should be employed and children between 14 and 18 should not be engaged in hazardous works, in compliance with the labour rules of Nepal[76];

[76] The Labour Act, 1992, and Labour Rules, 1993, The Child Labour (Prohibition and Regulation) Act, 1999

b. **Road Shifting**

598. Where road shifting is necessary, e.g. due to sub-mergence in the dam foot prints, shifting of the roads should be done prior to the inundation to avoid any disruption in traffic.

c. **Trek shifting**

599. Where shifting of treks is necessary, e.g. due to sub-mergence in the dam foot prints, shifting of the treks should be done prior to inundation to avoid any disruption in trekking.

D. General Environmental Guidelines during Construction

600. Based on the findings of the EIA and consideration of the necessity to limit environmental impact during construction, the following general guidance would be devised and incorporated into the Tender Documents.

1. Contractor's responsibilities with respect to the Environment

601. The contractor‟s environmental responsibilities would be prescribed in the Tender Documents and later on award in the Contract and they would include the need to adhere to environmental clauses in the Contract and the guidelines provided. In the detailed design and during construction the contractor shall take due considerations to the following:

a. **General**

602. The Contractor shall take all reasonable steps to protect the environment and to prevent environmental damage and public nuisance resulting from construction activities.

603. Contractor shall comply with all statutory requirements, environmental regulations and environmental quality standards, as stated in the Environmental Protection Act, 1997 of GoN; for any works in the SNNP adhere to the Forest Act, 1993 (amendment 2007) and rules prescribed by the SNNP authorities, GoN, and Nepal environmental guidelines relevant to the project and the updated EMP.

604. Permission for any pre-construction activities must be obtained in writing from DNPWC or any other appropriate approval authority.

605. Necessary permission for personnel to enter the Park must be sought from DNPWC.

606. Contractor shall bear all costs associated with environmental pollution avoidance and environmental mitigation, including any clean-up operations if necessary.

b. **Pollution from wastes**

607. Maintain all construction sites in a clean and safe condition and provide and maintain appropriate facilities for temporary storage of all wastes before transportation and disposal.

608. Organise disposal of all wastes generated during construction in an environmentally acceptable manner. This shall include consideration of the nature and location of disposal sites, so as to cause least environmental impact.

609. Take all precautionary measures when handling and storing fuels and lubricants, to avoid causing environmental pollution. This is to include establishment of contingency plans for clean up in the event of spillage. All sites must be restored after completion of works.

c. **Protection of Human Health**

610. Provision of adequate sanitation facilities on all construction sites, contractor's office(s) etc., if and when established. The contractor must ensure that a proper health and safety operational plan is approved and in place prior to starting construction works.

611. Disposal from all sanitary systems should be undertaken to avoid causing environmental pollution. Wastewater should be routed through suitable sanitary facilities and soak ways, without contaminating either ground or surface water or causing a health risk.

612. Provision of an adequate supply of water for drinking and washing purposes for all site personnel, including all workers, as appropriate. Drinking water quality should comply with GoN standards (see Appendix 3), and WHO guideline values.

d. **Noise**

613. Avoid any unnecessary noise for disturbance during construction.

614. Maintenance of all vehicles and mechanics to a high standard, in accordance with manufacturer‟s maintenance procedures.

615. Careful siting of noise generating activities to avoid unnecessary noise disturbance to local residents, in accordance with GoN noise guidelines, see Appendix 3.

e. **Air Quality and Dust**

616. Minimisation of dust nuisance by regular watering of material stockpiles, access roads, bare soil, sand and other areas, as appropriate and as determined by weather conditions

f. **Disruption to Road Traffic and other Access Routes**

617. Minimise of disruption to road traffic and other access routes, in consultation with local authorities and representatives.

E. **Summary of Impacts, Compensation and Mitigation Measures**

618. A general summary of Impacts, Compensation and mitigation Measures is given in Table IX-3 and for Phase I and Phase II. Two tables are provided for the two phases of the project as implementation is to be in two distinct phases and will be in two different contract packages.

Table IX-3: General Summary of Impacts, Compensation and Mitigation Measures, Phase I

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		[77]
The proposal for creating a storage capacity in the Upper Bagmati is dictated by the need to increase the environmental flow in the Bagmati River during the dry season.	S	P	Implementation of the prosed Dhap dam in the SNNP will require extensive compensations, following GoN rules and regulations. 25 trees have to be planted for each tree cleared.	D&BC/SNNP	SNNP							+
Design and Pre-construction												
Roadside drainage should receive particular attention by the detailed design team to assure that the surface of rehabilitated access roads does not concentrate rainfall and cause erosion.	M	P	Apply engineering and hydrological criteria to the design of drainage structures.	D&BC	Access Roads							+
			Incorporate appropriate roadside drainage structures into the design construction drawings									+
During detailed design of the shifting of the road north of the Dhap to flow the top of the saddle dam, identification of appropriate methods of excavation or cutting to minimize landslides and enable slope stability are needed during the detailed design stage.	M	P	Apply adequate engineering and hydrological criteria to the design of drainage structures	D&BC PCMU	Road north of Dhap							+
			Use bioengineering techniques to stabilize soils both during construction and for finishing slopes for long range operational integrity.									+
Disposal of spoil material to the lower	S	P	Adequate and safe locations for deposit	PCMU/	Access							0

Sig = Significance of Impact (S = Not/Small Significance; M = Moderately Significant; H = Highly Significant).
Dur = Duration of Impact (T = Temporary; P = Permanent)
D = Detailed Design period; Op = Period when infrastructure is operating;
PCMU = Project Coordination and Management Unit; D&BC = Design & Build Contractor; SNNP = Shivapuri Nagarjun National Park; HPCIDBC = High Powered Commission for the Development of Bagmati Civilisation; DOI = Department of Irrigation; PIU = Project Implementation Unit

[77] This column shows impacts remaining after mitigation: 0 = zero impact (impact successfully mitigated); + = positive impact (mitigation provides a benefit); -= negative impact remains

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		[77]
slopes below access road destructive to forest and vegetation.			of spoil materials must be identified. Any deposits from the shifting of the road north of the Dhap will be in the footprint of the Dhap reservoir.	DOI PIU	Roads							
Site clearing for worker‟s camp and construction sites for dams	M	T	Site clearing and earthworks should not be carried out during excessively wet and rainy periods.	D&BC	Dhap Dam site							0
			A sediment retention facility shall be installed to prevent any discharge of sediment into the Nagmati River. The contractor to provide an erosion and sediment control plan prior to initiating construction works.									
Drying out of the Nagmati River during filling of reservoir	H	P	Provide facilities for natural diversion release of flows during the dry season in the design of dams.	D&BC	Dhap Dam site							+
Deteriorated water quality in water released downstream of dams to provide environmental flow	H	P	Include safe water release facilities (to maintain good oxygen conditions in the Nagmati downstream reservoirs) in dam design.	PCMU/ DOI PMU	Dhap Dam site							+
Dam failure due to seismic activity	H	P	Select safest dam type and take optimal consideration to dam safety in final design.	D&BC/PCMU	Dhap Dam site							-
Shrines or areas of local importance could be damaged	M	T	Consult community to identify any sensitive areas	PCMU	Sundarijal to Sinamangal							0
			Adjust design to avoid any especially sensitive sites	D&BC								0
			Avoid working at times when sensitive sites may be used	D&BC								0
Environmental aesthetics in river bank improvement and green zones design	H	P	Local architectural elements, design, construction materials and construction	D&BC/PCMU	Gokarna to							+

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		[77]
			methods to be incorporated in the design of all components in order to achieve an aesthetical beautification of the river environment		Sinamangal							
Construction												
Accidents involving workers and the public on site	M	T	Prepare, get approval and implement an Health and Safety and Emergency Response Plan that includes measures to:	D&BC	Dhap site Upper Bagmati							0
			- Exclude the public from all construction sites;									0
			- Ensure that workers use Personal Protective Equipment									0
			- Provide Health & Safety Training for all personnel;									0
			- Follow documented procedures for all site activities;									0
			- Keep accident reports and records.									0
Inadequately maintained and operated equipment, machinery and vehicles used for the project may create air pollution	M	T	All equipment, machinery and vehicles used for the project must be well maintained in order for proper functioning as well as reduction in air pollution	D&BC	Dhap site Upper Bagmati							
Excavation at dam construction site will create waste soil	M	P	Use soil/stone from dam sites for dam construction, if suitable	D&BC	Dhap Dam site							0
			If dam material is quarried, refill pits with soil from dam site									0
			Re-use material elsewhere if possible									0
			Liaise with SNNP staff to find other beneficial material uses									+
A rock crushing plant will be operated at	M	T	Areas where dust accumulates should be	D&BC	Dhap							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		77
the quarry at the Dam site			watered regularly		Dam site							
			Any changes in location of crushing plant must be approved by the SNNP authorities.									
			Cover material stockpiles using sheets or jute bags.									
			Upon completion ensure site is restored, with proper compation and safe disposal of unwanted material.									
Transporting construction material to construction sites will cause noise, dust, vehicle emissions at site and along route	M	T	Source material from as close to dam sites only from reservoir foort print as possible	D&BC	Dhap Dam site							0
			Use tarpaulins to cover sand/soil when carried on trucks									0
			See that vehicles comply with the National Vehicle Mass Emission Standards, 2056 BS. Regular maintenance of vehicles.									
			Limit vehicle speed.									
Excavation and infilling may cause dust in windy weather in semi-urban and urban areas	M	T	Cover and spray excavated soil	D&BC	Gokarna to Sinamangal Bridge							0
			Cover or spray stockpiled soil and sand									0
			Only bring sand to site when needed									0
Spills of toxic materials could affect aquatic ecology in Bagmati River Basin	M	T	Do not store toxic materials at or near Nagmati/Bagmati Rivers	D&BC	Dhap site Upper Bagmati							0
			Build watertight bunds to separate work areas from the river									0
			Include accident & spill prevention in Method Statement									0
Dust emissions from soil and road	M	T	The site access road segments in semi-	D&BC	Gokarna							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		77
surfaces disturbed by project related traffic.			urban and urban areas will need spraying of water to lessen the dust pollution. To be done twice daily or as needed to minimize impacts		to Sinamangal Bridge							
Traffic, people and activities could be disrupted by trucks carrying waste soil or delivering materials to site	M	T	plan routes with VDCs and local communities to limit entry of heavy vehicles Semi-urban and urban areas,, avoid congested roads, etc.	D&BC	Sundarijal to Sinamangal							0
			plan work to avoid peak traffic periods									0
Noise impacts on wildlife in the SNNP will originate from the operation of construction equipment and from rock blasting and rock crushing to provide rock-fill for the dams	H	T	The blasting, rock crushing and transport activities in the SNNP should be carried out during the daytime to prevent disturbance to wildlife during the night, dawn and dusk	D&BC	Dhap site							-
Noise impacts in semi-urban and urban areas will originate from the operation of construction equipment and transport of construction material to the construction sites	M	T	Noise impacts are an unavoidable consequence of construction that should be mitigated by limiting the times of construction to daylight hours in the vicinity of sensitive locations such as schools, health clinics etc.	D&BC	Gokarna to Sinamangal Bridge							-
The access to the Dhap dam site in SNNP will be by the existing Ring Road east of SNNP from Sundarijal to Chisapani. The road is in poor state and needs upgrade. .	M	P	The road will be upgraded, both to serve as a safe access road, but also to reduce the present high erosion rate in the lower part, including proper drainage.	D&BC	Sundarijal to Dhap							+
			Where the extended reservoir at the Dhap will inundate the road, this will be shifted to be on top of the saddle dam.									+
Workers and nearby visitors" safety during blasting	M	T	The contractor will prepare a blasting procedure requiring area restrictions; prior warning of workers and others	D&BC	Dhap Quarry							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		[77]
			passing through the SNNP; restrictions on the timing of blasts; and worker safety procedures.		site							
			The quarry operation shall utilise an environmental friendly blast initiation system in its blasting operation									0
			The shotfirer shall have experience in blasting operation at sensitive areas and possess good knowledge in the latest technology in blasting operations									0
The operation of the quarry at the Nagmati site, particularly during clearing, drilling and preparation of benches may cause sediment spills.	M	T	The quarry must maintain a buffer zone of 20 meter to the Nagmati River and all clearing of the quarry site should be restricted to the necessary area of rock extraction	D&BC	Dhap Quarry site							0
			A sedimentation pond for retention of eroded particles should be put in place.									0
There will be social, economic benefits and increased acceptance of Project when local people are employed in Contractor‟s workforce	M	T	Contractor should employ as many as possible to the workforce from communities in vicinity of work sites,	D&BC	Dhap site Upper Bagmati							+
Steep slopes and unstable terrain in the construction site areas have a risk of erosion and slope failure.	H	T	Areas of steep slopes and unstable terrain should be terraced, stabilized, strengthened and re-vegetated where possible	D&BC/ PCMU	Dhap site							+
			Soil erosion at construction sites shall be minimized using soil protection such as terracing, plastic sheeting and installing silt traps at strategic locations. Contractor to provide a soil and erosion control plan at start of construction works.									+

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		77
Construction works in the Bagmati River from Gokarna to Sinamangal may affect dry season flows. Furhtermore disposal of excavated material from river bed could impact on groundwater quality and landuse.	M	T	Any construction works affecting the river flow, such as the construction of weirs, will typically be planned and carried out in two phases, with the construction going on in one half of the cross section, leaving the river to flow in the other half. All material excavated from river bed will be disposed of at the Sisdol engineerd landfill. Trucks transporting the material wll be covered during transportation.	D&BC	Gokarna to Sinamangal							0
Water quality in the River can be affected by discharges of sediments from erosion increasing Suspended matter concentrations and increase Turbidity etc.			Mitigation measures are similar to the measures mentioned above with respect to provision of sediment traps, slope stabilisation, provision of adequate drainage at access roads etc.	D&BC	Dhap site Upper Bagmati							0
An estimated 1580 trees are expected to be cleared in the Dhap reservoir area.	H	P	Compensation planting of 39,000 trees will be required, with provision of maintenance and protection for 5 years.	PCMU/SNNP	SNNP							+
During clearing of the forest at the reservoir area there is a risk that nesting is taking place for some species.	H	T	Clearing of the forest will be carried out during the dry season where nesting is less common for most species	PCMU/SNNP	Dhap site							-
			The branches and canopy of trees must be checked for nests with eggs/checks before clearing. Any such nests must be handled carefully and displaced in other area with the help of experts									-
Local residents as key stakeholders may have objections to project activities if not informed properly.	M	T	Local residents and stakeholders should be informed regularly and consulted on project activities in line with teh communications strategy developed for the project.	PCMU	Dhap site Upper Bagmati							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		[77]
			There will be social, economic benefits and increased acceptance when local people are employed. The contractor should be encouraged to do this.									
There will be social, economic benefits and increased acceptance of Project when local people are employed in Contractor"s workforce	M	T	Contractor will be encouraged to employ at least 50% of workforce from communities in vicinity of work sites if possible	D&BC	Dhap site Upper Bagmati							+
During construction the communities in the SNNP and nearby will have income generating opportunities by supplying to the non-skilled work force needed for a range of activities such as serving in the workers camps, transport of materials, forest clearing, guarding planted trees etc.	M	T	Employment of workers from the local communities will mitigate some of these effects.	D&BC/ SNNP	Dhap site Upper Bagmati							+
			The contractors will need to enforce strict rules for the behaviour of the workforce hosted in the camps									
During the works in the Upper Bagmati sites, encountering any finding of archaeological value and working at heritage sites	M	T	The Contractor will be provided with a Chance Find Protocol by the PCMU M&E Unit before start of works	D&BC/ PCMU	Upper Bagmati							0
			In the event the Contractor encounters any findings of archaeological value during the works he will follow the Chance Find Protocol instructions									
			Photographing all working sites within/close to any heritage sites to enable before and after comparison (all sites surrounding heritage to be reinstated to original character, with heritage sites left untouched)									
Operation and Maintenance:												
During the seasonal filling of reservoirs there is a risk of drying out of the Nagmati	M	T	The dry season flow release facilities provided should be adequately operated to provide an environmental flow of 10 l/s	D&BC/ HPCIDBC	Dhap site							+

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		[77]
River downstream.			and 100 l/s downstream the Dhap and the Nagmati Dams, respectively. However, the operational targets are at 40 l/s and 400 l/s for normal operation periods, respectively.									
The estimated 39,000 trees planted as compensation for the clearance of the Dhap reservoir needs protection against cutting.	H	P	Guards will be provided (from community where possible) for protection for a period of 5 years.	PCMU/SNNP	SNNP							+
All structures, dams etc. require maintenance	H	P	HPCIDBC regularly inspect river structures, dams, river banks, river bed scour protections etc. and record any need for repair and maintenance and instigate the repair works	PCMU	Dhap site Upper Bagmati							

Table IX-4: General Summary of Impacts, Compensation and Mitigation Measures, Phase II (the construction of the Nagmati Reservoir and the Powerhouse)

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		[78]
In order to establish the small powerhouse necessary on the left bank of the Bagmati River at Sundarijal, it is necessary to acquire $500m^2$ of land. The suitable site is presently used for growing paddy.	S	P	The acquisition of the 500 m^2 of land needed for the powerhouse will follow the Resettlement Framework developed for the Project with respect to compensation etc.	PCMU	Sundarijal							0
The proposal for creating a storage capacity in the Upper Bagmati is dictated by the need to increase the environmental flow in the Bagmati River during the dry season.	S	P	Implementation of the proposed dams in the SNNP will require extensive compensations, following GoN rules and regulations. 25 trees have to be planted for each tree cleared.	D&BC/SNNP	SNNP							+
Design and Pre-construction (Detailed Design of the Nagmati Dam will take place in Phase II, but impacts and mitigations shown here for convenience)												
Roadside drainage should receive particular attention by the detailed design team to assure that the surface of rehabilitated access roads does not concentrate rainfall and cause erosion.	M	P	Apply engineering and hydrological criteria to the design of drainage structures.	D&BC	Access Roads							+
			Incorporate appropriate roadside drainage structures into the design construction drawings									+
During detailed design of the shifting of the Mulkharka-Chisapani road, identification of	M	P	Apply adequate engineering and hydrological criteria to the design of	D&BC	Mulkharka-							+

Sig = Significance of Impact (S = Not/Small Significance; M = Moderately Significant; H = Highly Significant).
Dur = Duration of Impact (T = Temporary; P = Permanent)
D = Detailed Design period; Op = Period when infrastructure is operating;
PCMU = Project Coordination and Management Unit; D&BC = Design & Build Contractor; SNNP = Shivapuri Nagarjun National Park; HPCIDBC = High Powered Commission for the Development of Bagmati Civilisation; DOI = Department of Irrigation; PIU = Project Implementation Unit

[78] This column shows impacts remaining after mitigation: 0 = zero impact (impact successfully mitigated); + = positive impact (mitigation provides a benefit); -= negative impact remains

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		78
appropriate methods of excavation or cutting to minimize landslides and enable slope stability are needed during the detailed design stage			drainage structures	PCMU	Chisapani Road							
			Use bioengineering techniques to stabilize soils both during construction and for finishing slopes for long range operational integrity.									+
Disposal of spoil material to the lower slopes below access road destructive to forest and vegetation.	S	P	Adequate and safe locations for deposit of spoil materials must be identified.,	PCMU/ DOI PIU	Access Roads							0
Site clearing for worker‟s camp and construction sites for dams	M	T	Site clearing and earthworks should not be carried out during excessively wet and rainy periods.	D&BC	Nagmati Dam site							0
			A sediment retention facility shall be installed to prevent any discharge of sediment into the Nagmati River.									
Drying out of the Nagmati River during filling of reservoirs	H	P	Provide facilities for release of environmental flows in the design of dams.	D&BC	Nagmati Dam site							+
Deteriorated water quality in water released downstream of dams to provide environmental flow	H	P	Include safe water release facilities (to maintain good oxygen conditions in the Nagmati downstream reservoirs) in dam design.	PCMU/ DOI PIU	Nagmati Dam site							+
Dam failure due to seismic activity	H	P	Select safest dam type and take optimal consideration to dam safety in final design.	D&BC/PCMU	Nagmati Dam site							-
Shrines or areas of local importance could be damaged	M	T	Consult community to identify any sensitive areas	PCMU	Bagmati tributaries							0
			Adjust design to avoid any especially sensitive sites	D&BC								0
			Avoid working at times when sensitive sites may be used	D&BC								0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		78
Environmental aesthetics in river bank improvement and green zones design	H	P	Local architectural elements, design, construction materials and construction methods to be incorporated in the design of all components in order to achieve an aesthetical beautification of the river environment	D&BC/PCMU	Bagmati tributaries							+
Construction												
Accidents involving workers and the public on site	M	T	Prepare, get approval and implement a Health and Safety and Emergency Response Plan that includes measures to:	D&BC	Dhap Dam site Bagmati Tributaries							0
			- Exclude the public from all construction sites;									0
			- Ensure that workers use Personal Protective Equipment									0
			- Provide Health & Safety Training for all personnel;									0
			- Follow documented procedures for all site activities;									0
			- Keep accident reports and records.									0
Inadequately maintained and operated equipment, machinery and vehicles used for the project may create air pollution	M	T	All equipment, machinery and vehicles used for the project must be well maintained in order for proper functioning as well as reduction in air pollution	D&BC	Dhap Dam site Bagmati Tributaries							
Excavation at dam construction sites will create waste soil	M	P	Use soil/stone from dam sites for dam construction, if suitable	D&BC	Nagmati Dam site							0
			If dam material is quarried, refill pits with soil from dam site									0
			Re-use material elsewhere if possible									0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		78
			Liaise with SNNP staff to find other beneficial material uses									+
A rock crushing plant will be operated at the quarry at the Nagmati Dam site	M	T	Areas where dust accumulates should be watered regularly	D&BC	Nagmati Dam site							0
			Any changes in location of crushing plant must be approved by the SNNP authorities.									
			Cover material stockpiles using sheets or jute bags.									
			Upon completion ensure site is restored, with proper compation and safe disposal of unwanted material.									
Transporting construction material to construction sites will cause noise, dust, vehicle emissions at site and along route	M	T	Source material from as close to dam sites as possible	D&BC	Nagmati Dam site							0
			Source material from within reservoir footprint if suitable									0
			Use tarpaulins to cover sand/soil when carried on trucks									0
			See that vehicles comply with the National Vehicle Mass Emission Standards, 2056 BS. Regular maintenance of vehicles.									
			Dust needs to be suppressed through regular watering of working surfaces									
			Limit vehicle speed.									
Excavation and infilling may cause dust in windy weather in semi-urban and urban areas	M	T	Cover and spray excavated soil	D&BC	Bagmati tributaries							0
			Cover or spray stockpiled soil and sand									0
			Only bring sand to site when needed									0
Spills of toxic materials could affect aquatic ecology in Bagmati River Basin	M	T	Do not store toxic materials at or near Nagmati/Bagmati Rivers	D&BC	Dhap Dam site							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		[78]
			Build watertight bunds to separate work areas from the river		Bagmati Tributaries							0
			Include accident & spill prevention in Method Statement									0
Dust emissions from soil and road surfaces disturbed by project related traffic.	M	T	The site access road segments in semi-urban and urban areas will need spraying of water to lessen the dust pollution. To be done twice daily or as needed to minimize impacts	D&BC	Bagmati tributaries							0
Traffic, people and activities could be disrupted by trucks carrying waste soil or delivering materials to site	M	T	Currently plan routes with VDCs and local communities to limit entry of heavy vehicles Semi-urban and urban areas,, avoid congested roads, etc.	D&BC	Bagmati tributaries							0
			Currently plan work to avoid peak traffic periods									0
Noise impacts on human settlements and wildlife in the SNNP will originate from the operation of construction equipment and from rock blasting and rock crushing to provide rock-fill for the dams	H	T	The blasting, rock crushing and transport activities in the SNNP should be carried out during the daytime to prevent disturbance to wildlife during the night, dawn and dusk	D&BC	Nagmati dam site							-
Noise impacts in semi-urban and urban areas will originate from the operation of construction equipment and transport of construction material to the construction sites	M	T	Noise impacts are an unavoidable consequence of construction that should be mitigated by limiting the times of construction to daylight hours in the vicinity of sensitive locations such as schools, health clinics etc.	D&BC	Bagmati tributaries							-
The access road to the Nagmati Dam site will be via the existing road from Sundarijal via Mulkharka to the Nagmati site.	M	P	The roads will be upgraded, both to serve as a safe access road, but also to reduce the present high erosion rate, including proper drainage.	D&BC	Sundarijal to Dhap Mulkharka to							+
			Where the reservoir in Nagmati will									+

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		78
			inundate the existing road when filled during the monsoon, the road will be shifted to a higher, non-inundated level. The shifting of the road will include proper drainage, provision of culverts and slope protection to avoid any soil erosion and damage to the road		Chisapani							
Workers and nearby visitors" safety during blasting	M	T	The contractor will prepare a blasting procedure requiring area restrictions; prior warning of workers and others passing through the SNNP; restrictions on the timing of blasts; and worker safety procedures.	D&BC	Nagmati Quarry site							0
			The quarry operation shall utilise an environmental friendly blast initiation system in its blasting operation									0
			The shotfirer shall have experience in blasting operation at sensitive areas and possess good knowledge in the latest technology in blasting operations									0
The operation of the quarry at the Nagmati site, particularly during clearing, drilling and preparation of benches may cause sediment spills.	M	T	The quarry must maintain a buffer zone of 20 meter to the Nagmati River and all clearing of the quarry site should be restricted to the necessary area of rock extraction	D&BC	Nagmati Quarry site							0
			A sedimentation pond for retention of eroded particles should be put in place.									0
There will be social, economic benefits and increased acceptance of Project when local people are employed in Contractor"s workforce	M	T	Contractor should employ at where possible employ as many workforce from communities in vicinity of work sites,	D&BC	Dhap Dam site Bagmati Tributaries							+

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		78
Steep slopes and unstable terrain in the construction site areas have a risk of erosion and slope failure.	H	T	Areas of steep slopes and unstable terrain should be terraced, stabilized, strengthened and re-vegetated where possible	D&BC PCMU	Nagmati Dam site							+
			Soil erosion at construction sites shall be minimized using soil protection such as terracing, plastic sheeting and installing silt traps at strategic locations. Contractor to provide a soil and erosion control plan at start of construction works.									+
Construction works in the Bagmati River from Gokarna to Sinamangal may affect dry season flows.	M	T	Any construction works affecting the river flow, such as the construction of weirs, will typically be planned and carried out in two phases, with the construction going on in one half of the cross section, leaving the river to flow in the other half	D&BC	Bagmati tributaries							0
Water quality in the Nagmati River can be affected by discharges of sediments from erosion increasing Suspended matter concentrations and increase Turbidity etc.			Mitigation measures are similar to the measures mentioned above with respect to provision of sediment traps, slope stabilisation, provision of adequate drainage at access roads etc.	D&BC	Dhap Dam site Bagmati Tributaries							0
An estimated 1580 trees are expected to be cleared in the Dhap reservoir area.	H	P	Compensation planting of 39,000 trees will be required, with provision of maintenance and protection for 5 years.	PCMU/SNNP	SNNP							+
An estimated 25,400 trees are expected to be cleared in the Nagmati reservoir area.	H	P	Compensation planting of 636.500 trees will be required, with provision of maintenance and protection for 5 years.	PCMU/SNNP	SNNP							+
During clearing of the forest at the reservoir areas there is a risk that nesting is taking place for some species.	H	T	Clearing of the forest will be carried out during the dry season where nesting is less common for most species	PCMU/SNNP	Nagmati Dam site							-
			The branches and canopy of trees must									-

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						01	02	03	04	05		[78]
			be checked for nests with eggs/checks before clearing. Any such nests must be handled carefully and displaced in other area with the help of experts									
Local residents as key stakeholders may have objections to project activities if not informed properly.	M	T	Local residents and stakeholders should be informed regularly and consulted on project activities. There will be social, economic benefits and increased acceptance when local people are employed. The contractor should be encouraged to do this.	PCMU	Nagmati Dam site Bagmati Tributaries							0
There will be social, economic benefits and increased acceptance of Project when local people are employed in Contractor"s workforce	M	T	Contractor should employ at least 50% of workforce from communities in vicinity of work sites if possible	D&BC	Nagmati Dam site Bagmati Tributaries							+
During construction the communities in the SNNP and nearby will have income generating opportunities by supplying to the non-skilled work force needed for a range of activities such as serving in the workers camps, transport of materials, forest clearing, guarding planted trees etc.	M	T	Employment of workers from the local communities will mitigate some of these effects. The contractors will need to enforce strict rules for the behaviour of the workforce hosted in the camps	D&BC/ SNNP	Nagmati Dam site Bagmati Tributaries							+
During the works if any finding of archaeological value are found	M	T	The Contractor will be provided with a Chance Find Protocol by the PCMU M&E Unit before start of works In the event the Contractor encounters any findings of archaeological value during the works he will follow the Chance Find Protocol instructions Photographing all working sites within/close to any heritage sites to	D&BC/ PCMU	Bagmati Tributaries							0

Activity and Potential Negative Impacts	Sig	Dur	Compensation and Mitigation Activities and Method	Responsibility	Location	D	Construction				Op	
Location						**01**	**02**	**03**	**04**	**05**		[78]
			enable before and after comparison (all sites surrounding heritage to be reinstated to original character, with heritage sites left untouched)									
Operation and Maintenance:												
During the seasonal filling of reservoirs there is a risk of drying out of the Nagmati River downstream.	M	T	The dry season flow release facilities provided should be adequately operated to provide an environmental flow of 10 l/s and 100 l/s downstream the Dhap and the Nagmati Dams, respectively. However, the operational targets are at 40 l/s and 400 l/s for normal operation periods, respectively.	PCMU/ HPCIDBC	Nagmati Dam site							+
The estimated 636.500 trees planted as compensation for the clearance of the Nagmati reservoir needs protection against cutting.	H	P	Guards will be provided for protection for a period of 5 years.	PCMU/SNNP	SNNP							+
All structures, dams etc. require maintenance	H	P	HPCIDBC regularly inspect river structures, dams, river banks, river bed scour protections etc. and record any need for repair and maintenance and instigate the repair works	PCMU	Nagmati Dam site Bagmati Tributaries							

F. Monitoring and Reporting

619. The objective of environmental monitoring is to ensure the effectiveness of environmental mitigation measures, compliance with environmental standards and to facilitate any needed project design or operational changes. Monitoring is required during the pre-construction, construction and the operational phase of the Project.

620. The monitoring requirements for Phase I and II are described in Tables IX-5 and IX-6.

Table IX-5: Monitoring Requirements, Phase I

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
Pre-Construction phase				
Permits and approvals	Compliance with license and permit conditions	SNNP	D&B Contractor&DOI PIU/ PCMU	Once weekly
Delineation of project area	Surveying and pegging of land to be affected by project activities	Gokarna to Sinamangal	D&B contractor/ PCMU	As an when it is needed
Construction phase				
Statutory responsibilities	-Compliance with license and permit condition	Dhap site in SNNP. River work sites from Gokarna to Sinamangal	D&B contractor/ PCMU	As an when it is needed
Environmental flow	-Rainfall, temperature -River flow variation	Immediate Catchment area (Rainfall: Mulkharka/Sundarijal. Flow: Sundarijal).	DOI PIU/PCMU M&E Unit	Daily Daily
Landslides	-Catchment stability	Immediate and upper catchment in SNNP	D&B Contractor/PCMU	Annually after monsoon
Erosion and sedimentation	-Effectiveness of controls	Immediate catchment	D&B Contractor/ PCMU	Daily
Tree Felling and Vegetation clearance	-Number of trees cut in project siting and in the project vicinity -Area of vegetation clearance	Dhap project site Dhap project site	D&B Contractor/ PCMU and SNNP officials D&B Contractor/ PCMU and SNNP officials	Daily

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
Spoil disposal	Reuse of spoil wherever possible (within and outside the project) -Surplus spoil disposed in the reservoir footprint -Adopted mechanism of spoil disposed in the designated area	Dhap project site and access roads Spoil disposal sites Spoil disposal sites	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/ PCMU	Daily
Waste management	-Waste material reused and recycled from project sites, camps and ancillary sites. - proper waste disposal options available at worker camps/sites -Management of non – recyclable waste	Dhap project site and River work sites from Gokarna to Sinamangal Same.	D&B Contractor/PCMU D&B Contractor/ PCMU	Daily
Water quality	Worker"s camps drinking water quality (Parameters include as mentioned in table 3.2) -River water quality (DO, BOD, COD, TSS, NO_3-N, NH_4-N, PO_4-P, Faecal Coli) . Regular parameters measured by HPCIDBC laboratory. See Table IV-14. BOD to be included as soon as laboratory is upgraded.	Dhap project site camp and work sites Sample station 500 m downstream dam site From Sundarijal to Sinamangal monitoring at HPCIDBC stations in Bagmati River, see Figure IV-10	D&B Contractor/ PCMU D&B Contractor/ PCMU HPCIDBC laboratory/PCMU	Monthly Monthly Monthly
Air Quality	-Spraying of water regularly on work activity areas as appropriate. -Vehicular emission tests as per GON standard -Maintenance of the	Dhap project site, access roads and River work sites from Gokarna to Sinamangal -same. -same.	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/ PCMU	Daily Quarterly Daily

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
	equipment as per specifications			
Noise and vibration	-Monitoring of noise levels -Maintenance of equipment in accordance with manufacture"s specifications. -Traffic movement control and limit on horn -Controlled blasting -Monitoring of vibration levels	Dhap project site. Settlements at Ring Road east of SNNP River work sites from Gokarna to Sinamangal[79] At project sites	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/PCMU	Monthly Regular site inspections
Workforce Management, health and safety	-Environment/safety meetings informing on workforce rules and regulations. -Enforcement of safety rules and the use of health and safety gear. -provision of groceries, kerosene/gas and other goods of daily needs in the Dam camp. -Provision of first aids facility -Provision of adequate and well maintained utility services and facilities.	Dhap project site, access roads and River work sites from Gokarna to Sinamangal Dhap project site workforce camp Dhap project site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/ PCMU	Fortnightly Daily Daily Daily
Aquatic ecology	-Fish species and population size	Sample station 500 m downstream	PCMU	Once in three month

[79] As River works progresses, noise measurements will be done at sensitive sites, see Appendix 8 for specific sites.

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
		Dhap project site		
Terrestrial ecology	-Encroachment and vegetation at dam construction site borders. -Effects on habitat, migratory routes within 200 m from dam construction site borders.	Dhap project site Dhap project site	PCMU M&E Unit/ PCMU PCMU M&E Unit/ PCMU	Once in three month Once in three month
Traffic and access	Check maintenance records. -Enforcement on speed limits and horn noise levels- ensure signages are place on site and that they are been adhere to.	Dhap project site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor /PCMU	Random inspections
Drainage	-Direct observation of drainage condition and state of operation.	Dhap project site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor PCMU	Weekly
Risks	-Maintenance of warning systems and sirens. -Physical obstruction on project prohibited areas. -Appropriate safety gears to labours as required -Safety training to labourers and others involved in construction. -Storage of hazards materials in bounded areas	Dhap project site Dhap project site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor and PCMU D&B Contractor D&B Contractor D&B Contractor D&B Contractor	Every 4 months Daily Daily Monthly Weekly
Hazards	-Use of hazardous goods as per the specifications of the manufactures. -Storage of explosive in guarded bunkers		D&B Contractor /PCMU	Daily Weekly
Complaint	Complaints received and replied	Dhap project site, access roads and	Project Site offices fcal	As and when necessary

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
		River work sites from Gokarna to Sinamangal	person responsible to maintain the GRM	
Accidental and emergencies handling	-Enforcement of accidental and emergencies response measure -Maintenance of first aid facility with required facilities and staffs	Dhap project site, access roads and River work sites from Gokarna to Sinamangal Dhap project site camp	D&B Contractor D&B Contractor	As and when required At all times
Post construction phase				
Rehabilitation and re-vegetation	-Effectiveness of rehabilitation measures at sites - Effectiveness of site re-vegetation	Dam sites and other sites determined by MOFSC or Department of Wildlife Dam sites	D&B Contractor PCMU/SNNP D&B Contractor PCMU/SNNP	Every three months
Settlement of bilateral dealings with locals	-Meeting with concerned individuals/VDCs and community groups -Handling complaints, if any -Agreement and negotiation	Dhap project site and access roads. Gokarna to Sinamangal.	D&B Contractor/PCMU PCMU, D&BC, VDCs, GRM	Monthly When required When required
Operation Phase	**-**			
Aquatic ecology	-Fish stock, species and density survey using net trawling. Three transects. Fish stock, species and density survey using electro fishing.	Dhap reservoir Nagmati River, 200 and 500 meters downstream Dhap reservoir	PCMU M&E Unit/ PCM PCMU M&E Unit/ PCM	Once in 3 months Once in 3 months
River bed degradation	-Visual observation of river bed scouring, sedimentation and side erosion	Upper Bagmati River	HPCIDBC	Every 6 month

Environmental Issues	**Parameters to be Monitored**	**Location**	**Responsibility Implement/Monitor**	**Frequency**
Hydrology	-River flow discharge -Amenity flow of 0,4m^3/s -Flooding and inundation	Upper Bagmati River Upper Bagmati River Upper Bagmati River	HPCIDBC	Daily Daily During monsoon
Reservoir foreshore	-Landslides and slope stability -Removal of debris and logs	Dhap Dam site	HPCIDBC/SNNP HPCIDBC/SNNP	Two times in a year Monsoon season
Compensation planting of trees in SNNP and Buffer Zone	-State of vegetation -Landslides and slope stability -State of protection	SNNP & Buffer Zone SNNP & Buffer Zone SNNP & Buffer Zone	SNNP SNNP SNNP	Monthly Two times in a year Monthly
Water Quality	-Water quality measurements. Parameters: Regular parameters measured by HPCIDBC laboratory. See Table IV-14. BOD to be included as soon as laboratory is upgraded.	HPCIDBC monitoring stations in Bagmati River, see Figure IV-10	HPCIDBC regular programme	Monthly
Risk and hazards	-Structural soundness -Maintain flood Warning system and sirens -Monitor Landslides -Enforcement of Occupation Safety rules and regulations	All project structures Sundarijal and downstream Dhap Dam Upper Bagmati	HPCIDBC HPCIDBC HPCIDBC HPCIDBC	Annually Monsoon season Annually Daily

D&B Contractor = Design and Build Contractor, PCMU = Project Coordination and Management Unit, HPCIDBC = High Powered Commission for Integrated Development of Bagmati Civilization. SNNP = Shivapuri Nagarjun National Park. M&E Unit = Monitoring and Evaluation Unit (in PCMU),

Table IX-6: Monitoring Requirements, Phase II

Environmental Issues	**Parameters to be Monitored**	**Location**	**Responsibility Implement/Monitor**	**Frequency**
Pre-Construction phase				
Land acquisition and compensation	Compensation Procedures as per RAF	Plot for Powerhouse at the left bank of Bagmati at Sundarijal	DOI PIU/ PCMU	Period of land acquisition and compensation
Permits and approvals	Compliance with license and permit conditions	SNNP	D&B Contractor&DOI PIU/ PCMU	Once weekly
Delineation of project area	Surveying and pegging of land to be affected by project activities	Bagmati tributaries	D&B contractor/ PCMU	As an when it is needed
Construction phase				
Statutory responsibilities	-Compliance with license and permit condition	Nagmati Dam site in SNNP. River work sites Bagmati tributaries	D&B contractor/ PCMU	As an when it is needed
Environmental flow	-Rainfall, temperature -River flow variation	Immediate Catchment area (Rainfall: Mulkharka/Sundarijal. Flow: Sundarijal).	DOI PIU/PCMU M&E Unit	Daily Daily
Landslides	-Catchment stability	Immediate and upper catchment in SNNP	D&B Contractor/PCMU	Annually after monsoon
Erosion and sedimentation	-Effectiveness of controls	Immediate catchment	D&B Contractor/ PCMU	Daily
Tree Felling and Vegetation clearance	-Number of trees cut in project siting and in the project vicinity -Area of vegetation clearance	Nagmati Dam site Nagmati Dam site	D&B Contractor/ PCMU D&B Contractor/ PCMU	Daily
Spoil disposal	Reuse of spoil wherever possible (within and outside the project)	Nagmati Dam site and access roads Spoil disposal	D&B Contractor/ PCMU D&B Contractor/	Daily

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
	-Surplus spoil disposed in the reservoir footprint -Adopted mechanism of spoil disposed in the designated area	sites Spoil disposal sites	PCMU D&B Contractor/ PCMU	
Waste management	-Waste material reused and recycled from project sites, camps and ancillary sites. -Management of non – recyclable waste	Nagmati Dam site and River work sites Bagmati tributaries Same.	D&B Contractor/PCMU D&B Contractor/ PCMU	Daily
Water quality	Worker"s camps drinking water quality (Parameters include as mentioned in table 3.2) -River water quality (DO, BOD, COD, TSS, NO_3-N, NH_4-N, PO_4-P, Faecal Coli). Regular parameters measured by HPCIDBC laboratory. See Table IV-14.	Nagmati Dam project camp and work sites Sample station 500 m downstream Nagmati dam site In Bagmati/Bagmati tributaries the regular HPCIDBC WQ monitoring programme results will be used.	D&B Contractor/ PCMU D&B Contractor/ PCMU HPCIDBC laboratory/PCMU	Monthly Monthly Monthly
Air Quality	-Spraying of water regularly on work activity areas as appropriate. -Vehicular emission tests as per GON standard -Maintenance of the equipment as per specifications	Dam sites, access roads and River work sites Bagmati tributaries -same. -same.	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor/ PCMU	Daily Quarterly Daily
Noise and vibration	-Monitoring of noise levels -Maintenance of equipment in	Nagmati Dam site. Settlements in the SNNP. River	D&B Contractor/ PCMU D&B Contractor/ PCMU	Monthly Daily Daily

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
	accordance with manufacture‟s specifications. -Traffic movement control and limit on horn -Controlled blasting -Monitoring of vibration levels	work sites Bagmati tributaries -same. Nagmati Dam site Nagmati Dam site	D&B Contractor/ PCMU D&B Contractor/PCMU	On going On the advice of PCMU
Workforce Management, health and safety	-Environment/safety meetings informing on workforce rules and regulations. -Enforcement of safety rules and the use of health and safety gear. -provision of grocery shop for foodstuff, kerosene/gas and other goods of daily needs in the Dam camp. -Provision of first aids facility -Provision of adequate and well maintained utility services and facilities.	Nagmati Dam site, access roads and River work sites Bagmati tributaries Nagmati Dam workforce camp Nagmati Dam site, access roads and River work sites Bagmati tributaries	D&B Contractor/ PCMU D&B Contractor/ PCMU D&B Contractor(PCMU	Fortnightly Daily Daily Daily
Aquatic ecology	-Fish species and population size	Sample station 500 m downstream dam site	PCMU	Once in three month
Terrestrial ecology	-Encroachment and vegetation at dam construction site borders. -Effects on habitat, migratory routes within 200 m from dam construction site borders.	Nagmati Dam site Nagmati Dam site	PCMU M&E Unit/ PCMU PCMU M&E Unit/ PCMU	Once in three month Once in three month
Traffic and access	Check maintenance records. -Enforcement on speed limits and horn	Nagmati Dam site, access roads and River work sites Bagmati	D&B Contractor / PCMU	Weekly daily

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
	noise levels.	tributaries		
Drainage	-Direct observation of drainage condition and state of operation.	Nagmati Dam site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor/PCMU	Weekly
Risks	-Maintenance of warning systems and sirens. -Physical obstruction on project prohibited areas. -Appropriate safety gears to labours as required -Safety training to labourers and others involved in construction. -Storage of hazards materials in bounded areas	Nagmati Dam site Nagmati Dam site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor and PCMU D&B Contractor D&B Contractor D&B Contractor D&B Contractor	Every 4 months Daily Daily Monthly Weekly
Hazards	-Use of hazardous goods as per the specifications of the manufactures. -Storage of explosive in guarded bunkers		D&B Contractor	Daily Weekly
Complaint	Complaints received and replied	Nagmati Dam site, access roads and River work sites from Gokarna to Sinamangal	Project Site offices persons responsible for monitoring and maintaining the GRM	As and when necessary
Accidental and emergencies handling	-Enforcement of accidental and emergencies response measure -Maintenance of first aid facility with required facilities and staffs	Nagmati Dam site, access roads and River work sites from Gokarna to Sinamangal Dam camp Sites	D&B Contractor D&B Contractor	Daily Daily

Environmental Issues	**Parameters to be Monitored**	**Location**	**Responsibility Implement/Monitor**	**Frequency**
Post construction phase				
Rehabilitation and re-vegetation	-Effectiveness of rehabilitation measures at sites - Effectiveness of site re-vegetation	Nagmati Dam site and other sites determined by MOFSC or Department of Wildlife Dam sites	D&B Contractor PCMU/SNNP D&B Contractor PCMU/SNNP	Monthly 3-monthly Monthly 3-monthly
Settlement of bilateral dealings with locals	-Meeting with concerned individuals/VDCs and community groups -Handling complaints, if any -Agreement and negotiation	Nagmati Dam site, access roads and River work sites from Gokarna to Sinamangal	D&B Contractor/PCMU PCMU, D&BC, VDCs, GRM	Monthly When required When required
Operation Phase	-			
Aquatic ecology	-Fish stock, species and density survey using net trawling. Three transects. Fish stock, species and density survey using electro fishing.	Nagmati reservoir Nagmati River, 200 and 500 meters downstream Nagmati reservoir	PCMU M&E Unit/ PCM PCMU M&E Unit/ PCM	Once in 3 months Once in 3 months
River bed degradation	-Visual observation of river bed scouring, sedimentation and side erosion	Upper Bagmati River and tributaries	HPCIDBC	Every 6 month
Hydrology	-River flow discharge -Amenity flow of 0,4m^3/s -Flooding and inundation	Upper Bagmati River and tributaries	HPCIDBC	Daily Daily During monsoon
Reservoir foreshore	-Landslides and slope stability -Removal of debris and logs	Nagmati Dam site	HPCIDBC/SNNP HPCIDBC/SNNP	Two times in a year Monsoon season
Compensation planting of trees in SNNP and Buffer Zone	-State of vegetation -Landslides and slope stability -State of protection	SNNP & Buffer Zone SNNP & Buffer Zone	SNNP SNNP SNNP	Monthly Two times in a year

Environmental Issues	Parameters to be Monitored	Location	Responsibility Implement/Monitor	Frequency
		SNNP & Buffer Zone		Monthly
Water Quality	-Water quality measurements. Parameters: Regular parameters measured by HPCIDBC laboratory. See Table IV-14. BOD to be included as soon as laboratory is upgraded.	HPCIDBC monitoring stations in Bagmati/Bagmati tributaries, see Figure IV-10	HPCIDBC regular programme	Monthly
Risk and hazards	-Structural soundness -Maintain flood Warning system and sirens -Monitor Landslides -Enforcement of Occupation Safety rules and regulations	All project structures Bagmati tributaries All project sites Headwork and powerhouse sites	HPCIDBC HPCIDBC HPCIDBC HPCIDBC	Annually Monsoon season Annually Daily

D&B Contractor = Design and Build Contractor, PCMU = Project Coordination and Management Unit, HPCIDBC = High Powered Commission for Integrated Development of Bagmati Civilization. SNNP = Shivapuri Nagarjun National Park. M&E Unit = Monitoring and Evaluation Unit (in PCMU)

G. Monitoring and Reporting

621. The D&B contractors, should develop a construction environmental management plan (CEMP) based on the EMP. The CEMP should be approved by the PCMU. The D&B contractors are to submit monthly CEMP implementation status reports to the PCMU. The monthly progress report should contain information on the works carried out and the results of all monitoring and investigation works performed during that particular month. The report should also include cases of compliance and non-compliance and the corresponding further mitigation measures to be adopted to correct the non-compliances and also include the outcome of the monitoring, important issues identified and the measures to be undertaken to ameliorate them.

622. The monthly reports should be reviewed by the Safeguard and M&E Unit under the PCMU, will submit semi-annual monitoring reports to ADB and MOSTE in a similar format provided in Annex 6. Annual reports on the overall implementation of the EMP should be prepared by the Safeguard and M&E Unit for distribution to MOSTE.

623. The reporting system should be based on site supervision to see whether mitigation measures are carried out according to the EMP. The PCMU Safeguard and M&E unit together with the River Works Planning Unit and the Dam Design and Supervision Unit are responsible for checking the monthly progress reports submitted by the Contractors and have field verified whether or not the Contractors have complied with the approved conditions as stated in the CEMP. Quarterly reports should be prepared by the Safeguard and M&E Unit for review by the

Project Director and be distributed to the Steering Committee for review. The Environment specialist should review any comments received and act accordingly.

624. EA and PCMU shall keep all records pertaining to project environmental and safety management, mitigation measures, corrective actions and environmental monitoring during the pre-construction and construction phases of the Project. In the operation phase monitoring and maintenance of records of environmental related measures and monitoring will be the responsibility of the IA/Project operator.

625. The Independent Environmental Monitoring Consultant shall carry out quarterly compliance monitoring and reporting regarding the environmental performance during the construction phase. The independent consultant shall submit its reports to ADB, EA and IAs and MoSTE. The MOSTE shall review the Annual Report and if required visit the Project sites and provide recommendations for further environmental safeguards and updates of the EMP. The PCMU shall prepare a compiled audit report of the BRBIP after three months of the completion of the construction phase.

626. During the operation phase the IA/Project operator shall undertake a compliance audit of all project sites every six months over the initial three years of Project operation and then annually afterwards.

H. Environmental Management Budget and Resources

Table IX-7: Environmental Management and Monitoring Costs (USD)

Item	Quantity	Unit Cost	Total Cost	Sub-total
1. EMP consultants				
Domestic Environmental Monitoring Specialist	14 month	4,500	63,000	
Watershed Management Specialist	4 month	4,500	18,000	81,000
2. Environmental Monitoring				
Air, Noise, Soil testing	4 years	7,000	28,000	
Aquatic and Terrestric Ecology	4 years	21,000	84,000	
Hydrology	4 years	6,000	24,000	136,000
3. Public Consultations				
Domestic Consultant/NGO	4 years	10,000	40,000	40,000
4. Independent Environment M&E				
Environment consultant	10 months	4,500	45,000	
Transport and other costs, lump sum			8,500	53,500
5. Watershed Management				
Tree Planting Compensation, Dhap	16 ha[i]	450	39,150	
Watchmen, Dhap compensation	7 over 5 years	1,400	121,800	
Tree Planting Compensation, Nagmati (Phase II)	255 ha	450	114,750	
Watchmen, Nagmati compensation (Phase II)	112 over 5 years	1,400	784,000	

Watershed improvement &income generation	4 years	14,000	56,000	
Formation management plan & committees	4 years	15,000	60,000	
Waste & wastewater management	4 years	25,000	100,000	1,275,700
Organic farming &				
6. Support Park Management				
Communication Equipment & Transport			43,000	43,000
7. PCMU Safeguard and M&E Unit				
Senior safeguard specialist	60 month	242	14,520	
Environmentalist	60 month	216	12,960	27,480
SUB-TOTAL				**1,656,680**
Contingencies 10%				**165,668**
TOTAL				**1,822,348**

I: Planting density is 2500 trees/ha

X. CONCLUSION AND RECOMMENDATIONS

627. Overall, the BRBIP project will provide substantial environmental benefits and increase water security for the population in the Upper Bagmati. The Project will be implemented over 2 Phases with the major interventions in Phase I being extension of the existing Dhap Dam and reservoir in the Svivapuri Nagarjun Nation Park, and provision of river protection, green zoning and beautification in the Upper Bagmati, with a range of support interventions.

628. During Phase II it is envisaged to implement a larger storage facility at the Nagmati River, a tributary to the Bagmati River in Shivapuri Nagarjun National Park. In addition extend the river protection, green zoning and beautification in the tributaries in the Upper Bagmati basin.

A. Phase I

1. Extension of the Dhap:

629. The environmental impacts caused by siting, planning, design, pre-construction; construction and operation of the Dhap are generally minor. The negative impact from clearing of the trees at the borders of the Dhap will be fully compensated through replanting of trees following GoN rules.

630. Extension of the Dhap will provide important benefits for securing a more sustainable low flow during the dry season, and improve water availability and safe bathing standards at temple sites during festivals. It is recommended that the extension of the Dhap is implemented following the Bagmati Action Plan.

2. Watershed Management and Livelihood Improvement

631. Watershed management initiatives will have no negative environmental impacts.

632. Watershed management initiatives in the Shivapuri Nagarjun National Park will reduce soil erosion in the catchment in Shivapuri Nagarjun National Park and provide improved livelihood through income generating initiatives such as organic farming, provision of fuel efficient stove cooking facilities, solid waste and wastewater handling. It is recommended to implement the proposed watershed initiatives.

3. Upper Bagmati River Improvement:

633. The river improvement works for the Upper Bagmati will have only minor negative impacts that will be reduced or entirely mitigated through the EMP.

634. The considerable environmental benefits over the lifetime of the interventions by far outweigh any minor, temporary impacts during construction.

635. During operation the interventions will provide a sustainable river environment for the benefit of the population along the Upper Bagmati. It is recommended to implement the Upper Bagmati River Improvement works.

4. Rainwater Harvesting

636. The implementation of rainwater harvesting in the urbanising areas in the Upper Bagmati will have no negative environmental impacts.

637. Installing rainwater harvesting retains the groundwater recharge capacity in areas, where traditional housing and urbanisation will prevent groundwater recharge. It is recommended to implement the rainwater harvesting facilities.

5. Community Mobilisation and Awareness Raising

638. Community mobilisation and awareness raising is an important component of Phase I that will create ownership of the improved river environment among the people living along the Bagmati River with the target that they adopt the river environment and help to protect and maintain it.

B. Phase II

639. Where the extension of the Dhap Dam during Phase I create opportunity for achieving bathing water quality standards at temple sites down to Pashupatinath during festivals in the dry season, establishing the Nagmati dam will provide a storage capacity to achieve year round bathing water quality at the temple sites down to Pashupatinath.

640. The environmental impacts caused by siting, planning, design, pre-construction; construction and operation of the Nagmati are generally minor and can be mitigated. The negative impact from clearing of the trees in the Nagmati reservoir area will be fully compensated through replanting of trees following GoN rules.

641. It is recommended that the Nagmati Dam is implemented following the Bagmati River Environment Management Plan.

APPENDIX 1: LIST[80] AND MAP OF PROTECTED AREAS OF NEPAL

National parks

- Chitwan National Park – 932 km^2
- Sagarmatha National Park – 1,148 km^2
- Langtang National Park – 1,710 km^2
- Rara National Park – 106 km^2
- Khaptad National Park – 225 km^2
- Shey Phoksundo National Park – 3,555 km^2
- Bardiya National Park – 968 km^2
- Makalu Barun National Park – 1,500 km^2
- Shivapuri Nagarjun National Park – 159 km^2
- Banke National Park – 550 km^2

Wildlife reserves

- Koshi Tappu Wildlife Reserve – 175 km^2
- Parsa Wildlife Reserve – 499 km^2
- Sukla Phanta Wildlife Reserve – 305 km^2

Conservation areas

- Annapurna Conservation Area – 7,629 km^2
- Manaslu Conservation Area – 1,663 km^2
- Kanchenjunga Conservation Area – 2,035 km^2
- Makalu-Barun Conservation Area-1,500;km^2
- Api nampa conservation area-1,903; km^2
- Gaurishankar Conservation Area-2,179 km^2
- Blackbuck Conservation Area-15,95 km^2

Hunting Reserve

- Dhorpatan Hunting Reserve – 1,325 km^2

Ramsar Sites

- Beeshazar Tal – 3,200 ha
- Ghodaghodi Tal – 2,563 ha
- Jagdishpur Reservoir – 225 ha

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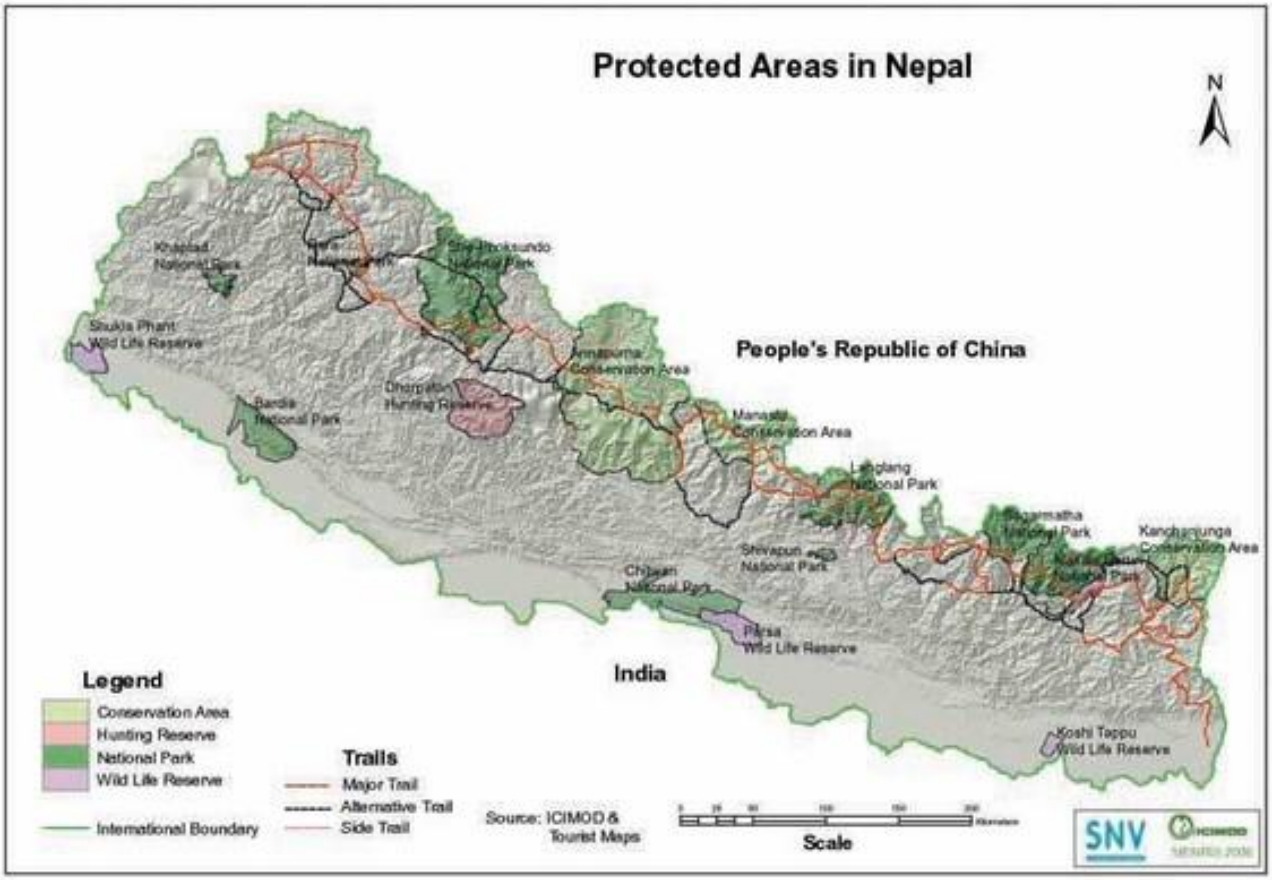
[80] Bhuju, U. R., Shakya, P. R., Basnet, T. B., Shrestha, S. (2007) *Nepal Biodiversity Resource Book. Protected Areas, Ramsar Sites, and World Heritage Sites*. International Centre for Integrated Mountain Development, Ministry of Environment, Science and Technology, in cooperation with United Nations Environment Programme, Regional Office for Asia and the Pacific. Kathmandu, ISBN 978-92-9115-033-5
Bhushal, R. P. (2010) *Nod to Banke National Park*. The Himalayan Times, 13 May 2010


Protected Areas in Nepal
N
People's Republic of China
India
Shukla Phant
Wild Life Reserve
Bardia
National Park
Dhorpatan
Hunting Reserve
Annapurna
Conservation Area
Manaslu
Conservation Area
Langtang
National Park
Sagarmatha
National Park
Kanchanjunga
Conservation Area
Shivapuri
National Park
Chitwan
National Park
Parsa
Wild Life Reserve
Koshi Tappu
Wild Life Reserve
Legend
Conservation Area
Hunting Reserve
National Park
Wild Life Reserve
International Boundary
Trails
Major Trail
Alternative Trail
Side Trail
Source: ICIMOD &
Tourist Maps
Scale
SNV

APPENDIX 2:NATIONAL AND INTERNATIONAL WATER, AIR AND NOISE QUALITY STANDARDS

Water Quality Standards

Parameter	Drinking Water Source[a]			Aquatic Life[b]	Bathing[b]	Agriculture[b]
	World Bank	EPA, USA	Nepal Standard			
pH	6.5 – 9.2	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	6.5 – 9.0	6.5 – 9.0
TDS, mg/l	1,500	500	-	1,000	1,500	500 – 3,000
SS, mg/l	-	-	-	25	50	-
DO, mg/l	-	< 6	-	6	3	3
Cl, mg/l	600	-	-	500	1,000	100 – 1,000
SO_4, mg/l	400	-	-	500	1,000	1,000
NO_3-N, mg/l	-	10	50	20	20	25
NO_2-N, mg/l	-	1.0	-	0.15	1.0	1.0
NH_3, mg/l	-	0.5	1.5	0.02	0.2	0.2
Total PO_4-O, mg/l	0.1	50	-	0.1	0.2	0.2
BOD, mg/l	4	5	-	4	6	10
F, mg/l	3	0.3	0.3	1.0	1.5	1.5
Total Hg, mg/l	-	-	-	0.0001	0.001	0.001
Total Cd, mg/l	-	0.005	-	0.005	0.005	0.01
Total Pb, mg/l	0.05	0.005	0.01	0.05	0.05	0.1
Cr, mg/l	-	0.1	0.05	0.05	0.05	0.1
Phenol, mg/l	0.002	-	-	0.005	0.1	0.1
Total Cyanide, mg/l	0.2	-	-	0.005	0.2	0.2
Total Coliform, /100	20,000	1.0	-	-	1,000	1,000

[a] as a raw source; [b] from World Bank, 1994
Source: World Bank, 1994; DHM, 2008

National Ambient Air Quality Standards for Nepal , 2003

Parameters	Units	Averaging Time	Concentration in Ambient Air, maximum	Test method
TSP (Total Suspended Particulars)	µg/m^3	Annual	-	
		24-hours*	230	High Volume Sampling
PM 10	µg/m^3	Annual	-	
		24-hours*	120	Low Volume Sampling
Sulphur Dioxide	µg/m^3	Annual	50	Diffusive sampling based on weekly average
		24-hours**	70	To be determined before 2005A.D
Nitrogen Dioxide	µg/m^3	Annual	40	Diffusive sampling based on weekly average
		24-hours**	80	To be determined before 2005A.D
Carbon Monoxide	µg/m^3	8 hours**	10,000	To be determined before 2005A.D
		15 minute	100,000	Indicative samplers ***
Lead	µg/m^3	Annual	0.5	Atomic Absorption Spectrometry, analysis of PM 10 samples****
		24-hours	-	
Benzene	µg/m^3	Annual	20*****	Diffusive sampling based on weekly average
		24-hours	-	

* Note: 24 hourly values shall be met 95% of the time in a year. 18 days per calendar year the standards may be exceeded but not on two consecutive days.

**Note: 24 hourly standards for NO2 an SO2 and 8 hours standard for CO are not to be controlled before MoPE has recommended appropriate test methodologies. This will be done before 2005.

***Note: Controlled by spot sampling at roadside locations: Minimun one sampler per week taken over 15 minutes during peak traffic hours, i.e in the period 8am-10am or 3pm-6pm on a work day. This test method will be re-evaluated by 2005.

****Note: If representativeness can be proven, yearly averages can be calculated from PM10 samples from selected weekdays from each month of the year.

WHO: Guideline values for community noise in specific environments[81].

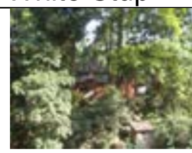
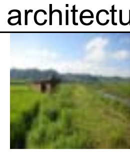
Specific environment	Critical health effect(s)	LAeq [dB]	Time base [hours]	LAmax, fast [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility and moderate annoyance, daytime and evening Sleep disturbance, night-time	35 30	16 8	 45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school bedrooms, indoors	Sleep disturbance	30	sleeping-time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial shopping and traffic areas, indoors and outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/ earphones	Hearing impairment (free-field value)	85 #4	1	110

81 http://www.who.int/docstore/peh/noise/Commnoise4.htm - Nepal does not have National Standards for noise, but usually WHO Standards are then followed.

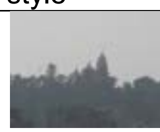
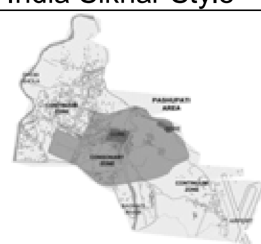
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservation areas	Disruption of tranquillity	#3		

#1: as low as possible;
#2: peak sound pressure (not LAmax, fast), measured 100 mm from the ear;
#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;
#4: under headphones, adapted to free-field values

APPENDIX 3: INVENTORY OF CULTURAL HERITAGE SITES ALONG BAGMATI RIVER FROM SUNDARIJAL TO SINAMANGAL

S. no.	Name of Temple	Location VDC	Remarks	Coordinates	
				N	E
1	Buddhist Stupa and Ghat	Sundarijal	  White Stup	27^0 45" 41.30”	85^0 25" 21.62”
2	Majuwa Temple	Sundarijal	 Temple surrounded by restaurant	27^0 45" 40.42”	85^0 25" 18.57”
3	Radha Krishna Temple	Sundarijal	 Hybrid tired style temple	27^0 45" 40.64”	85^0 25" 17.15”
4	Ganesh Temple	Sundarijal	 Hybrid tired style temple	27^0 45" 45.15”	85^0 25" 17.73”
5	Barah Mandir Sundarijal Bridge	Sundarijal	no particular architectural style	27^0 45" 21.31”	85^0 25" 14.25”
6	Buddhist Monastry	Sundarijal	 no particular architectural style	27^0 45" 15.28”	85^0 25" 19.96”
7	Kageshwori Mandir	Alapot/ Sundarijal	  One Kathmandu pagoda style, the other without any particular style	27^0 45" 12.14” 27^0 45" 08.27”	85^0 25" 19.05” 85^0 25" 21.00”
8	Nikhil Dham	Alapot	 European Cottage style	27^0 44" 48.21”	85^0 25" 16.62”

9	Kolmateshwor Mandir	Thali Danchhi	 Pagoda Style in concrete	27^0 44" 01.07”	85^0 24" 17.73”
10	Uttarbahini/Kanti Bhairab Temple Complex and Ghat	Gokarneshwor	  Chinese octagonal pagoda style	27^0 44" 07.06”	85^0 23" 50.11”
11	Krishna Temple and Ghat	Gokarneshwor	 No particular architectural style	27^0 44" 16.43”	85^0 23" 31.31”
12	Gokarneshwor Mahadev Temple Complex and Ghat	Gokarneshwor	 Kathmandu Pagoda style	27^0 44" 21.61”	85^0 23" 15.92”
13	Bhagwati Temple	Jorpati	 Pagoda Style in concrete	27^0 44" 16.81”	85^0 23" 05.47”
14	Maruwa Ghat (for cremation)	Alapot		27^0 44" 53.83”	85^0 25" 21.32”
15	Gajmai Ghat (for cremation)	Nayapati		27^0 44" 28.67”	85^0 24" 43.84”
16	Nayapati Khahare Ghat/Floriculture (for cremation)	Nayapati		27^0 44" 32.46”	85^0 24" 53.50”
17	Bhadrabas Ghat (for cremation)	Bhadrabas		27^0 45" 42.11”	85^0 25" 21.18”
18	Sri Dakshin Bahini Sankaleshwar (Ardha Narishwari) Mahadev	Jorpati	 Hybrid tired temple style	$27^0$43.273"	$35^0$35.930"

19	Rameshwar Siva Temple and Ghat	Jorpati	  non architectural style	27^0 43.071"	85^0 22.896"
20	Durga Tara Dayamayi	Jorpati	 Hybrid tired temple style	27^0 43.157"	85^0 22.962"
21	Saraswati Temple	Jorpati	 non architectural style	27^0 43.503"	85^0 23.000"
22	Radha Krishna Temple	Jorpati	 Hybrid tired temple style	27^0 43.584"	85^0 23.006"
23	Radha Krishna Temple	Gothatar	 India Sikhar Style	$27^0$42"47.41 "	$85^0$22" 33.12"
24	Pashupatinath Temple Complex	Kathmandu Metropolis	 Different rich Nepalese architectural style Temples and other structures. World Heritage Site.	Pashupati Temple – 27^0 42" 37.82" Guheshwari Temple – $27^0$42" 40.35"	85^0 20" 55.43" 85^0 21" 11.86"

APPENDIX 4: SCREENING OF PROTECTED BIRD SPECIES WITH RESPECT TO THEIR POSSIBLE PRESENCE IN OR IN THE VICINITY OF THE DHAP DAM SITE

SN	Bird Species	Status	Likely in SNNP1	Season	Habitat	Nesting Season	Food	Likely at Nagmati Site
1	Hodgson"s Bushchat (Saxicola insignis)	Vulnerable (IUCN 2012) and Endangered nationally (BCN and DNPWC 2011)	Yes	Winter visitor for Nepal	Grass land, tall grass and Reeds nearby river	June	Insects and fruits	Least possibility (only single unusual record from Chisapani area which is aerially 2 km far from Dhap
2	Saker Falcon (Falco cherrug)	Endangered (IUCN 2012)	Yes	Wintering and passage migrants	Open country	NA	Dove, piegon,, insects, rodents	Possible
3	White-rumped Vulture (Gyps bengalensis)	Critically Endangered (IUCN 2012, BCN and DNPWC 2011)	Yes	Residential (All year)	Open country, Tall tree and human habitation	Oct-April	Scavenger	Least possibility
4	Grey-sided Laughingthrush (Garrulax caerulatus)	Vulnerable nationally (BCN and DNPWC 2011) Globally Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
5	Blue-winged Laughingthrush (Garrulax squamatus)	Vulnerable nationally (BCN and DNPWC 2011 and Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
6	White-tailed Stonechat (Saxicola leucurus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes (Field survey 2012	Residential (All year)	Grass land	NA	Insects, fruits	Least Possible (It is recorded at downstream which is aerially 2 km far from Dhap
7	Brown Wood	Vulnerable	Yes	Residential	Primary	NA	Rodents,	Least

	Owl (Strix leptogrammica)	Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)		(All year)	Forest		birds and reptiles	Possibility
8	Spot-bellied Eagle Owl (Bubo nepalensis)	Nationally Endangered (BCN and DNPWC 2011) Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	Dec-March	Rodents, birds and reptiles	Least Possibility
9	Lammergeier Vulture (Gypaetus barbatus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
10	Egyptian Vulture (Neophron percnopterus)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
11	Himalayan Griffon (Gyps himalayensis)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
12	Cinereous Vulture (Aegypius monachus)	Near Threatened (IUCN 2012) and Nationally Endangered (BCN and DNPWC 2011)	Yes	Uncommon winter visitor	Open country	NA	Scavenger	Least Possibility
13	White-breasted Waterhen	Fairly common	Yes	Residential (all year)	Wetland	June-October	Insects, aquatic	Confirmed

	(Amaurornis phoenicurus)	and widespread (Grimmett et al 2009) and Least Concern (IUCN 2012)					vertebrates, small fishes and seeds	
14	Wedge-tailed Green Pigeon (Treron sphenura)	Fairly common in Nepal (Grimmett et al 2009) and global status not assessed (IUCN 2012)	Yes	Residential	Observed at Tree near by wetland	NA	Seeds	Confirmed

BCN and DNPWC (2011) *The State of Nepal's Birds 2010*. Kathmandu: Bird Conservation Nepal and Department of National Parks and Wildlife Conservation.
Grimmett, R., Inskipp, C. and Inskipp, T. (2009) *Birds of Nepal.* Second edition. London, UK: Christopher Helm.
SNP and BCN (2007). Birds of Shivapuri National Park. Shivapuri National Park and Bird Conservation Nepal, Kathmandu.
IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on 17 November 2012.

APPENDIX 5: SCREENING OF PROTECTED BIRD SPECIES WITH RESPECT TO THEIR POSSIBLE PRESENCE IN OR IN THE VICINITY OF THE NAGMATI DAM SITE

Bird Species	Status	Likely in SNNP (BCN and DNPWC 2010)	Season	Habitat	Nesting Season	Food	Likely at Nagmati Site
Hodgson‟s Bushchat (Saxicola insignis)	Vulnerable (IUCN 2012) and Endangered nationally (BCN and DNPWC 2011)	Yes	Winter visitor for Nepal	Grass land, tall grass and Reeds nearby river	June	Insects and fruits	Least possibility. Only one single unusual record from Chisapani area which is aerially 4 km far from Nagmati
Saker Falcon (Falco cherrug)	Endangered (IUCN 2012)	Yes	Wintering and passage migrants	Open country	NA	Dove, pieGoN,, insects, rodents	Possible
White-rumped Vulture (Gyps bengalensis)	Critically Endangered (IUCN 2012, BCN and DNPWC 2011)	Yes	Residential (All year)	Open country, Tall tree and human habitation	Oct-April	Scavenger	Least possibility
Grey-sided Laughingthrush (Garrulax caerulatus)	Vulnerable nationally (BCN and DNPWC 2011) Globally Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
Blue-winged Laughingthrush (Garrulax squamatus)	Vulnerable nationally (BCN and DNPWC 2011 and Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible

White-tailed Stonechat (Saxicola leucurus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes (Field survey 2012	Residential (All year)	Grass land	NA	Insects, fruits	Confirmed at downstream location
Brown Wood Owl (Strix leptogrammica)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	NA	Rodents, birds and reptiles	Least Possibility
Spot-bellied Eagle Owl (Bubo nepalensis)	Nationally Endangered (BCN and DNPWC 2011) Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	Dec-March	Rodents, birds and reptiles	Least Possibility
Lammergeier Vulture (Gypaetus barbatus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
Egyptian Vulture (Neophron percnopterus)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
Himalayan Griffon (Gyps himalayensis)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility

Cinereous Vulture (Aegypius monachus)	Near Threatened (IUCN 2012) and Nationally Endangered (BCN and DNPWC 2011)	Yes	Uncommon winter visitor	Open country	NA	Scavenger	Least Possibility

APPENDIX 6: SAMPLE FORMAT OF BI-ANNUAL ENVIRONMENTAL MONITORING REPORT

Initial Table of Contents

Subject	**Page No.**
Part 1: introduction	
1.1: Purpose of Report	
1.2: Scope and Status of Work	
Part 2: Incorporations of Environmental Requirements into Project Contractual Arrangements (How EMP requirements are incorporated into contractual arrangement or any other)	
Part 3: Environmental Management	
3.1 Mitigatory measures (i)describe if mitigatory measures were adopted as described in EMP (for each activity described in the EMP), if there were shortcomings how it was remedied and the effectiveness of the suggested mitigatory measures (ii) Status of Environmental licenses and permits (such as rock blasting, approvals obtained validity of permits) (iii) Any other mitigatory measures that should be included/were included not identified in the EMP	
3.2 Environmental Monitoring (i) Summary of Monitoring (ii) Results and Assessments (iii)identify reasons non-compliance /exceeding limits and suggest remedial action	
4. Record of Public Greivances (should describe location, nature, response taken and action and follow up)	
5. Conclusions and Recommendations (i) Overall Effectiveness of Environmental management (ii) Key issues and actions recommended (iii) proposed monitoring for next reporting period	

APPENDIX 7: NAGMATI & DHAP DAMS - ESTIMATED PEAK SITE WORKFORCE

NAGMATI & DHAP DAMS - ESTIMATED PEAK SITE WORKFORCE						
(A) Peak Construction Activities						
1. Rockfill dam - rockfill						
2. Rockfill dam - concrete face						
3. Spillway						
	Position	No Nagmati	Sub-total	Total		No Dhap
(B) WORKFORCE - CONSTRUCTION						
1. Rockfill dam - quarry & rockfill						
	Drill/blast crew					
	Loader driver					
	Truck drivers					
	Compactor operator					
	Trimmer					
	Supervisor					
2. Rockfill dam - concrete face						12
	Carpenters (formwork)					
	Steel placers					
	Concrete workers					
	Concrete truck drivers					
	Supervisor					
3. Spillway						17
	Carpenters (formwork)					
	Steel placers					
	Concrete workers					
	Concrete truck drivers					
	Supervisor					
4. Allied						7
	Road maintenance crew					
	Concrete plant operators					
	Mechanics					
	Crane operator					
	Other					
						6
(C) CAMP & RELATED						
	Camp supervisor					

	Camp maintenance/cleaners					
	Cooks & kitchen crew					
						11
(D) **CONTRACTORS OFFICE**						
	Manager					
	Procurement staff					
	Accountant					
	Clerks					
	Drivers					
						9
(E) SUPERVISORY CONSULTANT'S STAFF						
	Chief RE					
	Clerk of works					
	Admin					
	Driver					
					9	
						70

APPENDIX 8: NOISE AND DISTURBANCE SENSITIVE LOCATIONS

In accordance to the progress of the River Improvement works in the Upper Bagmati, noise measurements should be carried out once a week, when works are in progress within 200 meter at the sensitive positions. Noise not to exceed 55 dB, see WHO Guidelines, Appendix 3.

Name of Hospital

S.No	Name Of Hospital	Location	Distance
1.	Nepal medical college and teaching hospital	Jorpati	200 m
2.	Nepal AURTHOPEDIC Hospital Gaucher	Jorpati,	100m
3.	Tilganga Eye Hospital	Tilganga	50 m
4.	Shanti Sewa Griwa	Sinamangal	50 m
5.	Nobel Hospital & Research Center	Sinamangal	150 m

East/South of The River

S.No	Name of College/ Schools	Location	Distance
1.	Nobel College	At Sinamangal Bridge	60 m
2.	Everset Montashowori	Near Sinamangal Bridge	10m
3.	Sarada Lower Sec. School	Near Tilganga Bridge	185 m
4.	Akash Deep H. Sec. School	On Ganglal Way(Jorpati)	200m
5.	Jaya multiple campus	At Gokarna	100 m
6.	World youth international School	At Gokarna	50 m
7.	Shreee Okharani Sec. School	Sundarijal	200 m

North/West of The River

S.No	Name of College / Schools	Distance	Distance
1.	Amar Ardsha School	Near Sinamangal Bridge	20m
2.	Venue English School	-Near Sinamangal Bridge	35 m
3.	Classical International School	Near Sinamangal Bridge	42 m
4.	Paravane Public English School	Near Sinamangal Bridge	19 m
5.	Nepal Music Center	Between Sinamangal and Tilganga Bridge	150m
6.	Classic College	Near Tilganga Bridge	20 m
7.	New Shrine B.School	Near Tilganga Bridge	120 m
8.	Hilary High School	Near HPCIDBC (Gaurighat)	140 m
9.	Francis International Residental S. And Team	Near Gaurighat	150 m
10.	Kathmandu International School	Near Gaurighat	150 m
11.	Om Sai Monatashori	Near Gaurighat	150 m
12.	Peace Nepal Academy	Near Gaurighat	200 m
13.	Khagendra Navajeevan Kendra S. School	On Ganglal Way(Jorpati)	200m
14.	All Nepal Institute of medical Science	On Ganglal Way (Jorpati)	60 m
15.	Chamunda Secondary School	On Ganglal Way (Jorpati)	200 m
16.	SOS Children Village	On Ganglal Way (Jorpati)	200 m
17.	Rai School	Near Ganglal Way (Jorpati)	200m
18.	Sahayogi Multiple Campus	Gokarna	150 m
19.	Himalayan International Model HSS	Jorpati	100m
20.	Nepal Training Scout Sport	Sundarijal	150 m

APPENDIX 9: LIST OF PARTICIPANTS, EIA WORKSHOP 23RD APRIL 2013.

S.N.	Name	Organization	Email	Contact no.
1	Nawa Raj Khatiwada	NDRI	nawaraj9@yahoo.com	9841297381
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3	Janardan Khadka	Sundarijal Gokarna Sarokar		9841466147
4	Mr. Gopal Prakash Bhattarai	Shivpuri Nagarjun National Park	snpwh@hotmail.com	9851004501
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8	Meg Ale	NRCT	NRCT	9851031431
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15	Manjula Amerasinghe	ADB		
16	Santosh Bhandari	NGO Forum		01-4216606
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23	Sunil Kumar Shrestha	Power to the People	sks@powertopeople.org.np	9851090448
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30	Amita Bajracharya	Gokarna VDC	Amita-rajlawat@yahoo.com	9841702873
31	Him Gautam	DWSS	himage@yahoo.com	9841468377
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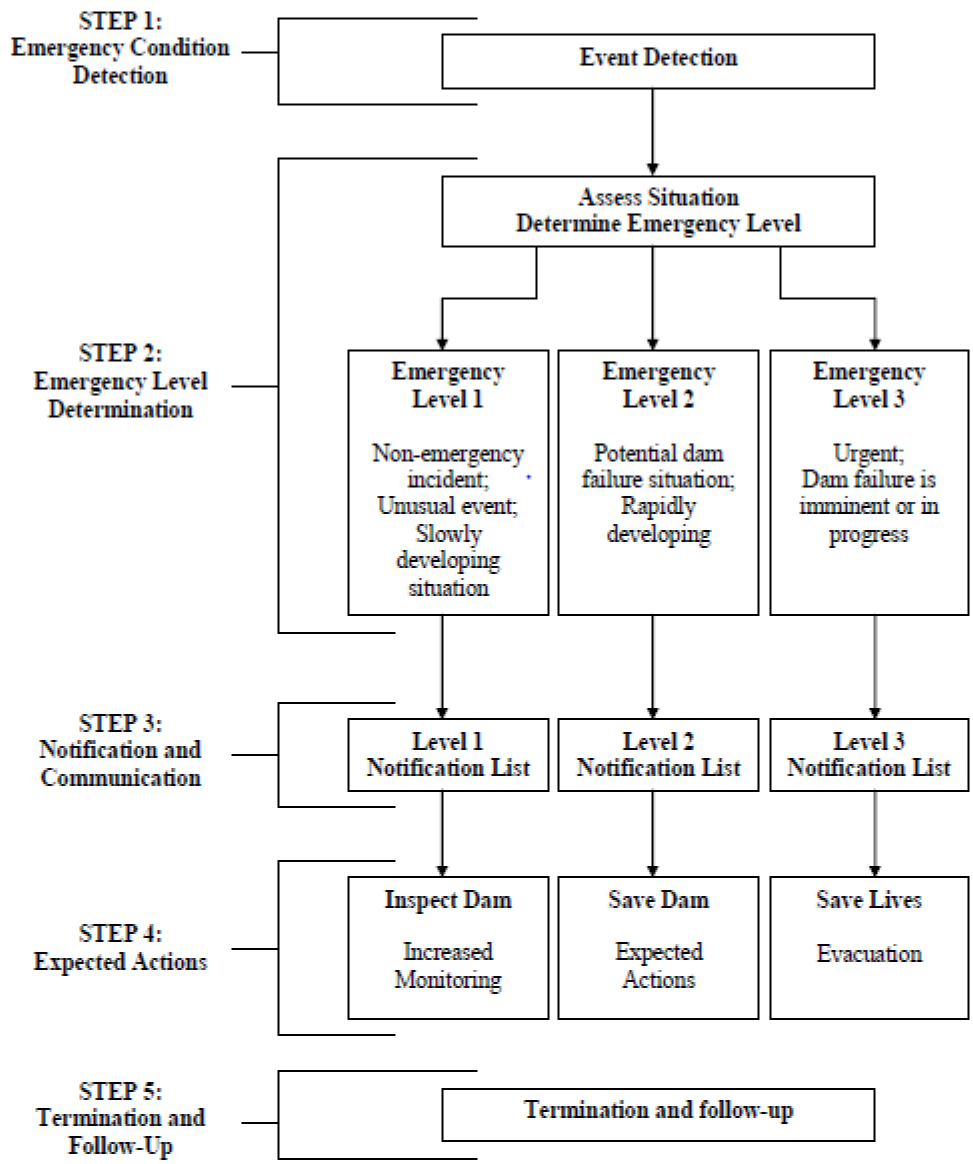
33	Bickey Shrestha	BRBIP	bickeyshrestha@yahoo.cpm	9808001406

APPENDIX 10: OUTLINE OF EMERGENCY ACTION PLAN.

EXAMPLE DAM EMERGENCY ACTION PLAN

EMERGENCY ACTION PLAN OVERVIEW



APPENDIX 11: FINAL REPORT OF THE FIELD SURVEYS CONDUCTED IN THE UPPER BAGMATI RIVER BASIN FOR THE PROPOSED DAM SITES AT DHAP AND NAGMATI

FINAL REPORT

of the Field Surveys Conducted in the Upper Bagmati River Basin for the Proposed Dam Sites at Dhap and Nagmati

Submitted to the:

Bagmati River Basin Improvement Project

(ADB TA 8050 Nep)

By:

Aquatic Ecology Centre

Kathmandu University
Dhulikhel-7, Kavre, Nepal

CONTENTS

1. GENERAL SUMMARY AND FINDINGS

Detailed field surveys to assess the present status of vegetation, wildlife, birds and aquatic invertebrates in the vicinity of the proposed dam sites at Thulo Dhap and Nagmati River and potential impacts due to dam construction and water impoundment were done during September thorugh November 2012. A brief summary of the overall findings are provided below.

2. Vegetation Survey of the Upper Bagmati River Basin

The vegetation survey yielded a total of 96 flowering plants along the survey area, out of which 38 tree species were documented. The average tree volume was highest in Nagmati area with 127.35 cu m per hectare, followed by Bagmati site with 84.53 cu m per hectare and least was recorded in Dhap area with 58.21 cu m per hectare. The volume of *Quercus glauca* was higher in Bagmati area with 36.98 cu m per hectare whereas the volume of *R. arboreum* was maximum in Nagmati area with 22.85 cu m per ha. Similarly, the volume of *Symplocos sumuntia* was higher in Dhap area with 8.58cu m per ha.

Seven species and two groups were identified as being sensitive taxa, and proper mitigation measures such as compensatory planting and exclusion of certain areas from inundation are suggested to minimize impacts. Dhap area was identified as an ecologically important habitat as it is a major source of water for Nagmati River and home to several important flora and fauna.

It is believed that the construction of dams will have a minimal effect on human settlement and further the forest is in secondary succession stage, therefore, inundation of mature trees is unlikely. Compensatory plantation of potential submerged species and plantation in the nearby habitat for orchids can easily nullify any potentially adverse impacts.

3. Wildlife Survey of the Upper Bagmati River Basin

The proposed project area was found to have more than 10 different species of wild mammals. Therefore, the project area can be said to have some core wildlife habitat and some important movement corridors for wildlife. The park record shows that the park provides shelter to 21 species of mammals including clouded leopard (*Neofelis nebulosa*), common leopard (*Panthera pardus*), leopard cat (*Prionailurus bengalensis*), jungle cat (*Felis chaus*), Himalayan black bear (*Ursus thibetanus*), Pangolin (*Manis* sp.), and many other prey species (Pandey, 2010). Different species of bats such as Great Roundleaf bat *Hipposideros armiger,* Greater False Vampire Bat *Megaderma lyra*, LittleTube–Nosed Bat *Murina aurata,* Common bent wing bat *Miniopterus schreibersii*, Intermediate horse shoe bat *Rhinolophus affinis*, Greater horse-shoe bat *Rhinolophus ferrumequinum*, Big-eared Horseshoe Bat *Rhinolophus macrotis* and Least Horseshoe Bat (*Rhinolophus pusillus)* have also been recorded.

The proposed project works is likely to inundate some core habitats and corridors for wildlife movement. Additionally, wildlife casualties, increased hunting and poaching may be deleterious to wildlife diversity in the project area unless stringent measures are taken to control such activities. Thus, appropriate practical measures like relocation of some animals, creating temporary animal shelters, and minimizing noise and worker movement during the construction phase, will be necessary to mitigate such impacts on wildlife and their habitat. On the other hand, some beneficial effects, such as the creation of new habitats (wetlands and grass lands) can also be anticipated as a result of the project implementation.

4. Birds Survey of the Upper Bagmati River Basin

The maximum number of birds recorded in SNNP in previous studies was 318 species. In this survey, five, fisrt ever reported species of birds have been recorded within the SNNP area making the new total recoded species at 323. Among them, one is a vulnerable species (National status). Studies showed 12 species of nationally and globally threatened birds in SNNP. This park also harbors the only endemic species of Nepal, Spiny babbler.

Cutting down the fruit bearing trees in the proposed site will have a major impact on the habitat of tree roosting birds, whereas submersion of breeding ground after the construction of dam may cause impact to the water birds. Plantation of fruit bearing trees species like *Pyrus pashia, Pyracantha crenulata Quercus semecarpifoloa,* etc., must be carried out to mitigate the habitat loss of tree birds and possible construction of islands within the dam or creating new wetlands in other parts of Dhap will help mitigate the impacts on breeding ecology of water birds.

As birds are highly mobile and the proposed project areas are small relative to the entire national park area, it may be concluded that the impacts to the existing bird speices and their habitats is likely to be minimal. It should also be noted that the creation of additional wetlands may in fact create new habitats to attract other migratory bird species to the area.

5. Aquatic Invertebrates Survey of the Upper Bagmati River Basin

Damming obviously modifies natural flow regimes and alters the habitat as well as other physical and chemical characteristics of the river. Physical habitat is a prime factor influencing the composition and abundance of stream faunal communities that form one of the important components in the lotic environment as indicators of environmental quality. Faunal characteristics of downstream to the dam site are altered due to dam buildings, which in turn also alter the physical and chemical characteristic features of the riverine environment.

The survey revealed that species diversity and abundances are very high for nearly all aquatic invetebrate groups in addition to algae (all groups) and other aquatic plants. The percentage of individuals and the taxon diversity of Chironomidae further increases (predominantly Orthocladiinae, in quietly flowing reaches Tanytarsini and Chironomini). The net-spinning trichopterans are usually numerous only where suitable current velocities are available; whereby Polycentropodidae can appear in large quantities in potamal regions. Macrophytes can cover areas but usually green algae (Chlorophyceae) do not yet appear in large quantities. The river qualities at the six sampled locations varied from category I-II to II, indicating comparatively clean/good water quality. The proposed project is likely to alter the distribution and diversity of species found along the sampled river stretches.

6. Fish Survey for Environmental Study of the Upper Bagmati River Basin

The fish sampling was done by “Wading Method” using backpack electro-fishing gear which is an internationally accepted standard method to sample fish in a wadeable river/stream. The fish sampling was done in two runs of around 20 minutes each to cover as much habitat condition as possible and the precise measure of the abundance of fish species is taken as the average of the two

The poor assemblage of fish species in the area corresponds with the physical conditions of the habitat governed by the rule of increasing altitude and decreasing temperature. Though the fishery is of minor interest, the occurrence of loaches, ***Schistura beavani*** **(Günther, 1868)** might have ecological significance as the species has not been reported from such altitudes in Nepalese rivers. However, this is one of the most common species in Nepalese rivers. Another species, ***Schizothorax richardsonii*** **(Gray 1832),** popularly known as Snow Trout or Asala, which was recorded from the lower sites, may have good future fishery value with potential to substitute the flourishing artificial rearing of exotic Rainbow Trout having considerable economic incentive, provided national park regulations would permit the establishment of hatcheries and distribution of fingerlings for production elsewhere. A healthy congregation of this species in the third site (downstream of the proposed Nagmati dam near the confluence of Bagmati River) again follow the established rule that in fragmented rivers and streams, downstream sites are normally least affected due to river connectivity compared to upstream sites. Therefore, any conservation or developmental work involving rivers and streams must focus on maintaining river connectivity in the lower reaches of Nagmati (near Sundarijal).

Apart from the normal disturbances which can be anticipated during the dam construction phase, the main impact of the dam would be the reduced flow of water downstream. As the downstream reaches of Nagmati River appear to presently have healthy numbers of the above two species of fish, it would be important to maintain certain amount of flow in the river to ensure sustaining the fish populations. Hence, the main mitigation measure to deal with potential impacts to fish would be to maintain minimum flow levels as required.

7. Water Quality and Soil Analysis

Detailed field surveys were conducted to assess the current status and quality of river water and soils in the vicinity of the proposed dam sites at Thulo Dhap and Nagmati River, as well as, beyond the national park boundaries downstream upto Tilganga. Field survey and soil/water sampling were conducted during the period from October thorugh December 2012, and laboratory analyses were done at the Aquatic Ecology Centre of Kathmandu Univeristy. A brief summary of the overall findings are provided below.

8. River Water Quality and Status

With the aim to establish the present (baseline) status of Bagmati river water quality and possible causes of pollution along the river course from the headwaters of Nagmati to Tilganga reach of the Bagmati River, a total of 28 water samples were taken from different sites from Dhap down to the Pahsupati area and analyzed using standard water testing methods. The water samples were analyzed for physio-chemical and microbiological characteristics, heavy metals, cations/anions, as well as oil/grease, phenolic compounds and anionic detergents. The results of water testing showed a distinct pattern of relatively unpolluted, good water quality at the upstream sites (Dhap and Nagmati) with progressive deterioration of the water quality down to the Pashupatinath temple area. The polluted downstream sites, especially from Gokarna to Pashupati area are affected mainly by agricultural and domestic effluent discharge (sewage and solid waste).

Properties such as pH (which ranged from 6.2 to 7.2), odour, and taste, the latter two being considered unobjectionable showed little variation from Dhap downstream to the Guheshwori area. While the pH increased somewhat at the lower reaches, reflecting the increase in cations and alkalinity, odour and taste were not significantly different for most of the sampling sites. This was likely due to the time of sampling, i.e., shortly after the monsoon season when the water flow was high. Most of the physical, chemical and microbiological properties of the water reflected the elevation/climatic zonation, geology and influence of human populations. Hence, the upstream (headwaters) reaches of Nagmati had low values of temperature, EC, turbidity, TDS, alkalinity and hardness, while these properties gradually increased downstream with maximum values seen near the Pashupatinath temple.

The values of chemical compounds such as ammonia, nitrate and phosphate were low at the upper reaches of Nagmati River, while the highest values were recorded at the Pashupatinath temple. Likewise, biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were low (1-2 mg/L) at the upstream sites and higher downstream, with the highest values (BOD = 128 mg/L; COD = 26.5 mg/L) recorded at Bag 11. Total (TC) and fecal coliform (FC) bacterial presence in the river water also revealed a generally increasing trend from the upstream to the downstream sites, while DO values where high in unpolluted upstream areas and dropped due to microbial consumption of oxygen in the water at polluted downstream sites.

The concentrations of heavy metals were below detection for most elements and low for copper, zinc and iron (ranging from 0.02 for Cu and Zn, and to 2.48 for Fe). The value of Al 23.4 mg/L at the Pashupatinath temple area exceeded the water quality guidelines standard of 10 mg/L limit for protection of aquatid ecosystems and the 5 mg/L limit for livestock watering. The presence of oil and grease, phenolic compounds and anionic detergent were all below the detection levels and hence negligible in the water samples analyzed.

The primary impact of dam construction on water resources would be the reduction of flows downstream of the dam site and inundation of areas upstream. As the water quality is good in the upstream stretches of the Nagmati River and downstream sites along the Bagmati River (particulary downstream of the Sundarijal area) are already significantly impacted by human settlements and activities, the damming of the Nagmati River is not expected to have major impacts on river water quality. While during the construction phase some disturbance in water quality, mainly sediment loads and irregular flows (discharge volume) can be expected, minimal impacts to water quality are likely to occur after completion of the dams provided minmum flows are maintained.

9. Soil Types and Status

A total of 40 soil samples were collected along the Nagmati and Bagmati River stretches from Dhap to the Guheshwori/Pashupatinath temples. The sampled locations ranged in elevation from nearly 2,100 meters at Dhap (Nag 01) to a low of about 1,315 meters near the Guheshwori Temple area. The soils were predominantly sandy textured with the textural class “sandy loam” (50-80% sand) being most common, hence the soils support high water infiltration rates and are important for water conservation and ground water recharge. The soils were mostly dark brown to dark grayish brown in colour with low to medium bulk densities and high moisture content due to the time of sampling (shortly after the monsoon season) and proximity to the river.

The soils were mostly acidic in nature with pH values ranging from less than 4 to 6.45, although most sites had pH in the range of 4-5. The total nitrogen statuses of the samples analyzed were mostly moderate to high and correlated with soil organic matter status. Available phosphorus levels were generally low to medium, while exchangeable potassium was highly variable and depended mainly on the rock/mineral types present. Soil organic matter and carbon reflected the land use and vegetation pattern, with forest and grass land sites have high values (3 to 18% SOM; 1.7 to 10.4% SOC) and agricultural areas in the downstream areas having mostly low values (1.3 to 5% SOM; 0.75 to 3% SOC).

The main impact of dam construction on soils upstream of the dam site would be the inundation and hence saturation of the soils with water, which is expected to affect about 48 ha of land within the Shivapuri National Park. The proposed dams at Dhap and Nagmati and the subsequent reservoirs formed by inundation of the upstream areas do not affect any existing agricultural land or settlement areas directly. Since the inundated areas (once the proposed dams are constructed) would cover less than 1 percent of the total area of the Park and do not include any agricultural areas or settlements, the impacts to soil/land resources can be regarded as minimal.

10. Air and Noise Level Monitoring

The study has helped to identify the negative impacts on the sound level and air quality sensitive environment located adjacent to the Upper Bagmati River Basin area due to New Dam Construction Activity. Overall, the monitored air quality parameters- respirable and non-respirable parameters, including the SOx, NOx and Lead, were found within the Nepal Standards at Sundarijal, Nagmati and Dhap area. But respirable particulate matter was found above both the Nepal and WHO Standards at Pashupati area whereas at the Gokarna and Sundarijal site, they were above WHO Standards but within the Nepal Standards. These dust particles were mainly contributed by the vehicular movements and anthropogenic activities at the Pashupati, Gokarna and Sundarijal, whereas in the case of Nagmati and Dhap, it was influenced by the natural state.

On the other hand, noise level was also not in adverse conditions. Regardless of the Lmax value on average of day and night along with hourly interval of all the sites, the sound pressure levels were found within the WHO Standards based on the Leq. At the Pashupati, Gokarna and

Sundarijal site, the sound pressure was mainly contributed by the vehicular movement along with their pressure horn and some anthropogenic and animal activities. Beside these activities, noise level, due to the current of water was also found increasing at the Gokarna site, whereas at the Nagmati and Dhap, it was mainly natural and caused due to sound made by current of Nagmati river, chirping sound of birds and occasional movement of motor bikes and mini trucks.

Field Survey Report 1

VEGETATION STUDY FOR PROPOSED BAGMATI RIVER BASIN IMPROVEMENT PROJECT

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Center
Kathmandu University

Submitted by:

Dipesh Pyakurel & Bhesh Raj Oli
November 2012

EXECUTIVE SUMMARY

As a part of Bagmati River basin Improvement Project, vegetation survey was carried out in Bagmati, Nagmati and Dhap area. A total of 26 sample plots were laid throughout the area to analyze the number of species inundated, total volume of trees inundated, identify the sensitive taxa and habitat, and to recommend the mitigation measures.

Point sampling technique was adopted for the survey with all the sample plots laid in the predetermined locations. A total of 96 flowering plants were recorded along the survey area, out of which 38 tree species were documented.

Density of *Quercus glauca* was higher in Bagmati area with 385 trees per hectare, followed by *Rhododendron arboreum* with 125 plants per hectare. Similarly, density of *Symplocos pyrifolia* was higher in Nagmati dam site with about 152 plants per hectare, followed by that of *Quercus glauca* with 102 plants per hectare. Likewise, *Symplocos sumuntia* has higher density in Dhap area with 100 plants per hectare followed by that of *Lyonia ovalifolia* with about 62 plants per hectare. Oak-Rhododendron forest dominates the Bagmati area, whereas Nagmati area is typically represented by Broad leaved forest and Dhap area is represented by temperate mixed broadleaved forest.

Average tree volume was highest in Nagmati area with 127.35 cu m per hectare, followed by Bagmati site with 84.53 cu m per hectare and least was recorded in Dhap area with 58.21 cu m per hectare.

Volume of *Quercus glauca* was higher in Bagmati area with 36.98 cu m per hectare and the volume of *R. arboreum* was maximum in Nagmati area with 22.85 cu m per ha. Similarly, the volume of *Symplocos sumuntia* was higher in Dhap area with 8.58cu m per ha.

Seven species and two groups were identified as sensitive taxa and proper mitigation measures were recommended. Dhap area was identified as ecologically important habitat as it is a major source of water for Nagmati River and home to several important flora and fauna.

Construction of dams has minimal effect on human settlement and further the forest is in secondary succession stage therefore inundation of mature trees is unlikely. Compensatory plantation of potential submerged species and plantation in the nearby habitat for orchids and lichens were the major recommendations of the study.

Finally, it is summarized that construction of two dams at Nagmati and Dhap has minimal effect on the vegetation and the effect can be easily nullified with compensatory plantation.

1. CHAPTER ONE: INTRODUCTION

Project Background

The Bagmati River has cultural and religious significance to residents of Kathmandu valley and Hindu devotees all over the world. The Bagmati and its associated Rivers and tributaries also has great economic importance as it plays a crucial role in meeting the water supply requirements and in sustaining irrigated agriculture in the Kathmandu Valley and throughout the Bagmati River basin.

In the last few decades, the Bagmati River has been converted to main sewage drain of the valley and now it is regarded as biologically Dead River. Solid waste is also regularly deposited on the river banks which further deteriorate the river environment. Rapid urbanization has put great pressure on the valley‟s water supply distribution system. Some 80% of flow in the Bagmati River is diverted for drinking water purposes during the dry season leaving very little flow for irrigation and other uses including cultural / religious and environmental aspects. As it exists in the city, heavily polluted water with sewage flows during the drier season, thereby endangering the health of downstream water users.

In this regard, Asian Development Bank (ADB) is carrying out a study for the proposed Bagmati River Basin Improvement Project to improve the water quality and quantity of Bagmati River, especially during the winter and early spring season. The project aims to improve the water security and restore the river environment of Kathmandu valley and to improve irrigation in the middle and lower basin. The project adopts Integrated Water Resources Management (IWRM) approach and the proposed six year project is expected to be completed by the year 2019.

Study Background

Three major outputs of the proposed project are: improved management of water in Bagmati River Basin, irrigation development in middle basin, and river improvement and development of water sources to maximize the flow of water during drier seasons. Two storage dams/reservoirs at Nagmati River and Dhap area (on Sundarijal VDC) will be constructed to achieve the third output.

Construction of proposed dams might have some implication on the existing environment around the construction sites. Forest area needs to be cleared with cutting and looping of trees and loss of several floral species during the construction of proposed dam. Therefore, as a part of Environmental Impact Assessment (EIA) study, a detailed vegetation survey was designed to achieve the current information of all potentially valuable forest resources and other significant forest features within the proposed dam areas.

This vegetation survey is a technical assistance study project of ADB, coordinated by Aquatic Ecology Centre of Kathmandu University. The information, outputs and anticipated recommendations of this assessment will be integrated into EIA report required for ADB.

Objectives

The major objective of this assignment is to focus on valuable forest resources and other significant vegetative features at two proposed dam sites in Nagmati and Dhap area. Specific objectives are:

- To access the vegetation pattern of different forest patches along the proposed dam area.
- To calculate volume of the tree species which is going to be removed during the construction of dam and inundated after the construction of dam.
- To enumerate Protected, Endangered and Rare plant Species on the forest patches along the proposed dam area.
- To determine the possible ecologically significant areas along the dam sites.
- To find the mitigation measures of loss of plant species during dam construction.

Limitation

The study was planned to carry out at the end of the monsoon and executed accordingly but unexpectedly, there was heavy rainfall during that period (11^{th} to 18^{th} of September). Water level at Bagmati and Nagmati River rose considerably and it was almost impossible to cross the river. Therefore, vegetation study on the other side of river was not well documented.

Picture 1: Measuring DBH in Nagmati River area

2. CHAPTER TWO: METHODOLOGY

The survey area was along the proposed dam sites and number and location of sample plots were predetermined. Therefore most of the sample plots were laid exactly on the predetermined location whereas few sample plots were laid nearby the proposed dam site due to difficulty in accessibility. Altogether 26 sample plots were laid along the survey area.

Vegetation Survey (Tree, Shrub, Herb)

Out of 26 sample plots, 5 were laid in Bagmati area, 11 were laid in Nagmati area and 10 sample plots were laid in Dhap area. Each sample plot was located in such a way that it either fell on potential inundated area or in the vicinity of the potential inundated area. Synopsis of all sample plot taken is given in annex 1.

The number and location of sample plot were already determined therefore point sampling method was applied during the survey. Size and method of sample plot complies with the standard as per the Community Forestry Inventory Guideline (GoN/MoFSC/DOF 2061 BS).

Sample Size

Sampling was taken within the composite sample plot. Each composite sample plots have three different sized plots. The outer plot has 400 sq m area (20 m × 20 m), sub plots laid at two corners of outer plot has 25 sq m area (5m × 5m) and finally four small sub plots laid at each corner of outer plot has 1 sq m (1m × 1m) area. Sample plot of 400 sq m was for the enumeration of tree species, sub plot of 25 sq m was for the enumeration of shrub species and sub plot of 1 sq m was for the enumeration of herb species (Figure 1). In this way, 26 outer plots, 52 medium sized plots (25 sq m) and 104 small sized sample plots were laid for the vegetation study.

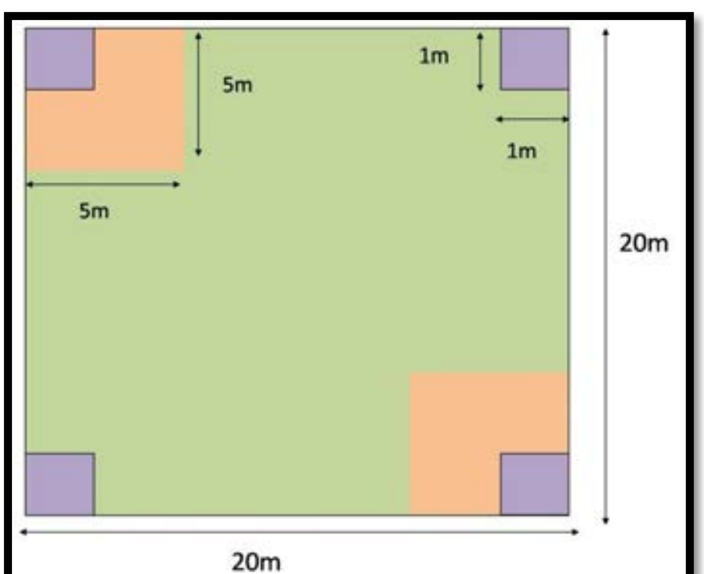


Figure 3: Diagrammatic representation of sample plot

Data Collection

The environmental variables at each sample plot such as aspect, slope (inclination), latitude, longitude, altitude etc were measured by using Global Positioning System (GPS), visual observation and with the help of Topo sheet. Subsequently, the plots taken were marked in Topo sheet.

Three different types of survey forms were used for data collection, each of which documents trees, herbs and shrubs. Diameter at Breast Height (using DBH meter), height (using Sunto Hypsometer), crown coverage (visual estimation) and number of seedlings were measured for trees. Number of plant species, average height and coverage percentage were recorded for shrubs. Finally, number and ground coverage were enumerated for herbs. Data obtained from two sub plots of 25 sq m and four sub plots of 1 sq m were also used to analyze the status of regeneration of trees. Format for the vegetation survey is given in Annex 2.

Most of the plant species were identified during field survey. Local name of the plants were identified with consultation of local people. Plant samples were made and photographs were taken for unidentified species in the field. These were then identified by consultation with experts and using books by Polunin and Stainton (1984), Stainton (1988) and Ghimire *et al.* (2008) as reference. Local, English and Scientific name and their proper citation were made with the help of books by Shrestha (1998) and Press *et al*. (2002).

Data Analysis

Ecological study of herbs was conducted following the methodology proposed by Raunkiaer (1934) and Zoebel *et al*. (1987) while the percentage coverage was estimated by employing visual observation.

Frequency and relative frequency

$$\text{Frequency} = \frac{\text{No. of quadrats in which species occured}}{\text{Total Number of quadrats studied}} \times 100$$

$$\text{Relative Frequency (RF) \%} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

Density and relative density

$$\text{Density Pl/ha} = \frac{\text{Total number of plant of any species}}{\text{Total number of quadrat studied} \times \text{area of quadrat}} \times 10000$$

$$\text{Relative Density (RD) \%} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100$$

Calculation of basal area was performed using the formulae proposed in Community Forestry Inventory Guideline (GoN/MoFSC/DOF 2061 BS).

Basal Area (BA) = Area occupied at breast height = $\pi d^2/4$ or πr^2

Volume (V) was calculated with the help of volume table published by the Government of Nepal, Ministry of Forest and Soil Conservation, Forest Survey and Statistics Division, Publication number 48, (Sharma and Pukkala 1990).

$$\text{Ln}(V) = A + B * \text{Ln}(D) + C * \text{Ln}(H)$$

In this equation,

V= Total stem volume with bark
A, B and C are constant numbers which vary according to species. In our case, we kept the values of A, B and C as per the constant given to trees of midhills.
D= Diameter at Breast Height (in cm)
H= Height in Meter

To obtain the stem volume in cubic meters, as it is presented in the volume tables, the model prediction must be divided by 1000.

Volume of individual trees survey area

Volume of individual trees was calculated using the equation proposed by Sharma and Pukala (1990). Average DBH and average height of all trees of particular area was taken and the same was used in the equation. Finally, average volume was calculated by multiplying the density with volume in cu m.

Picture 2: Determining the diameter of tree at breast height (left) and taking the data of sample plot (right).

3. CHAPTER THREE: FINDINGS

This chapter is divided into five parts. First part describes the vegetation and flora of the study area in holistic manner. Second part is about the volume of trees. Similarly, third part focuses on specific observations. Fourth part identifies the sensitive taxa or habitat and fifth part recommends the mitigation measures.

3.1 Existing Vegetation and Flora

Secondary information was used to understand the vegetation and flora of Shivapuri Nagarjun National Park and specific Shivapuri area.

3.1.1 Shivapuri Nagarjun National Park

Shivapuri Nagarjun National Park (ShNNP) is located between latitudes 27°45' to 27°52' and longitudes 85°15' to 85° 30" towards north of Kathmandu valley. It covers an area of over 150 sq km with an altitudinal range of about 1000 to 2700m. The National Park represents mid-hill flora, fauna and ecosystems. The lower belt of the park has ever green mixed broad-leaved forest followed by Pinus forest, Oak-Rhododendron forest, and upper mixed hardwood forest up to the highest range of the park. Table 1 describes the major forest types of ShNNP, along with altitude and dominant species.

Table 8: Forest and Vegetation Types of Shivapuri-Nagarjun National Park

SN	Altitude (m)	Forest types	Major Species
1	1000-1500	Ever green mixed broad-leaved forest	*Schima wallichii, Castanopsis indica, C. tribuloides, Alnus nepalensis, Prunus cerasoides, Pyrus pashia, Anthocephalus cadamba*, etc
2	1000-1600	Chir pine forest	*Pinus roxburghii, Myrica esculenta, Prunus cerasoides* etc
3	1500-2700	Upper mixed hardwood forest	*Fraxinus floribunda, Prunus cerasoides, Aseculus indica, Juglans regia, Alnus nepalensis, Quercus glauca, Q. lanuginosa, Q. semecarpifolia, Rhododendron arboretum,* etc.
4	2300-2700	Oak-Rhododendron forest	*Quercus semecarpifolia, Rhododendron arboreum, Ilex dipyrena, Michelia champaca, Eurya acuminata,* etc.

Source: www.dnpwc/shnp.org

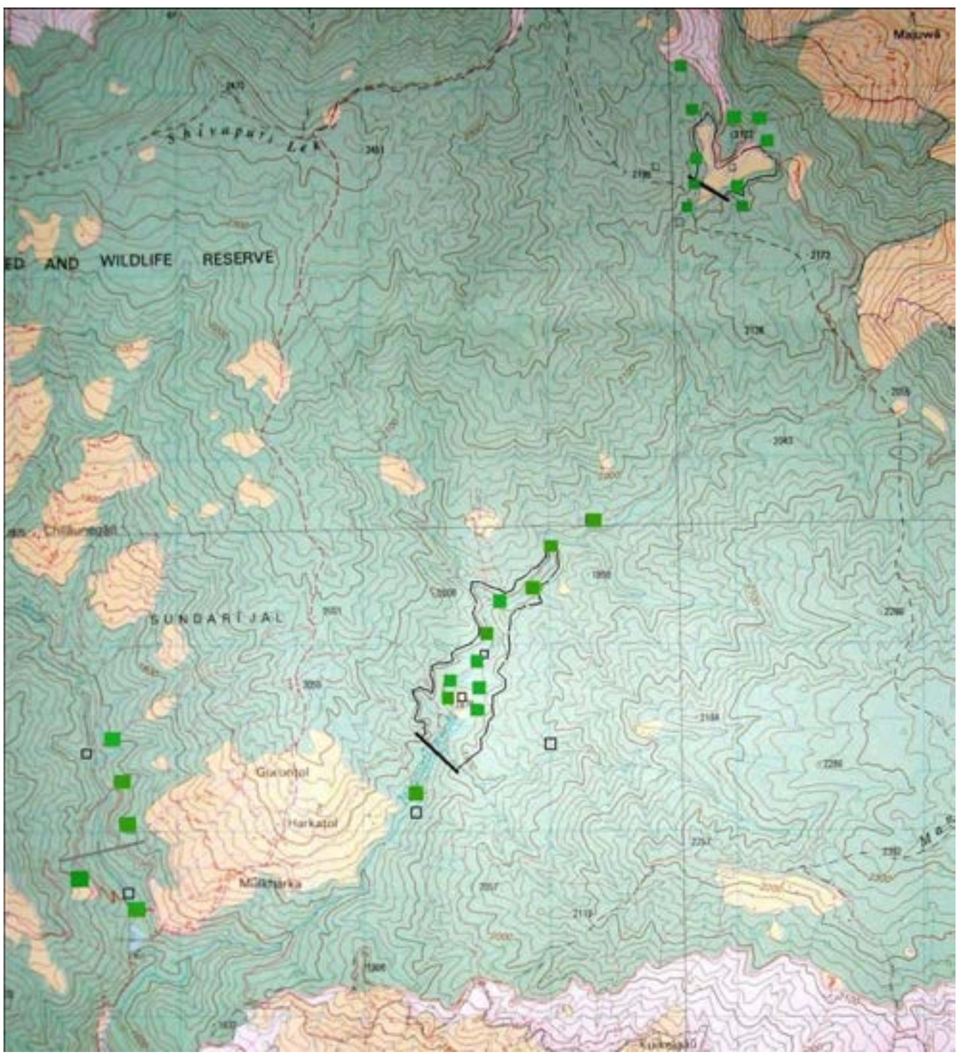
Unpublished management plan of ShNNP listed 2122 species of flowering plants including 16 endemic species. However, recent study documented 1254 species including 132 pteridophyte species, 6 gymnosperms, 325 monocotyledons and 791 dicotyledons.

3.1.2 Vegetation and Flora of Shivapuri Area

Nepal Biodiversity Resource Book (2007) recognized four vegetation types in Shivapuri area that includes *Schima-Castanopsis* forest (dominated by *Schima wallichii* and *Castanopsis indica*), Chir Pine and Broad-leaved forest (dominated by *Pinus roxburghii*, *Alnus nepalensis,* *Rhododendron arboreum, Symplocos pyrifolia*), East Himalayan Oak-Laurel forest (dominated by *Quercus glauca, Q. lamellosa, Q. lanata, Lindera pulcherrima, Persea odoratissima*) and Temperate Mountain Oak forest (dominated by *Quercus semecarpifolia* forest). A total of 449 species of flowering plants was recorded from Shivapuri area, including 14 endemic plants. The list includes 4 gymnosperms, 313 dicotyledons and 132 species of monocotyledons. However, the list fails to incorporate *Taxus wallichiana* (Lauth salla), one important medicinal plant, which was distributed in the Nagmati River area.

3.2 Vegetation and Flora along the three study areas

Primary data were analyzed to describe the vegetation of Bagmati area and proposed dam sites in Nagmati and Dhap area. Vegetation survey started from Oak-Rhododendron forest at Bagmati area to temperate mixed broadleaved forest in Dhap area. A total of 26 sample plots were laid in three sites leading to active survey of 10,400 sq m area (Map 1). 96 plant species were documented within the sample plots and in the nearby areas. List of all plant species along with scientific name, english name, family and life form is given in annex 3.



Map 1: Map of study area showing the surveyed areas

3.2.1 Flora along the initially proposed Bagmati dam site

Five 20 x 20 m^2 sized sample plots were laid in earlier proposed Bagmati dam area. Out of the five plots, one was laid in the upstream, two were laid exactly on the initially proposed dam site and three were laid on the downstream of Bagmati. *Quercus glauca* (*Phalant*) and *Rhododendron arboreum* (Guras/Lali guras) were dominant tree species of Bagmati area with the density of 385 and 125 plants per hectare respectively. *Schima wallichii* (Chilaune) is the major associated species in the area. All three species are homogenously distributed along the initially proposed Bagmati dam site (Table 2). Details of population parameters in all three survey site is given in annex 4.

Table 9: Population parameters of major trees in initially proposed Bagmati dam site

SN	Scientific name	Density	Relative Density	Frequency	Relative Frequency
1	*Quercus glauca*	385	54.23	100	16.67
2	*Rhododendron arboreum*	125	17.61	100	16.67
3	*Schima wallichii*	55	7.75	80	13.33
4	*Cleyera japonica*	40	5.63	60	10.00
5	*Castanopsis indica*	35	4.93	80	13.33

3.2.2 Flora along the proposed Nagmati dam site

A total of eleven 20 x 20 m^2 sized sample plots were laid in the proposed Nagmati dam area. Out of the eleven plots, five plots were laid in the upstream, three were laid exactly on the proposed dam site and remaining three plots were laid on the downstream of Nagmati River. *Symplocos pyrifolia* (*Kharane/Kholme*), *Quercus glauca* (Phalant) and *Rhododendron arboreum* (Guras/Lali guras) were dominant tree species of proposed Nagmati dam area with the density of 152, 102 and 91 plants per hectare respectively. *Pinus roxburghii* (Khote salla), *Lyonia ovalifolia* (Bakal pate, Phalame) and *Camellia kissi* (Chiapate, Hingua) are the major associated species in Nagmati area. Among the listed species, *Symplocos pyrifolia* is the most common and uniformly distributed plant species in Nagmati area (Table 3).

Table 10: Population parameters of major trees in proposed Nagmati dam site

SN	Scientific name	Density	Relative Density	Frequency	Relative Frequency
1	*Symplocos pyrifolia*	152.27	20.24	90.91	12.35
2	*Quercus glauca*	102.27	13.60	63.64	8.64
3	*Rhododendron arboreum*	90.91	12.08	72.73	9.88
4	*Pinus roxburghii*	84.09	11.18	18.18	2.47
5	*Lyonia ovalifolia*	70.45	9.37	54.55	7.41
6	*Camellia kissi*	56.82	7.55	63.64	8.64
7	*Cleyera japonica*	45.45	6.04	36.36	4.94
8	*Quercus lamellose*	25.00	3.32	27.27	3.70
9	*Persea odoratissima*	22.73	3.02	36.36	4.94

10	*Pyrus pashia*	20.45	2.72	45.45	6.17

Table 3 also revealed that about 152 trees of *Symplocos pyrifolia* per hectare will be inundated after the construction of Nagmati dam. Similarly, 102 trees of *Quercus glauca*, 91 trees of *Rhododendron arboreum* and 84 trees of *Pinus roxburghii* per hectare will be inundated. Few scattered saplings of *Taxus wallichiana* (Lauth salla) was recorded along the Nagmati River. Being smaller in size, they were not incorporated in the above list.

3.2.3 Flora along proposed Dhap dam site

A total of ten 20 x 20 m^2 sized sample plots were laid in the proposed Dhap dam area. Out of the ten plots, three plots were laid in the upstream, six plots were laid around the proposed dam site and remaining one plot was laid on the downstream of Dhap i.e. along the outlet of Dhap. Vegetation along the Dhap area consists of bushes and shrubs of *Berberis asiatica* (Chutro), *Pyracanta crenulata* (Ghangaru), *Edgeworthia gardneri* (Argeli), *Rubus acuminatus* (Bhalu ainselu) etc. Therefore, numbers of trees are less compared to other two sites.

Symplocos sumuntia (*Lodh*), *Symplocos pyrifolia*, *Lyonia ovalifolia* (Angeri) and *Daphniphyllum himalense* (Rachan) were dominant tree species along Dhap area with the density of 100, 62 and 55 plants per hectare respectively. *Pyrus pashia* (Mayal), *Camellia kissi* (Chiapate, Hingua) and *Betula alnoides* (Saur) are the major associated species in the Dam area. Among the listed species, *Symplocos sumuntia* is the most common and uniformly distributed plant species in Nagmati area (Table 4).

Table 11: Population parameters of major trees in proposed Dhap dam site

SN	Scientific name	Density	Relative Density	Frequency	Relative Frequency
1	*Symplocos sumuntia*	100	22.60	100	13.70
2	*Lyonia ovalifolia*	62.5	14.12	60	8.22
3	*Daphniphyllum himalense*	55	12.43	90	12.33
4	*Pyrus pashia*	45	10.17	100	13.70
5	*Camellia kissi*	42.5	9.60	70	9.59
6	*Betula alnoides*	42.5	9.60	50	6.85
7	*Quercus glauca*	22.5	5.08	50	6.85
8	*Rhododendron arboreum*	15	3.39	40	5.48

Table 4 also showed that about 100 trees of *Symplocos sumuntia* per hectare will be inundated after the construction of Dhap dam. Similarly, 62 trees of *Lyonia ovalifolia*, 55 trees of *Daphniphyllum himalense* per hectare will be inundated.

3.2.4 Species richness along the proposed dam site

Altogether 30 plant species were recorded during vegetation survey in three different study sites. Species richness was least in the 1st sample plot taken at Nagmati with only two species. The plot was taken at the pocket area of *Pinus roxburghii*. Highest species richness was recorded from 8th and 9th sample plot at Nagmati, each with 11 different types of species (Figure 2).

Similarly, highest numbers of plants were recorded from 8th sample plot at Nagmati with 54 plants, followed by 40 plants in the 3rd sample plot taken at Nagmati. Least number of plants was recorded from the 4th sample plot at Dhap area with only 12 species (Figure 2). It is because of the presence of a big tree of *Symplocos pyrifolia* in that particular plot.

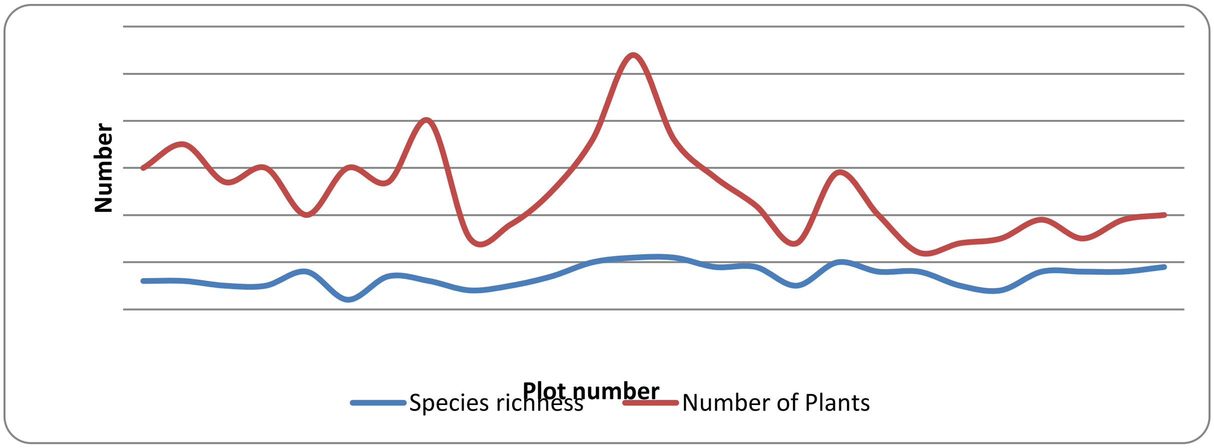


Figure 4: Species richness along the sample plots

3.3 Volume of Trees in different sample plots

Volume of trees was calculated in different sample plots. Maximum tree volume was recorded in plot 9th sample plot at Nagmati with the value of 240.95 cu. m per hectare followed by 3rd sample plot at Nagmati with the value of 165.55 cu. m per hectare. Similarly, least tree volume was recorded in the 1st plot of Dhap which have only 26.42 cu. m per hectare (Table 5).

Table 12: Volume of trees in each sample plot (formula proposed by Sharma and Pukkala, 1990)

Plot no	Vol per ha Volume in cubic meter per hectare	Ranking of volume in different plots
Bagmati 1	106.870	9
Bagmati 2	68.508	20
Bagmati 3	89.783	11
Bagmati 4	83.215	14
Bagmati 5	74.296	18
Nagmati 1	148.037	3
Nagmati 2	111.501	7
Nagmati 3	165.555	2
Nagmati 4	80.932	15
Nagmati 5	98.411	10
Nagmati 6	110.988	8
Nagmati 7	119.299	5
Nagmati 8	131.508	4
Nagmati 9	240.952	1
Nagmati 10	117.793	6
Nagmati 11	75.939	17
Dhap 1	26.426	26
Dhap 2	86.535	12
Dhap 3	66.271	21
Dhap 4	85.386	13
Dhap 5	70.370	19
Dhap 6	59.258	22
Dhap 7	26.882	25
Dhap 8	32.211	24
Dhap 9	48.206	23
Dhap 10	80.570	16

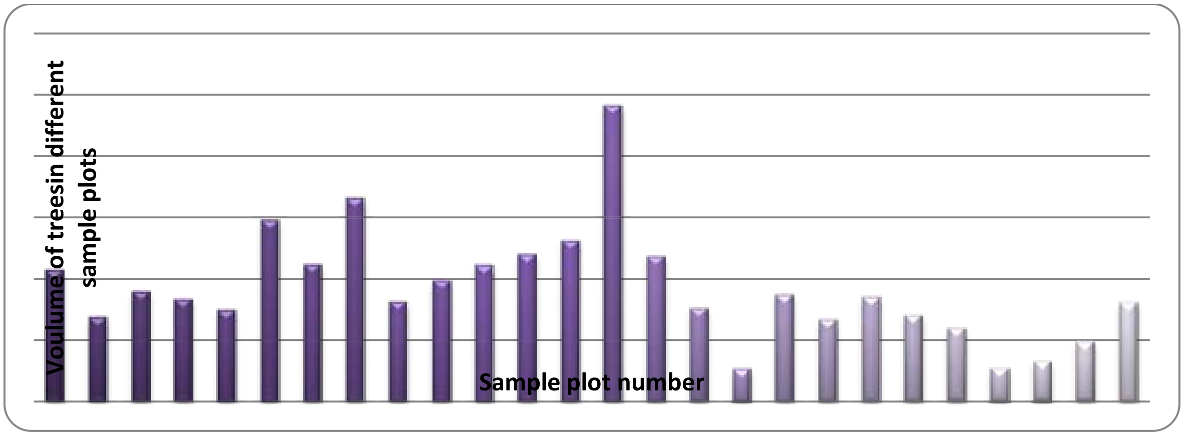


Figure 5: Volume of tress in different sample plots

As shown up earlier, a total of 26 sample plots were laid on 3 survey sites. Five sample plots were laid at Bagmati region and average tree volume for Bagmati site was found to be 84.53 cu m per hectare. A total of eleven sample plots were laid on the Nagmati region. Number of sample plots taken in this region was higher because the proposed main dam is going to be constructed in this region. Average volume in cubic meter per hectare of trees within the 11 sample plots is 127.35. Similarly, ten sample plots were laid in Dhap area. The area has plenty of open grasslands and bushes therefore tree volume is low. Average volume of trees in Dhap area is 58.21 cu m per hectare.

3.4 Volume of Individual trees in survey areas

3.4.1 Volume of individual trees in Bagmati area

Volume of *Quercus glauca* was maximum in Bagmati area with 36.98 cu m per hectare, followed by *Rhododendron arboreum* with 19.74 cu m per ha.

Table 13: Volume of major trees in Bagmati area

SN	Scientific name	Average volume in cu m (individual tree)	Volume in cu m per ha for individual trees
1	*Quercus glauca*	0.096	36.979
2	*Rhododendron arboretum*	0.157	19.736
3	*Castanopsis indica*	0.162	5.689
4	*Schima wallichii*	0.068	3.761
5	*Cleyera japonica*	0.088	3.528

3.4.2 Volume of individual trees in Nagmati area

Volume of *R. arboreum* was maximum in Nagmati area with 22.85 cu m per ha. Calculating the cu m per hectare with the total inundated area of 30 hectare, it can be concluded that total of

685.51 cu m volume of *R. arboreum* will be inundated after the construction of Dam site (Table 7).

Table 14 Volume of major trees in Nagmati area and total volume of individual tree species inundated

SN	Scientific name	Average volume in cu m (individual tree)	Volume in cu m per ha for individual trees	Total volume of trees inundated (cu m/area)
1	*Rhododendron arboretum*	0.25	22.85	685.51
2	*Pinus roxburghii*	0.19	15.97	479.23
3	*Quercus glauca*	0.15	15.35	460.57
4	*Symplocos pyrifolia*	0.10	15.31	459.18
5	*Quercus lamellose*	0.29	7.25	217.64
6	*Lyonia ovalifolia*	0.06	4.33	129.86
7	*Cleyera japonica*	0.08	3.56	106.75
8	*Camellia kissi*	0.06	3.45	103.62
9	*Pyrus pashia*	0.15	3.00	90.13
10	*Persea odoratissima*	0.10	2.24	67.20

3.4.3 Volume of individual trees in Dhap area

Volume of *Symplocos sumuntia* was maximum in Dhap area with 8.58cu m per ha, followed by Camellia kissi of 6.37 cu m per hectare. As anticipated, the volume of trees per hectare was less as compared to Nagmati area (Table 8).

Table 15: Volume of major trees in Dhap area

SN	Scientific name	Average volume in cu m (individual tree)	Volume in cu m per ha for individual trees
1	*Symplocos sumuntia*	0.085	8.583
2	*Camellia kissi*	0.149	6.374
3	*Symplocos pyrifolia*	1.176	5.882
4	*Daphniphyllum himalense*	0.097	5.342
5	*Pyrus pashia*	0.097	4.397
6	*Betula alnoides*	0.080	3.405
7	*Quercus glauca*	0.148	3.331
8	*Lyonia ovalifolia*	0.045	2.818
9	*Rhododendron arboretum*	0.114	1.719
10	*Ilex dipyrena*	0.106	1.068

3.4 Specific Observations

This section describes specific recognizable features along the three proposed dam area. Photographs of the plots were taken where a suitable vantage point was available.

First five sample plots taken at initially proposed Bagmati dam site represents the blend of Oak-Rhododendron forest. The forest area was steep with plenty of pole sized trees.

First plot of Nagmati was taken in the pocket area of *Pinus roxburghii* forest. Plot no 2 to plot no 5 were laid exactly on the proposed dam site. Number of trees was quite less because of the presence of considerable sized grassland in the area. Few plants of *Taxus wallichiana* were also recorded from plot 6th to plot 11th but the size of *Taxus wallichiana* was very small. Similarly, terrestrial orchids are also recorded throughout the entire Nagmati area.

Entire Dhap area has huge ecological value. The area serves as source of water of Nagmati River. The region accumulates the rainfall, recharges the area and consequently pours downstream. The area is home to high valued medicinal plants like *Acorus calamus* (Bojho), and plants of ecological value like *Pyracantha crenulata* (Ghangaru), *Berberis aristata* (Chutro) etc.

It was observed that the whole forest is in the secondary stage of succession. It was very hard to find big and/or mature sized trees in the park area. Consultation with local residents disclosed that there were no security check posts in the Shivapuri area during the insurgency period. This lead to cutting and felling off of big trees. These trees were either used as timber or as fuelwood for alcohol distillation because considerable number of local residents is still involved in distillation. After the restoration of peace, practices of cutting and felling of trees has been stopped and now there are plenty of pole sized trees in the Shivapuri area.

Most abundant plant species found along the three dam sites were *Symplocos pyrifolia*, *Symplocos sumuntia*, *Quercus glauca*, *Rhododendron arboreum*, *Lyonia ovalifolia* and *Daphniphyllum himalense* etc. Similarly, most abundant shrub species include *Pyracantha crenulata*, *Berberis asiatica*, *Gaultheria fragrantissima*, *Rubus* sp., *Wikstroemia canescens* etc.

3.5 Protected, Endangered and Rare Species

List of protected plant species enlisted by different organizations is given in Table 7. Altogether seven species and two groups (Orchidaceae family and Lichens) of protected species were recorded from the surveyed sites.

Table 16: Protected, Endangered and Rare Species at different category

Species	Local Name	IUCN	CAMP	GN	CITES	Local Availability	Remarks
Asparagus racemosus	Kurilo		V			R	
Bergenia ciliate	Pakhanved	T				C	
Choerospondias axillaris	Lapsi	R				R	

Dioscorea deltoidea	Bhyaakur	T	EN		A II	R	
Lichen spp	Jhyaau			2		C	
Orchidaceae	Sungava, Sunakhari	T			A II	C	
Pinus roxburghii	Khote salla	LC				A	
Rubia manjith	Majitho		V			A	
Taxus wallichiana	Lauth salla	E	EN	2	A II	R	

Abbreviations:
IUCN: T = Threatened, R = Rare, LC = Least Concern
CAMP (Conservation Assessment Management Planning Workshop, 2001): EN = Endangered, V = Vulnerable
GoN (Government of Nepal, Forest Regulations 1995, amended in 2001): 1 = timber trees banned for felling, transportation and export: 2 = banned for export outside the country without processing:
CITES A II = Appendix II =species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled)
Local Availability (Observation by vegetation survey team): A = abundant, C = common, R = rare

3.6 Description and Mitigation Measures of Protected and Sensitive Species

In this part, individual mitigation measures are discussed, along with the reasons of being protected. But plantation of respective species is compulsory to reduce the threat of over exploitation.

Asparagus racemosus (*Nep*: Kurilo, *Eng*: Asparagus) is kept vulnerable by CAMP because of the unsustainable harvesting of tuber. Current market price of Rs 350-400 per kg for tuber is motivating the villagers for the collection of tuber, which is a reason for disappearance from the wild. It is found along the initially proposed Bagmati dam site. It can regenerate both by tuber and seeds if not disturbed and hence does not pose much threat of exploitation.

Bergenia ciliata (Nep: Pakhanved, Eng: Rockfoil) was threatened according to IUCN Red List category because of the unsustainable harvesting of its rhizome (modified stem). Though the market price is less (Rs 30-Rs 40/kg), it is threatened because of over harvesting. Rockfoil is perennial herb and it is an aggressive colonizer if not disturbed. Further, very few patches will be inundated and so does not pose much threat of exploitation.

Choerospondias axillaris (Nep: Lapsi) is extensively cultivated in the farmlands. It is not common in the wild. Therefore, it does not have any conservation concern.

Dioscorea deltiodea (*Nep:* Bhyakur, Bantarul, *Eng:* Potato Yam) is abundant in mid hills of Nepal and is encountered in the Bagmati dam site. It is regarded as threatened by IUCN, Endangered by CAMP and Appendix II by CITES because of the excessive collection of tuber which causes the destruction of this plant. Tubers have medicinal properties and are common in trade at the rate of Rs 80-100 per kg. Furthermore this is the supplementary food for ultra poor landless people. It will regenerate from its tuber and seeds, so it should be planted nearby forests or barren lands in the park area. It was recorded from plot 4 and 5 in Bagmati area.

Lichen (*Nep*: Jhyau) is the symbiotic association of Alga and fungi. The death of the host tree will not affect the life cycle of lichens. Lichens disseminate the spores around new habitat and its population will not be affected at all. Lichens are common along the three dam sites and are good indicators of undisturbed forest. Lichen has been banned for export by Government of Nepal due to the extensive use for dye and medicines, especially in the hilly regions of Nepal. It is difficult to cultivate or regenerate but the best and effective method is to transplant the Lichen bearing stem or branches in the nearby habitat.

Orchids (Nep: Sungava, Sunakhari, Chandigava, Bandar kera) has been regarded as threatened by IUCN and falls under CITES Appendix II (CITES Appendix II lists species that are not necessarily now threatened with extinction but that may become so unless trade is closely controlled). It has been protected because of the excessive collection for trade. Orchids are used as medicine and ornamental plants. Some species of terrestrial and epiphytic orchids are recorded in the proposed dam sites of Nagmati. Most common among them are *Coelogyne critsata, C. ovalifolia, Calanthe tricarinata, Spiranthes sinensis, Satyrium nepalense* etc. Aerial species are succulent in nature hence they absorb moisture from environment and food from the host tree, whether the host tree is living or dead. Cut branches must be kept in nearby habitat. By doing so, the population will not decrease even after the construction of dam. Epiphytic orchids were recorded from almost all sample plots.

Pinus roxburghii (*Nep:* Khote salla, Eng: Pine) is kept as least concern species by IUCN. Pine resin is extracted from mature trees in different parts of Nepal. It is locally abundant in the area and plenty of new seedling and sapling are recorded in the sample plots. However, compensatory plantation is required for this species. Equivalent numbers of inundated Pine trees have to be planted in the degraded sites or open areas within the park area.

R*ubia manjith* (*Nep*: Majitho, *Eng*: Madder) is protected by CAMP under vulnerable category. It is used as dye and have medicinal properties therefore it is overexploited in some places. It is traded at Rs 80 to Rs 100 per kg. However, it is abundant in Bagmati and Nagmati area. It is a fast growing shrub and can germinate on suitable environment. It will regenerate from seeds and plantation in nearby habitat will overcome the threat of exploitation. It was recorded from all the sample plots of Bagmati area and first five sample plots of Nagmati area.

Taxus wallichiana (*Nep*: Lauth Salla, *Eng*: Himalayan Yew) is the most important plant species encountered in the study area. It is kept as endangered by IUCN and CAMP and falls in CITES Appendix II category. Using the authority given Forest Act and Guideline, Government of Nepal has banned the export of *T. wallichiana* without processing. Its local availability is rare mainly because of its natural distribution. Its natural habitat commences from 2100m and extends up to 3400m. Surveyed area is the lowest point of its availability therefore it is not abundant in the region. It was recorded from sample plot 6 to 10 along the Nagmati River.

Compensatory plantation in the slightly higher elevation is recommended for *T. wallichiana*. Being commercially important species, several nurseries raise saplings of *T. wallichiana.* Its plantation in the ratio of 1:10 (10 saplings needs to be planted on the removal of one *Taxus* saplings) is, therefore, recommended.

Picture 3: Picture of Taxus wallichiana taken along the Nagmati River. It falls under CITES appendix II. It also falls in Government protected list and cannot be exported without processing.

4. CHAPTER FOUR: CONCLUSION AND RECOMMENDATION

4.1 Conclusion

For the construction of proposed dams at Bagmati, Nagmati and Dhap area, vegetation was surveyed along the three sites as a part of Environmental Impact Assessment. A total of 26 sample plots were laid in three sites. Out of 26 plots, 5 were laid in Bagmati area, 11 were laid in Nagmati area and 10 sample plots were laid in Dhap area. Square sample plot of the size of 400 sq. m was used during the survey.

Three different forest types were recorded in three survey sites. Bagmati area is mixed representation of Oak-Rhododendron forest, Nagmati area is typically represented Broad leaved forest and Dhap area is represented by temperate mixed broadleaved forest. A total of 30 different tree species are represented in 26 sample plots, showing the homogeneity of forest.

Quercus glauca and *Rhododendron arboreum* were the most dominant species in Bagmati area, each with the density of 385 and 125 trees per hectare respectively. Both species are uniformly distributed in Bagmati area.

Symplocos pyrifolia and *Quercus glauca* were the dominant species in Nagmati area, each with the density of 152 and 102 plants per hectare respectively. *S. pyrifolia* is uniformly distributed throughout the Nagmati area.

Likewise, *Symplocos sumuntia* and *Lyonia ovalifolia* are the dominant species of Dhap area, each with the density of 100 and 62 trees per hectare respectively. Dhap area has higher number of bushes therefore number of trees is less. *S. sumunita* and *Lyonia ovalifolia* are uniformly distributed in Dhap area.

Tree volume was maximum in the 9th sample plot at Nagmati with the value of 240.95 cu. m per hectare followed by 3rd sample plot at Nagmati with the value of 165.55 cu. m per hectare. In Bagmati area, volume of *Quercus glauca* was maximum with 36.98 cu m per hectare. Similarly, volume of *R. arboreum* was maximum in Nagmati area with 22.85 cu m per ha. Likewise, volume of *Symplocos sumuntia* was maximum in Dhap area with 8.58cu m per ha.

Dhap and its vicinity has been identified as the area of huge ecological value as it recharges water, is the major source of Nagmati River and is a home to several medicinal plants, birds and mammals.

The forest of entire survey area is in secondary succession stage with plenty of slender pole sized trees, having diameter less than 10 cm at breast height. It shows that the forest was heavily destroyed by cutting and felling of trees earlier.

Altogether seven species, one group (Lichens) and one family (Orchidaceae) were recorded that falls under different conservation categories. Two species were protected by Government of Nepal, six species by IUCN, four species by CAMP and three species by CITES. Among the protected species, *Taxus wallichiana* was kept under conservation category by all four i.e. GoN, IUCN, CAMP and CITES.

4.2 Recommendations

Following recommendations were proposed for future intervention:

- Forest along all three surveyed sites is at secondary succession stage; therefore, chances of inundation of big sized trees are negligible.
- Construction of Dam in all three sites has minimal effect on human settlement and movement as there is no settlements or hamlets along the proposed dam site.
- Dhap area is the area of high ecological value. Inundation of lower area of Dhap might affect the habitat of certain medicinal plants, birds and mammals. Therefore, area on the west of Dhap (towards Chisapani) needs to be conserved.
- Compensatory plantation is mandatory for major species which will be inundated. Similarly, compensatory plantation is needed for those species which have high ecological value and for the protected species.
- Forest Rules and Regulation have conserved several species and its cutting and felling is prohibited. But for nationally prioritized projects/programmes, such ban will be lifted. Therefore, the project should inform GoN, MoFSC, Department of National Parks and Wildlife Conservation and get the ban lifted for specific area and purpose.

5. References

Chapagain D. and Dhakal J. 2005. *Nepalma CITES Karyanwayan*, DNPWC, Kathmandu, Nepal.

GoN/MFSC. 2002. *Nepal Biodiversity Strategy*. Government of Nepal, Ministry of Forests and Soil Conservation.

GoN/MoFSC/DOF. 2061 (BS). Community Forestry Inventory Guideline. Government of Nepal, Ministry of Forests and Soil Conservation, Department of Forests.

http://www.fao.org/forestry/17109/en/

Polunin O. and Stainton J.D.A. 1984. *Flowers of the Himalaya*. Oxford University Press, Delhi.

Press J.R., Shrestha K.K. and Sutton D.A. 2000. *Annotated Checklist of the Flowering Plants of Nepal.* The Natural History Museum, London, UK and Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Raunkair C. 1934. *The life forms of Plants and Statistical plant geography.* Oxford.

Sharma E.R. and Pukkala T. 1990. *Volume tables for forest trees of Nepal*. Ministry of Forest and Soil Conservation, Forest Survey and Statistics Division, Publication number 48, Volume tables for forest trees of Nepal.

Sharma U.R., Malla K. J. and Uprety R. K. 2004. Conservation and management efforts of medicinal and aromatic plants in Nepal. *Banko Jankari*. **14** (2). pp 3-11

Shrestha K. 1998. *Dictionary of Nepalese Plant*. Mandala Book Point. Kathmandu, Nepal.

Stainton J. D. A. 1988. *Flowers of the Himalaya, A Supplement*. Oxford University Press, Delhi.

http://www.snnp.gov.np

Zobel D. B., Jha P.K., Behan M. J. & Yadav U. K. R. 1987. *A Practical Manual for Ecology*. Ratna Book Distributors, Kathmandu, Nepal.

Field Survey Report 2

WILDLIFE SURVEY OF UPPER BAGMATI CATCHMENT

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Centre, Kathmandu Unvierity

Submitted by:

Yadav P. Ghimire
And
Bal Mukunda Pokhrel

Background

The major works of the Bagmati River Basin Improvement Project (BRBIP) have been proposed in the upper reaches of the Bagmati River basin. The upper reaches of the Bagmati River lies within the boundary of the Shivapuri Nagarjuna National Park (SNNP) that lies on the northern and western fringes of the Kathmandu Valley. SNNP is a home to rich faunal diversity with a number of protected and threatened species (Bhuju *et al.* 2007, Chaudhary 1998). This study intends to document the mammalian species and their habitat present in the project area. To address the intended objectives, researchers used scientific techniques like sign survey along the transects aided by literature review, informal interviews and random survey.

1. Objectives

The specific objectives of the undertaking were to:

1) Document the mammalian species present in the project area
2) Identify the valuable ecological habitat of the mammalian species in the project area
3) Identify the possible impacts that the implementation (construction and operation) of the proposed project will bring about on the mammalian fauna and their habitat
4) Recommend pragmatic measures to mitigate the impact of the proposed project on mammalian fauna and their habitat

2. Methodology

The approaches followed during the study are described, in brief, as follows:

Literature Review

Previous study reports on wildlife of SNNP, publications of SNNP and DNPWC and other relevant literatures were reviewed during the study. Information of the mammalian diversity of SNNP and the project area was obtained as such. The protection status and threat categories for the existing wildlife were also identified by literature review.

Direct Sightings

Animals sighted directly were recorded and their locations (GPS Coordinates and Elevations) were noted with GPS. Additionally, the habitat attributes of the area of the sightings were also recorded. Habitat attributes included the vegetation types and coverage, proximity from water bodies, aspects, etc. Altogether 12 random line transects of varying lengths were laid in and around the project area in order to document any direct mammal observations encountered.

Sign Survey

Another important method applied during the study was identification of animal signs. Such signs included footprints, faeces (pellets/scats/droppings), diggings, scents, etc. Animal signs occurring along the 5m left and right along the transect trails were identified and wild mammals were documented. GPS location and habitat attributes as mentioned earlier were noted for those signs too.

Table 1: Transect Details

Transect No Date	Starting Point	Ending Point	Elevation	GPS Accuracy	Location	VDC
1 (012-9-12)	$27^{0}46.749"$ N $85^{0}25.618"$ E	$27^{0}46.549"$ N $85^{0}25.502"$ E	1622m 1669m	+/- 6m +/- 6m	d/s-B	Mulkharka, Sundarijal
2 (012-9-12)	$27^{0}46.917"$ N $85^{0}25.611"$ E	$27^{0}46.849"$ N $85^{0}25.601"$ E	1694m 1657m	+/- 5m +/- 6m	u/s-B	Mulkharka, Sundarijal
3 (012-9-12)	$27^{0}46.513"$ N $85^{0}26.361"$ E	$27^{0}46.691"$ N $85^{0}26.512"$ E	1833m 1851m	+/- 4m +/- 5m	d/s-N	Harkatol, Sundarijal
4 (012-9-14)	$27^{0}46.694"$ N $85^{0}26.530"$ E	$27^{0}46.732"$ N $85^{0}26.609"$ E	1850m 1857m	+/- 7m +/- 5m	d/s-N	Harkatol, Sundarijal
5 (012-9-14)	$27^{0}46.874"$ N $85^{0}26.622"$ E	$27^{0}46.958"$ N $85^{0}26.777"$ E	1891m 1866m	+/- 6m +/- 5m	d/s-N	Sanodhap, Sundarijal
6 (012-9-14)	$27^{0}47.291"$ N $85^{0}26.869"$ E	$27^{0}47.384"$ N $85^{0}26.863"$ E	1904m 1955m	+/- 6m +/- 8m	u/s-N	Sanodhap, Sundarijal
7 (012-9-14)	$27^{0}47.400"$ N $85^{0}27.085"$ E	$27^{0}47.569"$ N $85^{0}27.388"$ E	1905m 1935m	+/- 6m +/- 7m	u/s-N	Sanodhap, Sundarijal
8 (012-9-14)	$27^{0}47.682"$ N $85^{0}27.487"$ E	$27^{0}47.975"$ N $85^{0}27.595"$ E	1935m	+/- 5m +/- 7m	u/s-N	Sanodhap, Sundarijal
9 (012-9-16)	$27^{0}48.633"$ N $85^{0}27.635"$ E	$27^{0}48.623"$ N $85^{0}27.762"$ E	2080m 2087m	+/- 5m +/- 5m	u/s-Dh	Dhap, Sundarijal
10 (012-9-16)	$27^{0}48.532"$ N $85^{0}27.771"$ E	$27^{0}48.459"$ N $85^{0}27.729"$ E	2084m 2089m	+/- 4m +/- 5m	u/s-Dh	Dhap, Sundarijal
11 (012-9-16)	$27^{0}48.475"$ N $85^{0}27.579"$ E	$27^{0}48.243"$ N $85^{0}27.491"$	2084m 2069m	+/- 4m +/- 5m	u/s-Dh	Dhap, Sundarijal

		E				
12 (012-9-17)	$27^0$48.193" N $85^0$27.487" E	$27^0$47.975" N $85^0$27.595" E			d/s-Dh	Dhap, Sundarijal

Note: Location: d/s=downstream, u/s=upstream, B=Bagmati Dam, N=Nagmati Dam, Dh=Dhap Dam

Interview and Discussion

It is a fact that people living at human wildlife interface are better acquainted with the wildlife diversity in their neighborhoods and their core habitats. So, informal interviews and discussions mainly concerning on the wildlife, were conducted at various places with different people specially aged people and herders.

3. Findings

General

Altogether 10 mammalian species were recorded in and around the project area through direct sighting and sign survey technique. Of these five species, orange bellied Himalayan squirrel *Dremomys lokriah,* rhesus macaque *Macaca mulata,* barking deer *Muntiacus muntjak,* large hare *Lepus nigricollis* and yellow throated marten *Martes flavigula* were recorded by direct sighting. Four species were recorded in Bagmati area, two in Nagmati area and seven in *Dhap* area. The periphery of *Dhap* supports important habitat for wild animal. The 10 species belonged to 5 orders and 8 families.

Table 2: Wild Mammals of Project Area

SN	Common/Scientific Names	Order	Family	Identification	No. of Sightings	Location
1	Orange-bellied Himalayan Squirrel (*Dremomys lokriah*)	Rodentia	Scuridae	V	1	B
2	Rhesus Macaque (*Macaca mulata*)	Primates	Cercopithecidae	V	>5	B
3	Barking Deer (*Munitacus muntjak*)	Artiodactyla	Cervidae	P, V	3	B, Dh
4	Large Hare (*Lepus nigricollis*)	Lagomorpha	Laporidae	V	2	Dh
5	Yellow-throated Marten (*Martes flavigula*)	Carnivora	Mustelidae	F, V	2	Dh
6	Leopard Cat (*Prionailurus*	Carnivora	Felidae	S	4	N, Dh

	bengalensis)					
7	Jungle Cat (*Felis chaus*)	Carnivora	Felidae	S	1	N
8	Common Leopard (*Panthera pardus*)	Carnivora	Felidae	S	2	Dh
9	Large Civet (*Viverra zibetha*)	Carnivora	Viverridae	Sc	2	N, Dh
10	Wild Boar (*Sus scrofa*)	Artiodactyla	Suidae	D	>3	Dh

Note: Identification: V=Direct Sighting, P=Pellet, F=Footprint, S=Scat, Sc=Scent, D=Digging; Location: B=Bagmati, N=Nagmati, Dh=Dhap

Source: Field Survey, 2012

Bagmati Dam Area

Two transects were laid around the proposed Bagmati dam site to survey the signs of wild animals. None was recorded along the first transect. Fresh pellets casted by *Muntiacus muntjak* was found along the second transect trail. The details about the finding are presented in the table that follows.

Table 3: Wildlife of Bagmati Area

Animal	**Sign**	**Location**	**Coordinates**	**Elevation**	**Aspect**	**Crown Cover**	**Dominant Trees**	**Distance from Water**
Munitacus muntjak	Pellet	Transect 2	$27^0$46.861" N $85^0$25.626" E	1667 m	SE	86%	*Querqus glauca, Rhododendron arboreum, Thea sp.,* etc.	20m

Source: Field Survey, 2012

Nagmati Dam Area

Six transects were laid in the Nagmati dam area, 3 in the downstream and 3 in the upstream. Scats of *Prionailurus bengalensis* and *Felis chaus* and scent of *Viverra zibetha* were recorded in the area confirming the presence of those three carnivores. None of the animal was sighted directly in the area. Nagmati dam area seems to support important wildlife habitat and act as their important movement corridor.

Table 4: Wildlife Recorded at Nagmati Area

Animal	Sign	Location	Coordinates	Elevation	Aspect	Crown Cover	Dominant Trees	Distance from Water
Felis chaus	Scat	Transect No. 3	$27^{0}46.586$" N $85^{0}26.461$" E	1841 m	SE	Open	*Pinus roxburghii, Rhododendron arboreum, Myrica esculenta*, etc.	100 m from Nagmati
Felis bengalensis	Scat	Transect No. 4	$27^{0}46.696$" N $85^{0}26.561$" E	1856 m	E	4%	*Pinus roxburghii, Pyrus pashia, Quercus sp., Gultheria fragrantissima,* etc.	20 m
	Scat	Transect No. 6	$27^{0}47.373$" N $85^{0}26.824$" E	1921 m	E	28%	*Rhododendron arboreum, Quercus sps, Thea sps, Myrica esculenta,* etc.	20 m
	Scat with worms	Middle of the road	$27^{0}47.480$" N $85^{0}27.181$" E			64%	*Rhododendron arboreum, Lyonia ovalifolia, Daphniphyllum himalayensis*	20 m
Viverra zibetha	Scent	Transect No. 8	$27^{0}47.801$" N $85^{0}27.561$" E	1977 m	Ridge, S	85%	*Pyrus pashia, Thea sps, Myrica esculenta,* etc.	50 m

Source: Field Survey, 2012

Dhap Area

Dhap area consists of diverse habitat which supports variety of mammals. Four transects were laid surrounding the *Dhap.* Five different mammals were confirmed by identification of their signs encountered along those transects. *Viverra zibetha* was confirmed by scat and scent, *Sus scrofa* by digging, *Munitacus muntjak* by pellets, *Prionailurus bengalensis* by scat and *Martes flavigula* by pugmark. *Lepus nigricollis, Muntiacus muntjak and Martes flavigula* were also sighted directly in the vicinity of *Dhap* area. Additionally, relic scats of *Panthera pardus* found outside transect confirmed the presence of the carnivore.

Table 5: Wildlife of *Dhap* Area

Animal	Sign	Location	Coordinates	Elevation	Aspect	Crown Cover	Dominant Trees	Distance from Water
Viverra zibetha	Scat	Transect No. 9	$27^0$48.600" N $85^0$27.635" E	2088 m	N	1%	*Lyonia ovalifolia, Pyrus pashia, Berberis aristata, Daphniphyllum sps*	25 m
	Scent	Transect No. 10	$27^0$48.459" N $85^0$27.729" E	2089 m	NW	73%	Do	5 m
Sus scrofa	Digging	Transect No. 9	$27^0$48.587" N $85^0$27.724" E	2085 m	S	47%	Do	35 m
	Digging	Transect No. 9	$27^0$48.623" N $85^0$27.762" E	2087 m	S	48%	Do	35 m
	Digging	Transect No. 10	$27^0$48.532" N $85^0$27.771" E	2084 m	N	81%	Do	1 m
Munitacus muntjak	Pellet	Transect No. 11	$27^0$48.475" N $85^0$27.579" E	2084 m	SE	25%	Do	5 m
	Sight	-	-	-	-	-	-	-
Martes flavigula	Pug mark	Transect No. 11	$27^0$48.475" N $85^0$27.579" E	2084 m	SE	25%	do	5 m
	Sight	Grassla	$27^0$48.475"	2084 m	SE	25%	do	5 m

		nd	N $85^0 27.579$" E					
P.bengal -ensis	Scat	Transect No. 11	$27^0 48.246$" N $85^0 27.464$" E	2062 m	Plain	2%	*Alnus nepalensis, Rhododendr on arboreum, Lyonia ovalifolia, Berberis aristata,* etc.	< 1 m
Panther a pardus	Scat	Middle of the road	$27^0 47.515$" N $85^0 27.866$" E	2088 m	N	8%	*Daphniphyll um sp, Pyrus pashia, Alnus nepalensis*	100 m
Lepus nigricolli s	Sight	In the forest	$27^0 48.633$" N $85^0 27.635$" E	2090 m	E	20%	*Daphniphyll um sp, Pyrus pashia*	5 m

Source: Field Survey, 2012

4. Protected and Threatened Mammals

Of the animals recorded so far, only *Prionailurus bengalensis* finds strict protection under National Park and Wildlife Conservation Act, 1973 and Appendix I of CITES, while it is Least Concerned (LC) species in the IUCN Red List of threatened animals. *Pathera pardus* is listed as Near Threatened (nt) in the IUCN Red List and in Appendix I of CITES. Similarly, *Macaca mulata* and *Felis chaus* are listed in CITES Appendix II and *Martes flavigula* and *Viverra zibetha* in CITES Appendix III.

Table 6: Protected and Threatened Wildlife of Project Area

SN	Scientific Name	Protection Status		
		GoN	IUCN	CITES
1	*Prionailurus bengalensis*	Schedule 1	LC	I
2	*Panthera pardus*		Nt	I
3	*Macaca mulata*		LC	II
4	*Felis chaus*		LC	II
5	*Martes flavigula*		LC	III
6	*Viverra zibetha*		Vu	III

Note: Y=Protected under NPWC Act, 1973, LC=Least conern, Nt=Near threatened, Vu=Vulnerable; I, II& III=Appendices

5. Discussion

Altogether 10 different species belonging to 5 orders and 8 families were recorded in the project area by direct and indirect methods. Shrestha and Basnet, 2005 had documented 18 mammalian species belonging to 6 orders and 14 families by indirect sign validation technique. The park record shows that the park provides shelter to 21 species of mammals including clouded leopard (*Neofelis nebulosa*), common leopard (*Panthera pardus*), leopard cat (*Prionailurus bengalensis*), jungle cat (*Felis chaus*), Himalayan black bear (*Ursus thibetanus*), Pangolin (*Manis* sp.), and many other prey species (Pandey, 2010). Different species of bats such as Great Roundleaf bat *Hipposideros armiger,* Greater False Vampire Bat *Megaderma lyra*, LittleTube–Nosed Bat *Murina aurata,* Common bent wing bat *Miniopterus schreibersii*, Intermediate horse shoe bat *Rhinolophus affinis*, Greater horse-shoe bat *Rhinolophus ferrumequinum*, Big-eared Horseshoe Bat *Rhinolophus macrotis* and Least Horseshoe Bat (*Rhinolophus pusillus* have also been recorded in previous studies (Thapa *et al.* 2010, Thapa *et al.* 2009, Malla *et al.* 2000, Csorba *et al.* 1999) Bhuju et.al (2007) have mentioned that SNNP holds 10% (19) of the mammalian species of Nepal. No species other than that found in previous studies were recorded.

Documentation of mammalian species only by direct sighting is very difficult. Although direct observation is the most acceptable method in identifying mammalian species, non-invasive sampling and indirect methods with the aid of signs are equally efficient way of studying wild mammals. Moreover, the effectiveness of the study depends on duration spent in the field and time and season of observation. Most of the carnivores are nocturnal and rarely come out in the daylight. Wild cats are elusive and difficult to catch sight of. Since the field observation was conducted for a very short duration (11-18 September, 2012) covering a wide area (all the three, Bagmati, Nagmati and Dhap Dam areas), the result might not be able to portray the picture of overall wildlife diversity of the area. Therefore, a composite of both direct and indirect methods have been applied to document wild mammals of the project area and additionally the information obtained from local people and review of past studies was also given due attention. This picture should only be taken as a rough representation of the wildlife diversity of the project area and findings from previous studies should also be given due consideration.

Regarding the nature of the habitat and its physiographical location, the area could be a home to many more wildlife species besides those recorded in the limited field effort of a week representing only one season and with limited resources. As far as locating a development project in such area is concerned, the potential impact on wildlife species with probable occurrence should be considered equally important. Considering the habitat characteristics and physiography as well as previous study reports, an attempt has been made to present a precise inventory of the species occurring in the specific project areas in SNNP.

Table 7: Wildlife of Bagmati Area

SN	Common/Scientific Names	Status	Habitat	Food	Season	Likely at Bagmati
1	Chinese pangolin *Manis pentadactyla*	National: Endangered Global: Endangered	Forest/Burrows	Ants and termites	All year	Most likely
2	Himalayan black bear *Ursus thibetanus*	National: Endangered Global: Vulnerable	Forest with bamboo clumps	Omnivore	All year	Possible
3	Large civet *Viverra zibetha*	National: Near threatened Global: Near threatened	Forest and edge of human habitation	Rodents, birds and fruits	All year	Most likely
4	Clouded leopard *Neofelis nebulosa*	National: Vulnerable Global: Endangered	Forest	Monkeys, deer, Rodents	All year	Possible
5	Common Leopard *Panthera pardus*	National: Vulnerable Global: Near threatened	Forest	Deer, monkey, Rodents	All year	Most likely
6	Leopard Cat *Prionailurus bengalensis*	National: Vulnerable Global: Least concern	Forest/shrubland	Rodents and game birds	All year	Yes
7	Jungle cat *Felis chaus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Rodents and game birds	All year	Yes
8	Golden jackal *Canis aureus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Deer, rodents and game birds	All year	Most likely
9	Yellow-throated Marten *Martes flavigula*	National: Least concern Global: Least concern	Forest/shrubland	Rodents, birds and fruits	All year	Most likely
10	Crab eating mongoose *Herpestes urva*	National: Vulnerable Global: Least concern	Forest	Rodents, birds, crabs and snakes	All year	Most likely
11	Small mongoose *Herpestes javanicus*	National: Least concern Global: Least concern	Forest and nearby human habitation	Rodents, snakes, birds and insects	All year	Possible

			/Burrows			
12	Masked palm civet *Paguma larvata*	National: Least concern Global: Least concern	Forest	Rodents, birds, insects and fruits	All year	Most likely
13	Rhesus Macaque *Macaca mulata*	National: Least concern Global: Least concern	Forest/Nearby human habitation	Fruits, tubers, insects and crops	All year	Yes
14	Hanuman langur *Semnopithecus entellus*	National: Least concern Global: Least concern	Forest	Fruits, tubers, insects and crops	All year	Likely
15	Himalayan goral *Naemorhedus goral*	National: Near threatened Global: Near threatened	Steep cliff grasslands with forest cover	Grass and leaves	All year	Least possibility
16	Barking Deer *Munitacus muntjak*	National: Least concern Global: Vulnerable	Forest/Nearby human habitation	Grass and leaves	All year	Yes
17	Wild Boar *Sus scrofa*	National: Least concern Global: Least concern	Forest and grasslands	Tubers and scavenging	All year	Most likely
18	Orange-bellied Himalayan Squirrel *Dremomys lokriah*	National: Least concern Global: Least concern	Forest	Nuts, fruits and seeds	All year	Yes
19	Large Hare *Lepus nigricollis*	National: Least concern Global: Least concern	Forest/Burrows	Grass, forbs and leafy weeds	All year	Most likely
20	Indian crestless porcupine *Hystrix indica*	National: Data deficient Global: Least concern	Forest/ Nearby human habitation /Burrows	Fruits, grains and roots of plants	All year	Most likely

Table 8: Wildlife of Nagmati Area

SN	Common/Scientific Names	Status	Habitat	Food	Season	Likely at Nagmati
1	Chinese pangolin *Manis pentadactyla*	National: Endangered Global: Endangered	Forest/Burrows	Ants and termites	All year	Most likely
2	Himalayan black bear	National: Endangered	Forest with bamboo	Omnivore	All year	Possible

	Ursus thibetanus	Global: Vulnerable	clumps			
3	Large civet *Viverra zibetha*	National: Near threatened Global: Near threatened	Forest and edge of human habitation	Rodents, birds and fruits	All year	Yes
4	Clouded leopard *Neofelis nebulosa*	National: Vulnerable Global: Endangered	Forest	Monkeys, deer, rodents	All year	Most likely
5	Common Leopard *Panthera pardus*	National: Vulnerable Global: Near threatened	Forest	Deer, monkey, rodents	All year	Most likely
6	Leopard Cat *Prionailurus bengalensis*	National: Vulnerable Global: Least concern	Forest/shrubla nd	Rodents and game birds	All year	Yes
7	Jungle cat *Felis chaus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Rodents and game birds	All year	Yes
8	Golden jackal *Canis aureus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Deer, rodents and game birds	All year	Most likely
9	Yellow-throated Marten *Martes flavigula*	National: Least concern Global: Least concern	Forest/shrubla nd	Rodents, birds and fruits	All year	Most likely
1 0	Crab eating mongoose *Herpestes urva*	National: Vulnerable Global: Least concern	Forest	Rodents, birds, crabs and snakes	All year	Most likely
1 1	Small mongoose *Herpestes javanicus*	National: Least concern Global: Least concern	Forest and nearby human habitation /Burrows	Rodents, snakes, birds and insects	All year	Possibl e
1 2	Masked palm civet *Paguma larvata*	National: Least concern Global: Least concern	Forest	Rodents, birds, insects and fruits	All year	Most likely
1 3	Rhesus Macaque *Macaca mulata*	National: Least concern Global: Least concern	Forest/Nearby human habitation	Fruits, tubers, insects and crops	All year	Most likely
1 4	Hanuman langur *Semnopithecus entellus*	National: Least concern Global: Least	Forest	Fruits, tubers, insects and	All year	Most likely

		concern		crops		
15	Himalayan goral *Naemorhedus goral*	National: Near threatened Global: Near threatened	Steep cliff grasslands with forest cover	Grass and leaves	All year	Least possibility
16	Barking Deer *Munitacus muntjak*	National: Least concern Global: Vulnerable	Forest/Nearby human habitation	Grass and leaves	All year	Most likely
17	Wild Boar *Sus scrofa*	National: Least concern Global: Least concern	Forest and grasslands	Tubers and scavenging	All year	Most likely
18	Orange-bellied Himalayan Squirrel *Dremomys lokriah*	National: Least concern Global: Least concern	Forest	Nuts, fruits and seeds	All year	Most likely
19	Large Hare *Lepus nigricollis*	National: Least concern Global: Least concern	Forest/Burrows	Grass, forbs and leafy weeds	All year	Most likely
20	Indian crestless porcupine *Hystrix indica*	National: Data deficient Global: Least concern	Forest/ Nearby human habitation /Burrows	Fruits, grains and roots of plants	All year	Most likely

Table 9: Wildlife of Dhap Area

SN	Common/Scientific Names	Status	Habitat	Food	Season	Likely at Dhap
1	Chinese pangolin *Manis pentadactyla*	National: Endangered Global: Endangered	Forest/Burrows	Ants and termites	All year	Less likely
2	Himalayan black bear *Ursus thibetanus*	National: Endangered Global: Vulnerable	Forest with bamboo clumps	Omnivore	All year	Possible
3	Large civet *Viverra zibetha*	National: Near threatened Global: Near threatened	Forest and edge of human habitation	Rodents, birds and fruits	All year	Yes
4	Clouded leopard *Neofelis nebulosa*	National: Vulnerable Global: Endangered	Forest	Monkeys, deer, rodents	All year	Most likely
5	Common Leopard *Panthera pardus*	National: Vulnerable Global: Near	Forest	Deer, monkey, rodents	All year	Yes

		threatened				
6	Leopard Cat *Prionailurus bengalensis*	National: Vulnerable Global: Least concern	Forest/shrubland	Rodents and game birds	All year	Yes
7	Jungle cat *Felis chaus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Rodents and game birds	All year	Most likely
8	Golden jackal *Canis aureus*	National: Least concern Global: Least concern	Forest and edge of human habitation	Deer, rodents and game birds	All year	Most likely
9	Yellow-throated Marten *Martes flavigula*	National: Least concern Global: Least concern	Forest/shrubland	Rodents, birds and fruits	All year	Yes
10	Crab eating mongoose *Herpestes urva*	National: Vulnerable Global: Least concern	Forest	Rodents, birds, crabs and snakes	All year	Most likely
11	Small mongoose *Herpestes javanicus*	National: Least concern Global: Least concern	Forest and nearby human habitation /Burrows	Rodents, snakes, birds and insects	All year	Possible
12	Masked palm civet *Paguma larvata*	National: Least concern Global: Least concern	Forest	Rodents, birds, insects and fruits	All year	Most likely
13	Rhesus Macaque *Macaca mulata*	National: Least concern Global: Least concern	Forest/Nearby human habitation	Fruits, tubers, insects and crops	All year	Most likely
14	Hanuman langur *Semnopithecus entellus*	National: Least concern Global: Least concern	Forest	Fruits, tubers, insects and crops	All year	Most likely
15	Himalayan goral *Naemorhedus goral*	National: Near threatened Global: Near threatened	Steep cliff grasslands with forest cover	Grass and leaves	All year	Least possibility
16	Barking Deer *Munitacus muntjak*	National: Least concern Global: Vulnerable	Forest/Nearby human habitation	Grass and leaves	All year	Yes
17	Wild Boar *Sus scrofa*	National: Least concern Global: Least concern	Forest and grasslands	Tubers and scavenging	All year	Yes

18	Orange-bellied Himalayan Squirrel *Dremomys lokriah*	National: Least concern Global: Least concern	Forest	Nuts, fruits and seeds	All year	Most likely
19	Large Hare *Lepus nigricollis*	National: Least concern Global: Least concern	Forest/Burrows	Grass, forbs and leafy weeds	All year	Yes
20	Indian crested porcupine *Hystrix indica*	National: Data deficient Global: Least concern	Forest/ Nearby human habitation /Burrows	Fruits, grains and roots of plants	All year	Most likely

6. Specific Impacts on Wild Mammals due to Project Activities

Every development activities have environmental repercussions. One of the major aim of the study is to find the potential impact, beneficial or adverse, the implementation of the proposed project will bring about on wildlife and their habitat during construction phase and operation phase.

Beneficial Impact

Creation of Wetland Habitat: Construction of reservoir will create a wetland that might turn into important wildlife habitat. Perennial water bodies will remove the limit on wildlife distribution related to water availability. The impact will be of larger magnitude, medium in extent and permanent in duration.

Adverse Impact

Construction Phase

1) Disturbance to Wildlife: The presence of workforce and movement of heavy vehicles during the constructions and, the noise and vibrations caused by them, will disturb the wildlife which will, hence, force them to change their territory and move to other locations where the situations for them may not be welcoming and still worse.

2) Hunting and Poaching of Wildlife: The workforce may get involved in hunting and poaching of wildlife thus adversely affecting wildlife population and diversity of the area.

3) Loss of Wildlife Habitat: Quarrying and stockpiling, muck disposal activities, dredging and clearance of the field for dam construction will affect the wildlife habitat as the project is proposed in known wildlife habitat. Loss of wildlife habitat will have deleterious effect on existing wildlife population.

4) Wildlife Casualties: Rock fragments shot out from blasting activities and road collision with vehicles may kill wild animals.

Operation Phase

1) Habitat Fragmentation and Destruction: The pond created will inundate some of the core habitats of wildlife. Besides, permanent deep water pond creates a barrier to wildlife movement thus restricting their distribution. For example, grasslands that are being used by the free ranching animals around the *Dhap* area will be lost. They were found to support the herbivores like *Munitacus muntjak* and *Lepus nigricollis*. Similarly, hunting ground of the carnivores like *Martes flavigula, Prionailurus bengalensis* and *Panthera pardus* will be lost.

2) Loss of Wildlife Corridor: As evident in the field, some of the areas that will be inundated are currently serving as wildlife movement corridor. Especially areas at the immediate banks of the Nagmati River just upstream of the proposed dam, called as *Sano Dhap* and upstream of *Dhap* dam site were found to be important wildlife corridors. These will be permanently lost and this will have negative impact on wildlife population and distribution.

3) Impact to Burrowing Wildlife: Wildlife that live in burrows (for eg. Large hare, Chinese pangolin and Mongooses) will be impacted after the dams are made. Their habitat will be lost completely after the areas get submerged.

7. Conclusions

The project area was found to hold more than 10 different species of wild mammals. This number may come out to be more if we consider the past studies. Therefore, the project area can be said to have some core wildlife habitat and some important movement corridors for wildlife. The proposed project works is sure to inundate some core habitats and corridors of wildlife. Additionally, wildlife casualties, increased hunting and poaching will be deleterious to wildlife diversity of the project area. So, appropriate practical measures will be necessary to mitigate such impacts on wildlife and their habitat.

8. Recommendations and Measures to Mitigate Impact on Wildlife

Based on the findings of the study, some suggestions are made to reduce the effects of the project implementation on the wildlife of the project area. The following activities have been recommended to mitigate the impact of project implementation on the wildlife of the project area:

Restriction of the workforces in the camp

The movement of the workforces during the construction of the dams at three sites, even during non-working hours, will be extremely high inside the park area which will disturb the residing wildlife there. This could be significantly reduced by preparing and imposing do's and dont"s for them in the three areas.

Habitat manipulation that may include creation of new grasslands

Dhap area seems to be one of the most important sites in the whole area with diverse habitats (i.e. wetland, grassland and forest). The currently proposed *Dhap* dam (which is supposed to be 24 m high) is going to submerge the present *Dhap* area till the road that goes to *Chisapani*. As such, creation of new grasslands and edge habitats which encourages diverse wildlife is highly recommended to compensate the loss of the best habitat for wildlife.

Use of high efficiency vehicles that make least noise

Any projects with a development aspect (mostly infrastructure development) will have significant impact with loud noise in the project area. This will alter the movements of the wildlife that are primarily associated with daylight such as yellow throated marten and common hare. It is, thus, recommended that the use of high efficiency vehicles would maintain the normal mobility of the species.

Proper selection of quarry, stock piling and muck disposal sites

There will be a huge amount of waste and debris generated during the pre-construction and construction phase. The haphazard collection and disposal of these waste materials could pose serious problem to the aesthetic beauty of the park. Furthermore, the disposal of these wastes might attract undue attention of wild animals in the area. As such, it is suggested that the sites to dispose off the quarry and debris be properly selected so as to make sure that the natural environment of the park seems intact.

Maintaining the water level at dam at Dhap to preserve the grassland lying upstream of that area

The water level of the *Dhap* dam is supposed to submerge even the road to *Chisapani*. If possible, it would be extremely good for the mammals to maintain the wetland habitat instead of a big pond there as was evident from sightings of three different mammals in the present habitat i.e. barking deer, common hare and yellow throated marten.

Strict preservation of some area as core wildlife habitat following more detailed and rigorous research

Dhap area is an extremely important refuge for the wildlife in Shivapuri-Nagarjuna National Park. The area presented frequent sightings of different wildlife (Barking deer, common hare and yellow throated marten). Since the area will be submerged after the dam at *Dhap* is constructed, it is recommended that the area around *Dhap* be strictly looked after and protected during the project period.

Temporary wildlife refuge or animal care center

It is very likely that wild animals get wounded during equipment operation and other construction activities. Similarly, they may get strayed due to disturbances. Adults may abandon their juveniles when they run away from disturbances. These issues can be addressed by maintaining a well equipped wildlife refuge or care center. This can/should be done in co-ordination with the line agencies like SNNP.

Relocation of burrowing animals

Burrowing animals such as pangolin, hares and mongooses might get impacted due to the construction of the dams. A research on finding the active burrows should be done and the animals refuging there should be relocated to another area outside the impact zone of the reservoir.

9. References

Bhuju, U. R, Shakya, P. R., Basnet, T. B. & Shrestha, S. 2007. *Nepal Biodiversity Resource Book*. United Nations Environment Programme (UNEP), Ministry of Environment Science and Technology (MoEST), Government of Nepal.

Chaudhary, R.P. 1998. *Biodiversity in Nepal: Status and Conservation*. S. Devi, Saharanpur (U.P.), India and Tec. Press Books, Bangkok, Thailand.

Csorba, G., S.V. Kruskop, and A.V. Borissenko. 1999. Recent records of bats (Chiropetra) from Nepal with remarks on their natural history, *Mammalia*, issue 63, no. 1:61-78

Malla. R. 2000. Diet Analysis of *Hipposideros armiger* and *Rhinolophus pussilus* (Microchiroptera) of Nagarjun Cave. A thesis submitted to Central Department of Zoology, T.U. Kirtipur, Kathmandu, Nepal, 4-6pp

Pandey, B.P. 2010. *Presence Absence Survey of Clouded Leopard (Neofelis nebulosa) in Shivapuri Nagarjun National Park, Nepal.* Report submitted to Shivapuri-Nagarjuna NationaL Park.

Shrestha, B & Basnet, K. 2005. Indirect Methods of Identifying Mammals: A Case Study from Shivapuri National Park, Nepal. *Ecoprint,* Vol 12: 43-58.

Thapa, S., S., Shrestha and S., Dahal 2010. Detailed monitoring survey of bats and their conservation through radio awareness programme and outreach programme to school children in Kathmandu Valley. A second phase report submitted to Rufford Small Grants, UK

Thapa, S.B., R Kaphle, A. Thapa and S., Dahal 2009. A report on preliminary survey of microchiropteran bats in Kathmandu Valley. CDZ Small Mammals Club, Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu Nepal, ii+11pp

Field Survey Report 3

BIRD SURVEY ALONG THE PROPOSED DAM SITE OF BAGMATI, NAGMATI AND DHAP AREA

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Center
Kathmandu University

Submitted by:

Raju Acharya
Sagar Dahal
Bird Survey Team

October 2012

EXECUTIVE SUMMARY

Birds are one of the fundamental components of the biodiversity. They play a vital ecological role as both predator and prey, and also facilitate pollination and seed dispersal. Many a times, they act as the indicator species of a healthy ecosystem.

A brief survey of birds of the proposed dam site was carried out at the Shivapuri-Nagarjun National Park from 11 September 2012 to 17 September 2012. The main objective of the study was to observe and record the different species of birds found in and around the proposed dam site. The specific objectives were to record the diversity of birds and conduct on-site study and determine possible impacts on them by the proposed dam in Bagmati, Nagmati and Dhap area. Altogether, 12 transects of average length of 450m (the smallest transect 250m and the largest 700m transect) were taken along the walking trail at three sites. Both sides of transects were observed for birds with the aid of binoculars. Altogether 61 species of birds were recorded in the entire survey. The maximum number of birds recorded in SNNP was 318 species. In our survey, 5 species of birds have been recorded for the first time in the SNNP area, making the new total recoded species to 323. Among them, one is a vulnerable species (National status). Studies showed 12 species of nationally and globally threatened birds in SNNP. This park also harbors the only endemic species of Nepal, Spiny babbler.

Cutting down the fruit bearing trees in the proposed site will have a major impact to the habitat of tree roosting birds whereas submersion of breeding ground after the construction of dam will cause major impact to the water birds. Plantation of fruit bearing trees species like *Pyrus pashia, Pyracantha crenulata Quercus semecarpifoloa* etc. must be carried out to mitigate the habitat loss of tree birds and construction of islands within the dam or creating new wetlands in another area of Dhap will help mitigate the impacts on breeding ecology of water birds.

PART ONE: INTRODUCTION

Background

Water dams are major development projects. They have large impacts on the existing local environment. The severities of environmental impacts from water dam projects are largely determined by the dam site. While dams at good sites can be very defensible from an environmental standpoint, those proposed at bad sites will inherently be highly problematic, even if all feasible mitigation measures are properly implemented.

Three dams have been proposed by River Basin Improvement Project (BRBIP) at the upper reaches of the Bagmati River basin with the help of Asian Development Bank which lies with the Shivapuri-Nagarjun National Park (SNNP) boundary. SNNP (159 sq km) is situated on the northern fringe of Kathmandu valley and lies about 12 km away from the center of capital city. The area was gazetted as the country's ninth National Park in 2002. Prior its declaration as National Park, it was managed under the Shivapuri Watershed Development Board, and was later declared as Shivapuri Watershed and Wildlife Reserve (http://www.dnpwc.gov.np). This study intends to document the diversity of birds found in the proposed dam area which will be impacted by the construction of the dams. This study also recommends the mitigating measures to the probable adverse impact on the habitat destruction and casualties to the birds.

Objectives

The main objective of the survey was to:

i) record the number of birds species observed from the Shivapuri-Nagarjun National Park

The specific objectives were to:

i) record the diversity of birds in Bagmati, Nagmati and Dhap area
ii) identify the possible impacts that the implementation (construction and operation) of the proposed project will bring about on the avian fauna and their habitat
iii) recommend the measures to mitigate the impact of the proposed project on avian fauna and their habitat

Methods

The methods implied for the survey of the avian fauna species were:

1.3.1 Literature Review

List of Bird species recorded from Shivapuri-Nagarjun National Park were collected using the secondary source (BCN and DNPWC 2011, SNP and BCN 2007). “Birds of SNPP”, a booklet published by Bird Conservation Nepal was the major secondary source used (SNP and BCN 2007). Identification of birds was done using the field guide “Birds of Nepal” by Grimmet et al. (2009).

1.3.2 Direct Sightings

All the birds sighted directly from the SNNP were identified and recorded. Similarly, all the birds observed from the specific dam sites at Bagmati, Nagmati and Dhap area were also identified and recorded. For systematic sampling, altogether 12 transects were set up on the dam sites and the birds observed on these transects were identified and recorded. Major fruit bearing trees were also recorded from the specific dam sites.

Study Site

Bagmati, Nagmati and Dhap are the proposed dam site areas. Bagmati and Nagmati were near to Mulkharka whereas Dhap area was near to Chisapani of Shivapuri-Nagarjun National Park.

Transects Details

Table 1. GPS coordinates of each transect

Transect No Date	Starting Point	Ending Point	Elevation	GPS Accuracy	Location	VDC
1 (012-9-12)	$27^0$46.749" N $85^0$25.618" E	$27^0$46.549" N $85^0$25.502" E	1622m 1669m	+/- 6m +/- 6m	d/s-B	Mulkharka, Sundarijal
2 (012-9-12)	$27^0$46.917" N $85^0$25.611" E	$27^0$46.849" N $85^0$25.601" E	1694m 1657m	+/- 5m +/- 6m	u/s-B	Mulkharka, Sundarijal
3 (012-9-12)	$27^0$46.513" N $85^0$26.361" E	$27^0$46.691" N $85^0$26.512" E	1833m 1851m	+/- 4m +/- 5m	d/s-N	Harkatol, Sundarijal
4 (012-9-14)	$27^0$46.694" N $85^0$26.530" E	$27^0$46.732" N $85^0$26.609" E	1850m 1857m	+/- 7m +/- 5m	d/s-N	Harkatol, Sundarijal
5 (012-9-14)	$27^0$46.874" N $85^0$26.622" E	$27^0$46.958" N $85^0$26.777" E	1891m 1866m	+/- 6m +/- 5m	d/s-N	Sanodhap, Sundarijal
6 (012-9-14)	$27^0$47.291" N $85^0$26.869" E	$27^0$47.384" N $85^0$26.863" E	1904m 1955m	+/- 6m +/- 8m	u/s-N	Sanodhap, Sundarijal
7 (012-9-14)	$27^0$47.400" N $85^0$27.085" E	$27^0$47.569" N $85^0$27.388"	1905m 1935m	+/- 6m +/- 7m	u/s-N	Sanodhap, Sundarijal

		E				
8 (012-9-14)	$27^0$47.682" N $85^0$27.487" E	$27^0$47.975" N $85^0$27.595" E	1935m	+/- 5m +/- 7m	u/s-N	Sanodhap, Sundarijal
9 (012-9-16)	$27^0$48.633" N $85^0$27.635" E	$27^0$48.623" N $85^0$27.762" E	2080m 2087m	+/- 5m +/- 5m	u/s-Dh	Dhap, Sundarijal
10 (012-9-16)	$27^0$48.532" N $85^0$27.771" E	$27^0$48.459" N $85^0$27.729" E	2084m 2089m	+/- 4m +/- 5m	u/s-Dh	Dhap, Sundarijal
11 (012-9-16)	$27^0$48.475" N $85^0$27.579" E	$27^0$48.243" N $85^0$27.491" E	2084m 2069m	+/- 4m +/- 5m	u/s-Dh	Dhap, Sundarijal
12 (012-9-17)	$27^0$48.193" N $85^0$27.487" E	$27^0$47.975" N $85^0$27.595" E			d/s-Dh	Dhap, Sundarijal

Note: Location: d/s=downstream, u/s=upstream, B=Bagmati Dam, N=Nagmati Dam, Dh=Dhap Dam

Map of the Study site

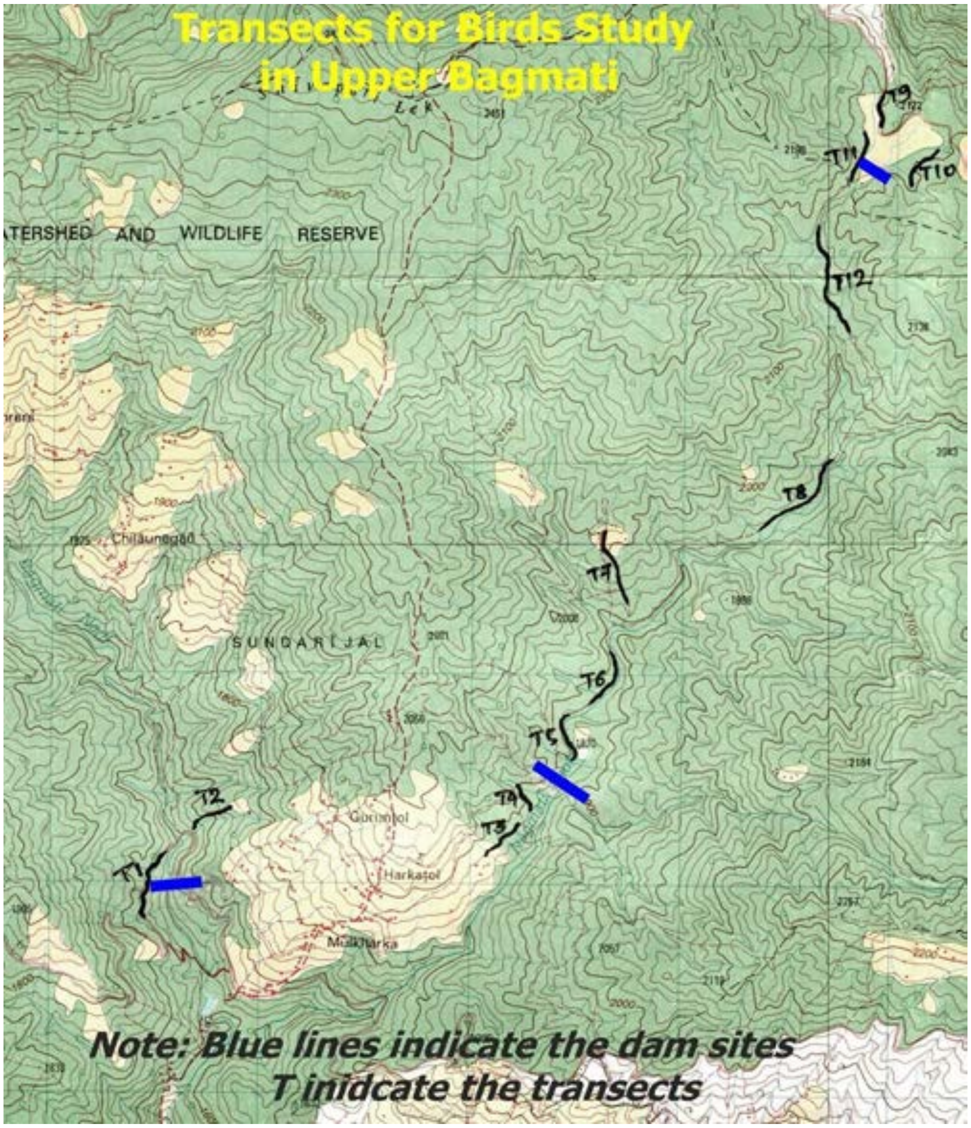


Figure 1. Map of the transects on the study site

Altogether 12 transects were taken at three dam sites during the survey (Figure 1). The beginning and end point of GPS coordinates, elevation and accuracy of GPS was taken. Location of transects and the name of village development committee were also recorded while setting up the transect (Table 1).

PART TWO: OUTPUTS/FINDINGS

Results

Altogether 64 species of birds were observed during the survey. Among them five species of birds were recorded for the first time. Previous studies showed 318 species of birds present in SNP (SNP and BCN 2007) which is increased to 323 species of birds from this survey. Eurasian Blackbird (*Turduus merula*), Sand Martin (*Riparia riparia*), Scaly Laughing Thrush (*Garrulax subunicolor*), White breasted waterhen (*Amaurornis phoenicurus*) and White-tailed Stonechat (*Saxicola leucura*) are recorded for the first time. The major fruit bearing tree species of the study area were *Castanopsis indica, Pyrus pashia, Syzygium cumini, Zizyphus incurva, Rubus ellipticus, Gaultheria fragrantissima, Pyracantha crenulata, Myrica esculenta.*

a.

b.

c.

d.

Figure 3. (a.) Shikra (Photo Y. Ghimire) (b.) Striated Laughingthrush (Photo S. Dahal) (c.) Green Pigeon (Photo Y. Ghimire) and (d.) Grey hooded Warbler (Photo Y. Ghimire)

Table 2 Birds recorded from project area

S.N.	Order	Family	English name	Scientific Name	Status	No. of Species
1	BARBETS	Megalaimidae	Blue Throated Barbet	*Megalaima asiatica*	r2	
			Golden Throated Barbet	*Megalaima franklinii*	r3	
			Great Barbet	*Megalaima virens*	r4	3
2	BULBULS	Pycnonotidae	Black Bulbul	*Hypsipetes leucocephalus*	r1	
			Himalayan Bulbul	*Pycnonotus leucogenys*	r2	
			Mountain Bulbul	*Hypsipetes mcclellandii*	r2	4
			Red-vented Bulbul	*Pycnonotus cafer*	r1	
3	DIPPER	Cinclidae	Brown Dipper	*Cinclus pallasii*	r4	1
4	FALCONS	Falconidae	Common Kestrel	*Falco tinnunculus*	r3	1
			Lesser Kestrel	*Falco naumanni*	r3	1
5	FRANCOLIN, PHEASANT AND PARTRIDGES	Phasianidae	Hill Partridge	*Arborophila torqueola*	r1	1
6	HOOPOE	Upupidae	Common Hoopoe	*Upupa epops*	m3	1
7	KITES, EAGLES AND VULTURES	Accipitridae	Black Eagle	*Ictinaetus malayensis*	r3	
			Black Kite	*Milvus migrans*	r2	4
			Crested Serpentine Eagle	*Spilornis cheela*	r2	
			Shikra	*Accipter badius*	r3	
8	MAGPIES, TREEPIE AND CROWS	Corvidae	Black Drongo	*Dicrurus macrocercus*	r1	
			Eurasian Blackbird	*Turduus merula*	A	
			Grey Treepie	*Dendrocitta formosae*	r1	
			House Crow	*Corvus splendis*	r1	
			Large -billed Crow	*Corvus macrorhynchos*	r1	9
			Scarlet Minivet	*Pericrocotus flammeus*	r1	
			Red-billed Blue Magpie	*Urocissa erythrorhyncha*	r1	

			Rufous Treepie	*Dendrocitta vagabunda*	r3	
			Yellow-billed Blue Magpie	*Urocissa flavirostris*	r5	
9	MARTINS AND SWALLOWS	Hirundinidae	Barn Swallow	*Hirundo rustica*	r3	2
			Sand Martin	*Riparia riparia*	A	
10	MYNAS	Sturnidae	Common Myna	*Acridotheres tristis*	r1	7
			Himalayan Swiftlet	*Collocalia brevirostris*	w3	
			White-tailed Nuthatch	*Sitta himalayensis*	r1	
			Oriental Turtle Dove	*Streptopilia orientalis*	r3	
			Rock Pigeon	*Columba livia*	r2	
			Spotted Dove	*Streptopelia chinensis*	r2	
			Wedge-tailed Green Pigeon	*Treron sphenura*	r3	
11	PRINIA AND WHITE EYE	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	r2	1
12	ROSEFINCHES AND BUNTINGS	Fringillidae	Yellow-breasted Greenfinch	*Carduelis spinoides*	r2	1
13	SPARROWS, PIPPETS, WAGTAILS, ACCENTORS AND MUNIAS	Passeridae	Eurasian Tree Sparrow	*Passer montanus*	r1	4
			Grey Wagtail	*Motacilla cinerea*	w2	
			House Sparrow	*Passer domesticus*	r1	
			White Wagtail	*Motacilla alba*	w2	
14	THRUSHES AND FLYCATCHERS	Muscicapidae	Blue Whistling Thrush	*Myophonus caeruleus*	r1	9
			Common Stonechat	*Saxicola torquata*	r1	
			Grey Bushchat	*Saxicola ferrea*	r3	
			Kashmir Flycatcher	*Ficedula suburba*		
			Plumbeous Water Redstart	*Rhyacornius phaenicuroides*	w4	
			Rufous-bellied Niltava	*Niltava sundara*	r2	
			Verditer Flycatcher	*Eumyias thalassina*	r2	
			White-tailed	*Myiomela leucura*	r3	

			Robin			
			White-tailed Stonechat	*Saxicola leucura*	A	
15	TITMICE	Paridae	Black-lored Tit	*Parus xanthogenys*	r1	4
			Black-throated Tit	*Aegithalos concinnus*	A	
			Great Tit	*Parus major*	r1	
			Green-backed Tit	*Parus monticolus*	r1	
16	WARBLERS	Sylviidae	Ashy-throated Warbler	*Phylloscopus inornatus*	w3	10
			Golden-spectacled Warbler	*Seicercus burkii*	r2	
			Grey-hooded Warbler	*Seicercus xanthoschistos*	r1	
			Hoary-throated Barwing	*Actinodura nipalensis*	r3	
			Rufous Sibia	*Heterophasia capistrata*	r1	
			Scaly Laughingthrush	*Garrulax subunicolor*	A	
			Striated Laughingthrush	*Garrulax striatus*	r1	
			Whiskered Yuhina	*Yuhina flavicollis*	r2	
			White-crested Laughingthrush	*Garrulax leucolophus*	r1	
			White-throated Laughingthrush	*Garrulax albogularis*	r1	
17	WATERHEN	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	A	1

Altogether 64 species of birds from 17 orders were recorded (Table 2) during the survey. Among them, five species of birds were recorded for the first time. Most of the birds recorded were Warblers which was followed by Thrushes and Flycatchers and Magpie, Tree pies and Crows each having nine species.

Table 3. Fruiting trees recorded from project area

SN	**Scientific name**	**Local Name**	**Family**	**Life Form**	**Edible part**
1	*Albizia julibrissin var mollis*	Siris	Leguminosae	Tree	Fruit
2	*Bauhinia variegate*	Koiralo	Leguminosae	Tree	Flower
3	*Benthamidia capitata*	Dimmar	Cornaceae	Small tree	Fruit
4	*Benthamidia capitata*	Damaru/ Dimmar	Cornaceae	Small tree	Fruit
5	*Berberis aristata*	Chutro	Berberidaceae	Shrub	Fruit

6	*Berberis asiatica*	Chutro	Berberidaceae	Shrub	Fruit
7	*Berberis wallichiana*	Chutro	Berberidaceae	Shrub	Fruit
8	*Bombax ceiba*	Simal	Bombacaceae	Tree	Flower
9	*Camellia kissi*	Hingua	Theaceae	Small tree	Fruit
10	*Castanopsis indica*	Katush	Fagaceae	Tree	Fruit
11	*Castanopsis tribuloides*	Musure Katush	Fagaceae	Tree	Fruit
12	*Choerospondias axillaris*	Lapsi	Anacardiaceae	Tree	Fruit
13	*Coccinia grandis*	Gol kankri	Cucurbitaceae	Climber	Fruit
14	*Daphniphyllum himalense*	Rachan	Daphniphyllaceae	Tree	
15	*Dendrophthoe falcate*	Ainjeru	Loranthaceae	Saprophyte	Fruit
16	*Drepanostachya falcate*	Nigalo	Gramineae	Shrub	Young twigs
17	*Elaeagnus parvifolia*	Gunyelo	Elaeagnaceae	Shrub	Fruit
18	*Engelhardia spicata*	Mahuwa	Juglandaceae	Tree	Fruit
19	*Eriobotrya dubia*	Jure Kafal	Rosaceae	Tree	Fruit
20	*Eriobotrya dubia*	Jure Kafal	Rosaceae	Tree	Fruit
21	*Ficus auriculata*	Nimaro	Moraceae	Tree	Fruit
22	*Ficus sarmentosa*	Ban timila	Moraceae	Tree	Fruit
23	Ficus sarmentosa	Bidulo/ Berulo	Moraceae	Tree	Fruit
24	*Ficus semicordata*	Khanyu	Moraceae	Tree	Fruit
25	*Gaultheria fragrantissima*	Dhasingre	Ericaceae	Shrub	Fruit
26	*Juglans regia*	Okhar	Juglandaceae	Tree	Fruit
27	*Lonicera sp*		Caprifoliaceae	Shrub	Fruit
28	*Lyonia ovalifolia*	Angeri	Ericaceae	Tree	Fruit
29	*Mahonia napaulensis*	Jamanemanor	Berberidaceae	Shrub	Fruit
30	*Myrica esculenta*	Kafal	Myricaceae	Tree	Fruit
31	*Osbeckia nepalensis*	Chulesi	Melastomataceae	Shrub	Fruit
32	*Persea odoratissima*	Kaulo	Lauraceae	Tree	
33	*Phyllanthus emblica*	Amala	Euphorbiaceae	Tree	Fruit
34	*Prunus cerasoides*	Paiyun	Rosaceae	Tree	Fruit
35	*Pyracantha crenulata*	Ghangaru	Rosaceae	Shrub	Fruit
36	*Pyrus pashia*	Mayal	Rosaceae	Tree	Fruit
37	*Quercul glauca*	Falat/ Phalat	Fagaceae	Tree	Fruit
38	*Quercus glauca*	Phalant	Fagaceae	Tree	Fruit
39	*Quercus semecarpifoloa*	Khasru	Fagaceae	Tree	Fruit
40	*Rublis paniculatus*	Ban Ainselu	Rosaceae	Shrub	Fruit
41	*Rubus ellipticus*	Ainselu	Rosaceae	Shrub	Fruit
42	*Rubus pentagonous*	Ban ainselu	Rosaceae	Shrub	Fruit
43	*Syzygium cumini*	Jamun	Myrtaceae	Tree	Fruit
44	*Zizyphus incurve*	Hade bayar	Rhamnaceae	Tree	Fruit
45	*Zizyphus mauritiana*	Bayar	Rhamnaceae	Tree	Fruit

Altogether 45 species of fruit bearing trees were recorded from the survey sites (Table 3). Fruits of theses tress are preferred by the birds.

Table 4. Different variables recorded at each transects

S.N.	Area	Transect Number	Distance from nearest settlement (hrs)	Human pressure	Livestock Pressure	Sign of Hunting	Sign of Forest Fire
1	Bagmati	1	<1	Medium	Low	None	None
		2	<1	Medium	Low	None	None
2	Nagmati	3	<1	Medium	Medium	Medium	None
		4	<1	Medium	Medium	Medium	None
		5	<1	Medium	Medium	Medium	None
		6	<1	Medium	Medium	Medium	None
		7	<1	Medium	Medium	Medium	None
		8	<1	Medium	Medium	Medium	None
3	Dhap	9	<5	Low	None	Low	None
		10	<5	Low	None	Low	None
		11	<5	Low	None	Low	None
		12	<5	Medium	None	Low	None

Transects at Bagmati and Nagmati area were near to the settlement within the walking distance of one hour whereas Dhap area is farther from the settlement. Hikers were commonly observed in Bagmati and Nagmati areas suggesting medium human pressure. Human movement was low in Dhap area. Livestock pressure was low at the Bagmati area whereas it was medium in Nagmati area. Buffalo dung and grazing buffaloes were commonly observed in Nagmati area which was not observed in Bagmati and Dhap area. No signs of hunting were found in Bagmati and Dhap areas whereas villagers fishing in the rivers and small children with catapult were common in Nagmati area. No signs of forest fire were observed during the survey.

Bagmati Dam Area

Table 5. List of birds recorded at the Bagmati dam site

S.N.	Common Name	Scientific Name	Location
1	Blue Throated Barbet	*Megalaima asiatica*	Transect Nos. 1 and 2
2.	Black Bulbul	*Hypsipetes leucocephalus*	Transect Nos. 1 and 2
3..	Brown Dipper	*Cinclus pallasii*	Transect No. 1
4.	Black Kite	*Milvus migrans*	Transect No. 1
5.	Black Drongo	*Dicrurus macrocercus*	Transect No. 1
6.	Barn Swallow	*Hirundo rustica*	Transect No. 1
7	Common Kestrel	*Falco tinnunculus*	Transect No. 2
8	Lesser Kestrel	*Falco naumanni*	Transect No. 2

9.	Spotted Dove	*Streptopelia chinensis*	Transect Nos. 1 and 2
10.	House Sparrow	*Passer domesticus*	Transect No. 1
11	Blue Whistling Thrush	*Myophonus caeruleus*	Transect No. 1

Altogether 11 species of birds were recorded from first and second transect (Table 5) from Bagmati area. Most of the birds were recorded from first transect.

Table 6. List of fruit bearing trees of the Bagmati dam site

S.N.	Common Nepali Name	Scientific Name	Location
1	Ainselu	*Rubus ellipticus*	Transects Nos. 1 and 2
2	Ban Ainselu	*Rublis paniculatus*	Transects Nos. 1 and 2
3	Ban Ainselu	*Rublis paniculatus*	Transects Nos. 1 and 2
4	Bidulo	*Ficus sarmentosa*	Transects Nos. 1 and 2
5	Damaru	*Benthamidia capitata*	Transects Nos. 1 and 2
6	Falat	*Quercul glauca*	Transects Nos. 1 and 2
7	Jure Kafal	*Eriobotrya dubia*	Transects Nos. 1 and 2
8	Kafal	*Myrica esculenta*	Transects Nos. 1 and 2
9	Katus	*Castanopsis indica*	Transects Nos. 1 and 2
10	Khanyu	*Ficus semicordata*	Transects Nos. 1 and 2
11	Khasru	*Quercus semecarpifoloa*	Transects Nos. 1 and 2
12	Koiralo	*Bauhinia variegate*	Transects Nos. 1 and 2
13	Mayal	*Pyrus pashia*	Transects Nos. 1 and 2
14	Nimaro	*Ficus auriculata*	Transects Nos. 1 and 2
15	Simal	*Bombax ceiba*	Transects Nos. 1 and 2

Altogether 14 species of fruit bearing trees were recorded each (Table 6) from both first and second transect at Bagmati Dam site.

Table 7. List of birds recorded at Nagmati dam site

S.N.	Common Name	Scientific Name	Locations
1	Black Bulbul	*Hypsipetes leucocephalus*	Transect No. 3
2	Chestnut-bellied Nuthatch	*Sitta castanea*	Transect No. 8
3	Common Hoopoe	*Upupa epops*	Transect No. 4
4	Grey Treepie	*Dendrocitta formosae*	Transect Nos. 3, 4, 6, and 8
5	Grey-hooded Warbler	*Seicercus xanthoschistos*	Transect No. 3
6	Himalayan Bulbul	*Pycnonotus leucogenys*	Transect No. 3
7	Hoary-throated Barwing	*Actinodura nipalensis*	Transect No. 3

8	Mountain Bulbul	*Hypsipetes mcclellandii*	Transect No. 8
9	Oriental Turtle Dove	*Streptopilia orientalis*	Transect No. 3
10	Rufous-bellied Niltava	*Niltava sundara*	Transect No. 8
11	Shikra	*Accipter badius*	Transect No. 3
12	Striated Laughingthrush	*Garrulax striatus*	Transect No. 4
13	White Wagtail	*Motacilla alba*	Transect No. 7
14	White-tailed Nuthatch	*Sitta himalayensis*	Transect Nos. 4 and 5
15	White-tailed Stonechat	*Saxicola leucura*	Transect No. 8
16	Yellow-breasted Greenfinch	*Carduelis spinoides*	Transect No. 8

Altogether 16 species of birds were recorded from five transects (Transect no. 3, 4, 5, 6, 7 and 8) set up at Nagmati dam site (Table 7).

Table 8. List of fruit bearing trees of Nagmati area

S.N.	Common Nepali Name	Scientific Name	Location
1	Angeri	*Lyonia ovalifolia*	Transect Nos. 3, 4,5,6,7 and 8
2	Dhansingare	*Gaultheria fragrantissima*	Transect Nos. 3, 4 and 6
3	Gurans	*Rhododendron sp.*	Transect Nos. 4, 5, 6. 7 and 8
4	Hinguwa	*Camellia kissi*	Transect Nos. 4, 7 and 8
5	Jamanemandro	*Mahonia napaulensis*	Transect Nos. 3 and 8
6	Jure Kafal	*Eriobotrya dubia*	Transect Nos. 6, 7 and 8
7	Kaulo	*Persea odoratissima*	Transect Nos. 5, 7 and 8
8	Khasru	*Quercus semecarpifoloa*	Transect Nos. 3, 4,5, 6,7 and 8
9	Mayal	*Pyrus pashia*	Transect Nos. 3, 4,5, 6,7 and 8
10	Rachan	*Daphniphyllum himalense*	Transect Nos. 4, 5 and 7
11	Seto Siris	*Albizia julibrissin var mollis*	Transect Nos. 4 and 7

Altogether 11 species of trees were recorded from five transects (Transect no. 3,4,5,6,7and 8) at Nagmati Dam site (Table 8).

Table 9. List of bird recorded from Dhap area

S.N.	English name	Scientific Name	Location
1	Blue Throated Barbet	*Megalaima asiatica*	Transect No. 9
2	Common Hoopoe	*Upupa epops*	Transect No. 11
3	Golden Throated Barbet	*Megalaima franklinii*	Transect No. 9
4	Great Barbet	*Megalaima virens*	Transect No. 9
5	Green-backed Tit	*Parus monticolus*	Transect No. 9
6	Grey Bushchat	*Saxicola ferrea*	Transect No. 9
7	Grey-hooded Warbler	*Seicercus xanthoschistos*	Transect Nos. 9 and 12
8	Himalayan Bulbul	*Pycnonotus leucogenys*	Transect No. 9
9	Himalayan Swiftlet	*Collocalia brevirostris*	Transect No. 9
10	Oriental Turtle Dove	*Streptopilia orientalis*	Transect No. 9
11	Red-vented Bulbul	*Pycnonotus cafer*	Transect No. 12
12	Rufous Sibia	*Heterophasia capistrata*	Transect Nos. 9 and 11
13	Rufous-bellied Niltava	*Niltava sundara*	Transect No. 10
14	Scaly Laughingthrush	*Garrulax subunicolor*	Transect No. 9
15	Striated Laughingthrush	*Garrulax striatus*	Transect No. 9, 10 and 11
16	Verditer Flycatcher	*Eumyias thalassina*	Transect No. 9
17	Wedge-tailed Green Pigeon	*Treron sphenura*	Transect No. 9
18	White-breasted Waterhen	*Amaurornis phoenicurus*	Transect No. 9
19	White-tailed Nuthatch	*Sitta himalayensis*	Transect No. 9
20	White-throated Laughingthrush	*Garrulax albogularis*	Transect Nos. 9 and 11
21	Yellow-billed Blue Magpie	*Urocissa flavirostris*	Transect Nos. 9 and 11

Altogether 21 species of birds were recorded from four transect (Transect 9,10,11 and 12) set up at Dhap Dam site (Table 9).

Table 10. List of fruit bearing trees recorded from Dhap area

S.N.	Common Nepali Name	Scientific Name	Location
1	Angeri	*Lyonia ovalifolia,*	Transect No. 9 and 11
2	Chutro	*Berberis aristata*	Transect No. 9 and 11
3	Gurans	*Rhododendron*	Transect No. 9 and

		arboreum,	11
4	Rachan	*Daphniphyllum* sp	Transect No. 9
5	Uttis	*Alnus nepalensis,*	Transect No. 11

Altogether five tree species were recorded at four transects (Transect no. 9,10,11 and 12) at Dhap area (Table 10).

Table 11. Birds recorded for the first time from Shivapuri-Nagarjun National Park

S.N.	Common Name	Scientific Name	Remarks
1	Eurasian Blackbird	*Turduus merula*	Outside the transect
2	Sand Martin	*Riparia riparia*	Outside the transect
3	Scaly Laughingthrush	*Garrulax subunicolor*	Transect No. 9
4	White-breasted Waterhen	*Amaurornis phoenicurus*	Outside the transect
5	White-tailed Stonechat	*Saxicola leucura*	Outside the transect

Five species of birds were recorded for the first tie from Shivapuri-Nagarjun National Park during the current survey (Table 11).

Table 12. Threatened species of birds of Bagmati dam site

SN	Bird Species	Status	Likely in SNNP (BCN and DNPWC 2011) (SNP and BCN 2007)	Season	Habitat	Nesting Season	Food	Likely at Nagmati Site
1	Hodgson‟s Bushchat (Saxicola insignis)	Vulnerable (IUCN 2012) and Endangered nationally (BCN and DNPWC 2011)	Yes	Winter visitor for Nepal	Grass land, tall grass and Reeds nearby river	June	Insects and fruites	Least possibility (only single unusual record from Chisapani area which is aerially 4 km far from Nagmati, 5 Km far from Bagmati and 2 km far from Dhap
2	Saker Falcon (Falco cherrug)	Endangered (IUCN 2012)	Yes	Wintering and passage migrant	Open country	NA	Dove, piegon, insects, rodents	Possible
3	White-rumped Vulture (Gyps bengalensis)	Critically Endangered (IUCN 2012, BCN and DNPWC 2011)	Yes	Residential (All year)	Open country, Tall tree and human habitation	Oct- April	Scavenger	Least possibility
4	Grey-sided Laughingthrush (Garrulax caerulatus)	Vulnerable nationally (BCN and DNPWC 2011) Globally Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
5	Blue-winged Laughingthrush (Garrulax squamatus)	Vulnerable nationally (BCN and DNPWC 2011 and Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
6	White-tailed Stonechat (Saxicola leucurus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern	Yes (Field survey 2012	Residential (All year)	Grass land	NA	Insects, fruits	Confirmed at downstream location

		(IUCN 2012)						
7	Brown Wood Owl (Strix leptogrammica)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	NA	Rodents, birds and reptiles	Least Possibility
8	Spot-bellied Eagle Owl (Bubo nepalensis)	Nationally Endangered (BCN and DNPWC 2011) Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	Dec-March	Rodents, birds and reptiles	Least Possibility
9	Lammergeier Vulture (Gypaetus barbatus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
10	Egyptian Vulture (Neophron percnopterus)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
11	Himalayan Griffon (Gyps himalayensis)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
12	Cinereous Vulture (Aegypius monachus)	Near Threatened (IUCN 2012) and Nationally Endangered (BCN and DNPWC 2011)	Yes	Uncommon winter visitor	Open country	NA	Scavenger	Least Possibility

Based on the secondary source, the premise of dam is a possible habitat for one species of Critically Endangered status, one species of Endangered status, eight species are with Vulnerable status, one species of Near Threatened and one species of Nationally Endangered (Table 12). Only one vulnerable species of nationally threatened bird White-tailed Stonechat was recorded from the current survey (Table 12). Dam site are also possible habitat for endemic species, Spiny babbler.

Table 13. Threatened species of birds of Dhap area

	Bird Species	**Status**	**Likely in SNNP (BCN and DNPWC 2011) (SNP and BCN 2007)**	**Season**	**Habitat**	**Nesting Season**	**Food**	**Likely at Nagmati Site**
1	Hodgson"s Bushchat (Saxicola insignis)	Vulnerable (IUCN 2012) and Endangered nationally (BCN and DNPWC 2011)	Yes	Winter visitor for Nepal	Grass land, tall grass and Reeds nearby river	June	Insects and fruits	Least possibility (only single unusual record from Chisapani area which is aerially 2km far from Dhap
2	Saker Falcon (Falco cherrug)	Endangered (IUCN 2012)	Yes	Wintering and passage migrant	Open country	NA	Dove, pigeon, insects, rodents	Possible
3	White-rumped Vulture (Gypsbengalensis)	Critically Endangered (IUCN 2012, BCN and DNPWC 2011)	Yes	Residential (All year)	Open country, Tall tree and human habitation	Oct- April	Scavenger	Least possibility
4	Grey-sided Laughingthrush (Garrulax caerulatus)	Vulnerable nationally (BCN and DNPWC 2011) Globally Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
5	Blue-winged Laughingthrush (Garrulax squamatus)	Vulnerable nationally (BCN and DNPWC 2011 and Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
6	White-tailed Stonechat (Saxicolaleucurus)	Vulnerable Nationally (BCN	Yes (Field survey 2012	Residential (All year)	Grass land	NA	Insects, fruits	Least Possibility (It is

		and DNPWC 2011) and Least Concern (IUCN 2012)						recorded at downstream which is aerially 2 km far from Dhap
7	Brown Wood Owl (Strix leptogrammica)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	NA	Rodents, birds and reptiles	Least Possibility
8	Spot-bellied Eagle Owl (Bubo nepalensis)	Nationally Endangered (BCN and DNPWC 2011) Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	Dec-March	Rodents, birds and reptiles	Least Possibility
9	Lammergeier Vulture (Gypaetus barbatus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
10	Egyptian Vulture (Neophron percnopterus)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
11	Himalayan Griffon (Gyps himalayensis)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
12	Cinereous Vulture (Aegypius monachus)	Near Threatened (IUCN 2012) and Nationally	Yes	Uncommon winter visitor	Open country	NA	Scavenger	Least Possibility

		Endangered (BCN and DNPWC 2011)						
13	White-breasted Waterhen (Amaurornis phoenicurus)	Fairly common and widespred (Grimmett et al 2009) and Least Concern (IUCN 2012)	Yes	Residential (all year)	Wetland	June-October	Insects, aquatic vertebrates, small fishes and seeds	Confirmed
14	Wedge-tailed Green Pigeon (Treron sphenura)	Fairly common in Nepal (Grimmett et al 2009) and global status not assessed (IUCN 2012)	Yes	Residential	Observed at Tree near by wetland	NA	Seeds	Confirmed

Table 14 Threatened species of birds of Nagmati area

SN	Bird Species	Status	Likely in SNNP (BCN and DNPWC 2011) (SNP and BCN 2007)	Season	Habitat	Nesting Season	Food	Likely at Nagmati Site
1	Hodgson‟s Bushchat (Saxicola insignis)	Vulnerable (IUCN 2012) and Endangered nationally (BCN and DNPWC 2011)	Yes	Winter visitor for Nepal	Grass land, tall grass and Reeds nearby river	June	Insects and fruits	Least possibility (only single unusual record from Chisapani area which is aerially 4 km far from Nagmati
2	Saker Falcon (Falco cherrug)	Endangered (IUCN 2012)	Yes	Wintering and passage migrants	Open country	NA	Dove, pigeon,, insects, rodents	Possible
3	White-rumped Vulture (Gypsbengalensis)	Critically Endangered (IUCN 2012, BCN and DNPWC 2011)	Yes	Residential (All year)	Open country, Tall tree and human habitation	Oct- April	Scavenger	Least possibility
4	Grey-sided Laughingthrush (Garrulax caerulatus)	Vulnerable nationally (BCN and DNPWC 2011) Globally Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible

5	Blue-winged Laughingthrush (Garrulax squamatus)	Vulnerable nationally (BCN and DNPWC 2011 and Least Concern (IUCN 2012)	Yes	Residential (All year)	Forest and bush	NA	Insects, fruits	Possible
6	White-tailed Stonechat (Saxicolaleucuru)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes (Field survey 2012	Residential (All year)	Grass land	NA	Insects, fruits	Confirmed at downstream location
7	Brown Wood Owl (Strix leptogrammica)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	NA	Rodents, birds and reptiles	Least Possibility
8	Spot-bellied Eagle Owl (Bubo nepalensis)	Nationally Endangered (BCN and DNPWC 2011) Least Concern (IUCN 2012)	Yes	Residential (All year)	Primary Forest	Dec-March	Rodents, birds and reptiles	Least Possibility
9	Lammergeier Vulture (Gypaetus barbatus)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
10	Egyptian Vulture (Neophron percnopterus)	Vulnerable Nationally (BCN and DNPWC 2011) and Endangered (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility

11	Himalayan Griffon (Gyps himalayensis)	Vulnerable Nationally (BCN and DNPWC 2011) and Least Concern (IUCN 2012)	Yes	Residential (All year)	Open country and cliff	NA	Scavenger	Least Possibility
12	Cinereous Vulture (Aegypius monachus)	Near Threatened (IUCN 2012) and Nationally Endangered (BCN and DNPWC 2011)	Yes	Uncommon winter visitor	Open country	NA	Scavenger	Least Possibility

Among twelve species of threatened birds present in the dam site area of Dhap (Table 13) as in Bagmati (Table 12), only one Nationally Vulnerable species Stone chat was recorded during the field survey.

Similar case was seen in Nagmati dam site area as in Bagmati and Dhap area, with one species Nationally Vulnerable status (Table 14).

PART THREE: ANALYSIS

Discussion

Altogether 64 species of birds from 17 orders were recorded (Table 2) during the survey. Among them five species of birds were recorded for the first time. Twelve species of birds are under protected categories (Table 12). The secondary source (SNNP and BCN 2007) shows 318 species of birds recorded previously from Shivapuri-Nagarjun National Park. Literature suggests SNP holds about one third of all the bird species present in the country. Among three survey sites within SNNP, Dhap area consisted of highest diversity of species with the record of 21 species. Nagmati Dam site area consisted of 16 species of birds. The edge of the forest area of Dam site with wetland habitat supported high diversity of Birds. Similarly, the habitat along the gorge of Nagmati Dam site also supported high diversity of birds. The Bagmati site area had relatively low diversity of birds compared to other sites but it may be due to short duration of survey, along just two transects. Spotted Dove and Black kites were commonly observed in Bagmati Dam site whereas Warblers and Barbets were more commonly observed in Nagmati Dam site. Green wedged- tailed Pigeon, Oriental Turtle Dove, White Wagtail, Sand Martin were most commonly observed in Dhap area.

Specific Impacts on Birds due to Dam Construction

Developmental activities obviously have Environmental Impacts, which directly affects the wildlife and birds. This study was carried out to innumerate the possible impacts (adverse and beneficial) on birds due to Dam construction on Bagmati, Nagmati and Dhap area with recommendations to promote the beneficial impacts while mitigating the adverse impacts.

3.1.1 Beneficial Impacts

The construction of Water Reservoir might increase the habitat of certain water birds. Different species of birds (for example, White-breasted Waterhen) will inhabit near the reservoir making high diversity. The impact will be permanent in duration.

3.1.2 Adverse Impacts

3.1.2.1 Construction Phase

Disturbance to the Birds

Logging off of large trees, drilling, collection and deposition of building materials and the high movement of labor force on the dam sites will disturb the habitat of birds. Large fruiting trees are the major nest building sites of most species of birds. Logging them off might destroy the nests of birds and young chicks. Drilling will disturb the feeding birds nearby and pollution due to deposition of construction materials may chase away the birds from their usual habitat. High movement of labor force might involve in hunting activities of birds. Blasting activities and rock fragments may injure the birds. Inundation of current water habitat will disturb the feeding and reproductive grounds of water birds mainly from the Dhap area.

3.1.2.2 Operation phase

Habitat Fragmentation

The micro topography of the dam site areas changes after the construction of dam which will fragment the habitat of birds like White-breasted Water Hen. Construction of dams will collect large amount of water from small rivulets which will decrease the habitat of birds like Forktails and Dipper which prefer to forage near fast flowing rivulets.

PART FOUR: CONCLUSIONS

Shivapuri-Nagarjun National Park holds high diversity of birds (318 species of birds from secondary source and 64 species recorded in the present survey with five new species recorded for the first time). Construction of dam will certainly have negative effect on the habitat and diversity of birds. Inundation of certain habitats like that of Dhap and Nagmati will displace the habitats of many birds. Casualties to the birds due to construction activities, probable hunting and poaching activities will have deleterious effect to the bird diversity and number. So, appropriate practical measures will be necessary to mitigate such impacts on avian fauna and their habitat.

Recommendations and Measures to Mitigate Impact on Birds

The following activities have been recommended on the basis of the results obtained from the survey to mitigate the adverse effect of construction of dams to the avian fauna.

i. **Orientation to the workforce:** The project must provide the information about the sensitivity of construction work within the National Park premise. Workers must be prevented for the hunting and poaching of birds during the project period. The work force must also be restricted within residential camp during the rest period. The bird conservation camps are recommended before the work began.

ii. **Re-plantation of the trees:** The number of trees logged off from the inundated area of dams must be replanted in other areas (Table 3). The ratio of replanted trees must be ten folds to the logged off trees to make sure survival of enough trees. Construction of plant nursery is recommended either in Mulkharak or nearby Chisapani. Replacement plantation could be done in both places of government land and private land.

iii. **Checking of the tree before logging off:** The branches and canopy of the trees must be checked before logging off to make sure that there are no nests with young chicks in them. This is a very important step to be taken to minimize the casualties to the bird nests and young chicks. Any nests with chicks found in the trees must be handled carefully and displaced in other area with the help of expert. The nesting tree can be cut after the chicks fly.

iv. **Construction of Islands:** Five small islands (50-100 square meters) must be constructed within a dam area which will sustain the present habitat of birds. This will maximally decrease the impact on the current habitat of water birds. The base of the island must be constructed from stone whereas upper part needs soft materials (soil) to support the habitat.

v. **Blasting:** Blasting when necessary must be done carefully with the implication of all the safety measures.

REFERENCES

BCN and DNPWC 2011) *The State of Nepal's Birds 2010*. Kathmandu: Bird Conservation Nepal and Department of National Parks and Wildlife Conservation.

SNP and BCN (2007). Birds of Shivapuri National Park. Shivapuri National Park and Bird Conservation Nepal, Kathmandu.

IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>. Downloaded on **17 November 2012**.

Grimmett, R., Inskipp, C. and Inskipp, T. (2009) *Birds of Nepal.* Second edition. London, UK: Christopher Helm.

Field Survey Report 4

MACRO-INVERTEBRATES SURVEY OF THE UPPER BAGMATI CATCHMENT

(Proposed Dhap and Nagmati Dam Site Areas)

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Center
Kathmandu University

Submitted by:

Subodh Sharma
and
Anandeeta Gurung

Species List of Aquatic Invertebrates as indicators of environmental quality in the River Nagmati of Bagmati River System

Damming modifies natural flow regimes and alters the habitat as well as other physical and chemical characteristics of the river. Physical habitat is a prime factor influencing the composition and abundance of stream faunal communities that form one of the important components in the lotic environment as indicators of environmental quality. Faunal characteristics of downstream to the dam site are altered due to dam buildings, which in turn also alter the physical and chemical characteristic features of the riverine environment.

The main purpose of this study was, in the above context, to document the composition of aquatic invertebrates, assess the mineralogenic and biotic composition, and analyse basic physical and chemical composition of water as baseline information, a comparison against which, after the completion of the project, will guide in understanding the scale of the impacts and thereby suggest appropriate mitigation measures to minimize such impacts.

A total of six sites were investigated, and the sites were designated as NAG01 to NAG 06 (figure 1). Selection of sites was based on first locating the proposed dam site and then selecting sites which are less disturbed, disturbed and highly disturbed.

Basic physicochemical characterization was performed on field as tabulated (table 1) using field test kits followed by habitat assessment for mineral and biotic composition (table 2). Samples of aquatic invertebrates were collected using a 250 µm mesh size net attached to a frame with a handle (figure 2). A well defined area of the substrate was disturbed for semi-quantitative assessment of the aquatic invertebrates" abundance. The samples of invertebrates were washed into the net by water current, which were emptied into a white enamelled tray, sorted, counted and brought to the laboratory for identification. Identified list of aquatic invertebrates are tabulated (table 3) with description on water quality of the sites, where the samples were collected.

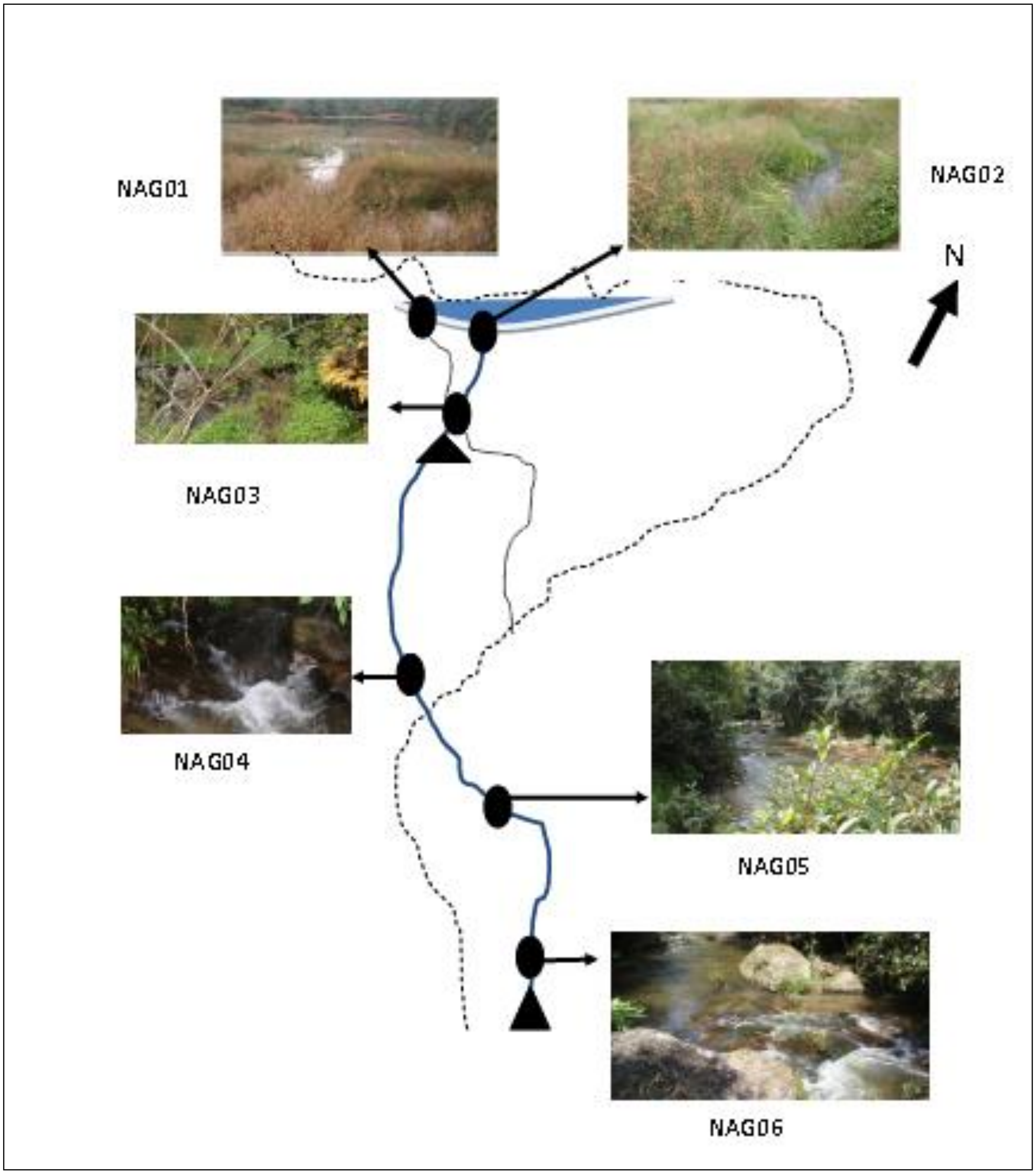


Figure 1: Location of investigated sites from NAG 01 to NAG 06, with dark pyramid shaped points indicating proposed dam sites (drawn not to the scale). Broken line indicate motorable way and solid line indicate short trail.

Basic physical parameters such as temperature, pH, Dissolved Oxygen, and conductivity measured in field using Multiparameter test kits revealed insignificant difference in parameters. Temperature varied from 16-18 deg C, and conductivity from 7-10 μS/cm (table 1).

Table 1: Basic physico-chemical characteristics of sites in the river Nagmati (date of sampling: 01/10/2012)

Sites Code	Exact location (coordinates)	Elevation (m)	Temperature (deg C)	pH (scale)	Conductivity (μS/cm)	Dissolved Oxygen (mg/l)
NAG01	27˚48.547′N 85˚27.493′E	2075	16.0	6.3	8.69	6.5
NAG02	27˚48.482′N 85˚27.509′E	2069	17.0	6.5	7.83	5.6
NAG03	27˚48.394′N 85˚27.379′E	2061	18.4	6.5	9.0	6.5
NAG04	27˚47.755′N 85˚27.377′E	1921	18.0	6.5	9.0	6.5
NAG05	27˚46.993′N 85˚26.654′E	1855	18.0	6.5	9.5	6.5
NAG06	27˚46.497′N 85˚26.326′E	1850	18.0	6.5	10.0	6.5

Figure 2: Sampling technique using MHS sampler, sample sorting, and transferring to plastic vials for identification in laboratory (from left to right).

All the sites investigated showed variable habitat, with NAG06 being a site with huge boulders followed by NAG04, whereas NAG02 is dominated by sandy substratum (Table 2).

Table 2: Abiotic and biotic habitat composition of the river Nagmati in the studied sites (date of observation: 01/10/2012)

Sites/ Mineral habitat	NAG01	NAG02	NAG03	NAG04	NAG05	NAG06
MINERAL HABITATS	%	%	%	%	%	%
Megalithal (large cobbles, boulders and blocks, bedrocks)				45	10	45
Macrolithal (coarse blocks, head-sized cobbles)			25	25	10	50
Mesolithal (coarse gravels, fist to hand sized cobbles)			65	20	65	5
Microlithal (coarse gravels, size of a child‟s fist)	20		10	10	10	
Akal (fine to medium sized gravel)	20				5	
Psammal (sand)	60	85				
Pelal (mud)		15				
BIOTIC HABITATS	%	%	%	%	%	%
Diatoms and other algae	0		0	0	80	
Macrophytes		70			10	
Living parts of terrestrial plants		30				

Table 3: Taxalist of aquatic invertebrates in the river Nagmati (date of sampling: 01/10/2012)

Order	Family	Genus/Species	Relative Abundance*	Environmental quality class
NAG 01				
Hemiptera	Gerridae	Metrobates spp.	10	II
Odonata	Gomphidae	Agrigomphus sp.	5	
Trichoptera	Glossosomatidae		2	
Ephemeroptera	Baetidae	Baetis spp.	15	
	Caenidae	Caenis sp.	5	
Diptera	Simuliidae		10	
NAG 02				
Diptera	Simuliidae	Simulium	10	II
Trichoptera	Philopotamidae	Philopotamus	1	
Diptera	Athericidae		1	
Coleoptera	Hydraenidae		1	
Diptera	Limoniidae		1	
Coleoptera	Heteroceridae		1	
Diptera	Chironomidae		2	
NAG 03				
Plecoptera	Perlodidae		3	II
Plecoptera	Nemouridae	Podomosta sp.	6	

Diptera	Simulidae	Simulium sp.	11	
Coleoptera	Hydraenidae		1	
Trichoptera	Philopotamidae		1	
NAG 04				
Trichoptera	Hydropsychiidae	Hydropsyche sp.	13	I-II
Plecoptera	Perlidae	Perla sp.	3	
Ephemeroptera	Baetidae	Baetis sp.	3	
Ephemeroptera	Heptageniidae	Heptagenia sp.	1	
Diptera	Tipulidae	Tipula sp.	1	
Coleoptera	Hydraenidae		1	
Coleoptera	Elmidae	Microcylloepus sp.	1	
Diptera	Limoniidae		1	
Coleoptera	Elminthidae		1	
Coleoptera	Psephenidae		1	
Plecoptera	Perlidae (Adult)		1	
Oligochaeta			1	

NAG 05				
Odonata	Gomphidae	Gomphus sp.	2	II
Ephemeroptera	Caenidae		2	
Trichoptera	Hydropsychidae		5	
Ephemeroptera	Baetidae	Baetis sp.	5	
Ephemeroptera	Heptageniidae		4	
Diptera	Simuliidae	Simulium sp.	1	
Coleoptera	Elmidae		2	
Coleoptera	Psephenidae		1	
NAG 06				
Ephemeroptera	Heptageniidae		7	I-II
Diptera	Simuliidae		2	
Coleoptera	Hydraenidae		1	
Trichoptera	Hydropsychiidae		4	
Plecoptera	Perlidae		1	
Ephemeroptera	Baetidae		1	
Coleoptera	Psephenidae		1	

**** Relative Abundance of the macroinvertebrates observed (1=very rare, 2=rare, 3=common, 4=abundant, 5=highly abundant). Impairment assessment is based on qualitative sampling of the macoinvertebrates.***

Environmnetal quality class I-II (Oligosaprobic to beta-mesosaprobic), Degree of pollution: slightly polluted. This transitional water quality class describes river reaches with little inorganic and organic nutrient content and, with the exception of glacier-fed brooks, clear water. The oxygen content is high. The concentration of suspended organic matter is very low. Fine substrates are of a brownish or light colour throughout; the undersides of stones have no visible black reduction spots. Primarily, these reaches are in salmonid rivers, which are densely and diversely colonized by algae, mosses, Turbellaria, Plecoptera, Ephemeroptera and Trichoptera larvae as well as Coleoptera (Elmidae, Hydraenidae) and dipteran larvae. Worms are generally represented by planarians, and sensitive oligochaets. Of the leeches (Hirudinea), at most Dina punctata and Erpobdella vilnensis exist in considerable quantities; net-spinning trichopterans appear only sporadically. The chironomids (predominantly, Orthocladiinae and Diamesinae) are slightly more numerous than in water quality class I.

Environmental quality class II (beta-mesosaprobic); Degree of pollution: Moderately polluted.
This water quality class is found in river reaches with moderate organic pollution, increased nutrient content and still a good oxygen supply (despite possible oxygen supersaturation or depletion). The water in middle and higher reaches is usually clear and at most contains a low amount of suspended organic particles. In lowland rivers the suspended solids can increase due to natural processes. The sediment is light or dark, but not black, and is often slippery due to algal growth; the undersides of stones are not coloured with black reduction-spots. Processes of biodegradation take place in aerobic areas. Reduction phenomena occur only occasionally, here and there, in lentic sites of potamal waters (e.g. backwaters).

Species diversity and abundances are very high for nearly all animal groups in addition to algae (all groups) and other aquatic plants. The percentage of individuals and the taxon diversity of Chironomidae further increases (predominantly Orthocladiinae, in quietly flowing reaches Tanytarsini and Chironomini). The net-spinning trichopterans are usually numerous only where suitable current velocities are available; whereby Polycentropodidae can appear in large quantities in potamal regions. Macrophytes can cover areas but usually green algae (Chlorophyceae) do not yet appear in large quantities. These rivers yield high numbers of fish of various species.

Field Survey Report 5

FISH SURVEY FOR ENVIRONMENTAL STUDY OF THE UPPER BAGMATI RIVER ENVIRONMENT, BAGMATI RIVER BASIN IMPROVEMENT PROJECT (BRBIP)

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Center
Kathmandu University

Submitted by:

Dr. Bibhuti Ranjan Jha

1. Project Background

According to the aim of the contract which was “to study potentially valuable river/stream habitats or other ecologically significant features at the proposed dam/reservoir sites in Shivapuri National Park and their vicinity”, this work was carried out from the headwaters of the Nagmati River in the area popularly called as Dhap. It is characterized by a natural wetland area dammed by local residents to form a pond, down to the confluence of the Nagmati and Bagmati Rivers. As per the contract the study area was divided into 3 sampling sites. The first site was in the Dhap area, the second was in the proposed Nagmati Dam area and the third was downstream, near the confluence of Bagmati.

The primary objective of the study was to conduct assessment of the fish biodiversity (species and abundance) using internationally accepted ecological assessment techniques and to make description of habitats, communities or species of the fish with respect to their ecological significance at a local, national and regional level.

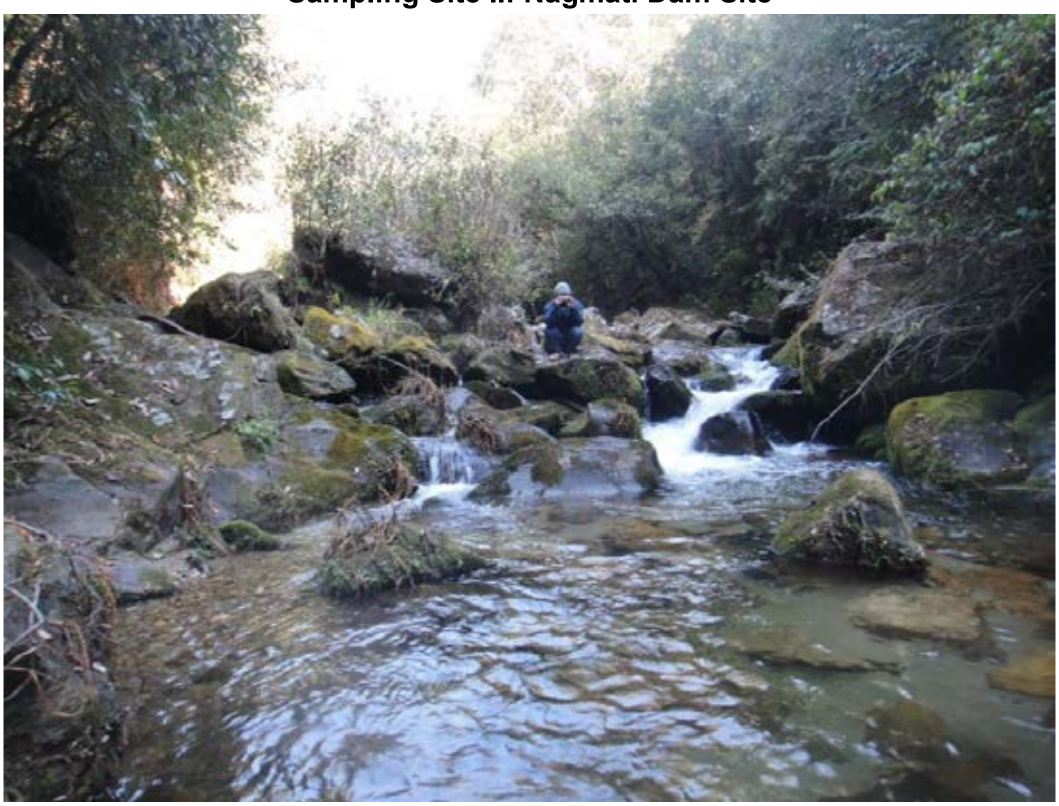
2. Methods

The fish sampling was done by “**Wading Method**” using backpack electro-fishing gear which is an internationally accepted standard method to sample fish in a wadeable river/stream. The same method was also used extensively in different rivers in Nepal for fish sampling (Jha 2006 and Sharma and Jha 2012). The fish sampling was done in two runs of around 20 minutes each to cover as much habitat condition as possible and the precise measure of the abundance of fish species is taken as the average of the two (Map 1). The unit of the abundance is CPUE (which is the number of catch/10 minutes of electro-fishing).

Map 1. Locations of sampling points for the Fish Survey at Dhap and along the Nagmati River.

Sampling Site I: Dhap

Sampling Site II: Nagmati Dam Site



Sampled fishes were identified upto species level using numerous keys and various information of the fish assemblage was taken in the field using established protocol (Jha 2006). In addition, information of the substrate and habitat were also gathered from the field.

3. Results:

The field survey made on 15th December, 2012 at the first sampling site in the pond and subsequent stream in Dhap showed very poor assemblage of fishes with one species and that too a very common species distributed in almost every natural water bodies of Nepal. The information regarding the sampled fishes is as follows:

Order: Cypriniformes
Family: Balitoridae
Genus: ***Schistura***
Species: ***beavani***
Common name: Creek loach, Pate Gadela (Nepali)
Abundance (CPUE): 1

***Schistura beavani* (Günther, 1868)**

4. The captured fish, ***Schistura beavani*** (Günther, 1868), popularly known as the Creek loach, is one of the most common fish species widely distributed in South Asian region. It"s a freshwater benthopelagic fish found in a shallow and swift clear hill stream with diverse substrate (www.fishbase.org). This is a fishery of minor interest and is mentioned under „Least Concern" in IUCN list. However, the species is previously reported from around 1600 meter above sea level (Jha 2006) and in the present study the sampling site called Dhap is at about 2100 meters above sea level, which is a new record for its occurrence. This could be its ecological significance.

5. Similarly the fish survey made on 29th January 2013 in the remaining two sampling sites, namely, Nagmati Dam and downstream above the Confluence of Bagmati, also showed a poor fish assemblage, though the latter site had a healthy congregation of a single species known to exist in this region (Jha 2006, Shrestha 1994, Shrestha 1990). The following is the detail of the one species captured from these two sampling sites:

Order: Cypriniformes
Family: Cyprinidae
Genus: ***Schizothorax***
Species: ***richardsonii***
Common name: Snow Trout, Buche Asala (Nepali)

Schizothorax richardsonii **(Gray 1832)**

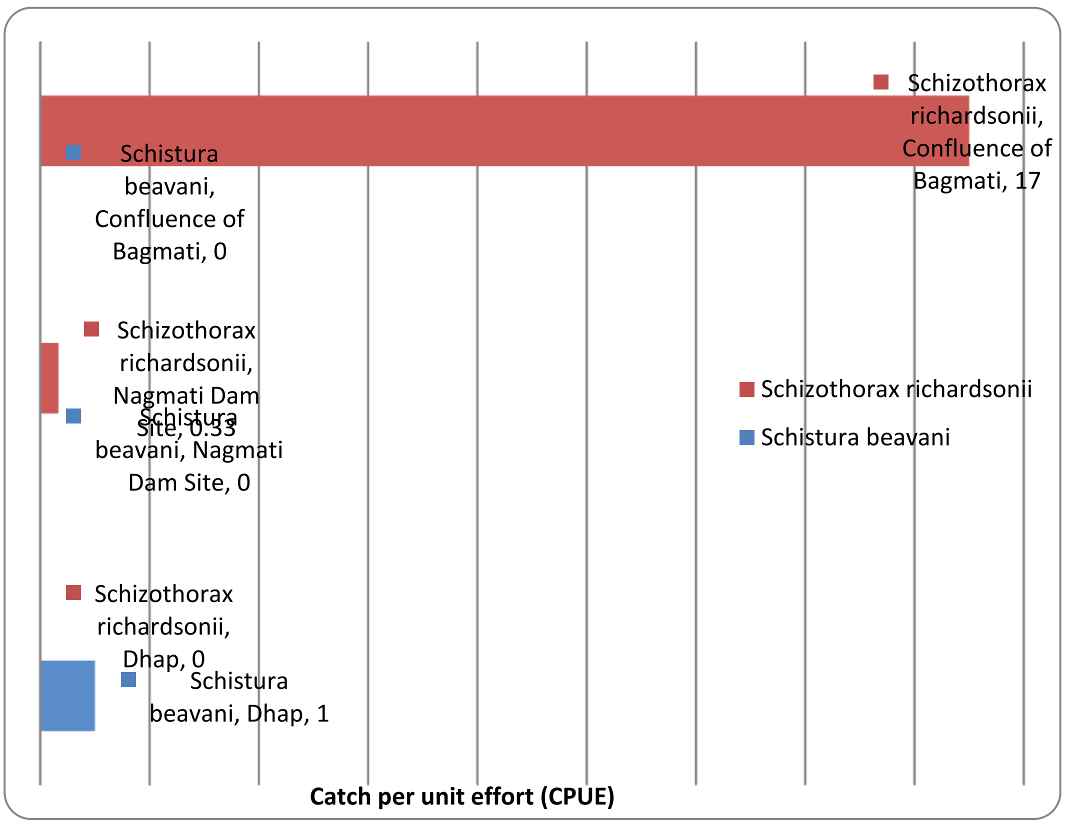
The more recent fish base study of the region (Maharjan 2009) too showed the occurrence of same two species indicating the authenticity of the present study. In terms of relative abundance of the two species *Schizothorax* dominates as had been reported in the same work. The following table and subsequent graph highlights the abundance of fish assemblage in all three

Sites → **Fish species** ↓	Dhap	Nagmati Dam Site	Confluence of Bagmati
Schistura beavani	1	0	0
Schizothorax richardsonii	0	0.33	17

locations (Dhap, Nagmati dam site and near confluence of Nagmati and Bagmati; see Map 1).

Table 1: Abundance of fish species (Catch per unit effort)

Figure 1: Abundance of fish species



6. The entire region showed the presence of only two species as mentioned above, however, they were not found together at any of the sites. The first site at Dhap had only *Schistura beavani* with CPUE value of 1, whereas the second and third site had only *Schizothorax richardsonii* with abundance of 0.33 and 17 respectively. The low numbers and poor assemblage of fish species in the first two sites could be mainly attributed to both natural and human influences. The upper reaches of the Nagmati River and particularly the Dhap area are at considerable elevations (1800 – 2000m), which leads to cold water temperatures (9 to 10 degrees C). Moreover, the steep river gradient and natural rapids may be unsuitable habitat for most fish species to live and spawn.

7. In recent years, the increasing number of tourists and local picnic goers, road crossing and increased vehicular traffic are regarded as the main sources of disturbances.

8. It should be noted that the Dhap area is not a natural lake as impoundment was done due to the construction of an earthen (rock-fill) dam, by the local people. Also, there was a report of complete drainage of Dhap, few years back, which could have wiped out any existing fish in the lake.

9. Although the drilling may cause temporary disturbance in the immediate vicinity of the proposed Nagmati dam site, it is unlikely to be the cause of low fish numbers and species. At least, high abundance of even one species, *Schizothorax richardsonii,* was expected from this site. Therefore, the poor number of fish in this site could be a temporary phenomena coinciding with the drilling compounded by the severity of the winter season. However, this site too should not be richer in fish biodiversity even during favorable time as both upstream and downstream of this site showed poor diversity.

10. The abundance of *Schizothorax richardsonii* in the third site obtained in the survey puts it in the range of common species as categorized by Jha (2006) and is in fact an improvement in their number as compared with the work of Maharjan (2009). Generally it spawns upstream near the headwaters, however, due to an existing dam/diversion of the Nagmati to divert water to the Sundarijal reservoir, it cannot go upstream beyond that point, which is below the proposed dam site and hence the abundance here is high. This is also an indication of the effective conservation measure taken by the Shivapuri National Park.

11. Conclusions:

The poor assemblage of fish species in the area corresponds with the physical conditions of the habitat governed by the rule of increasing altitude and decreasing temperature. Though the fishery is of minor interest, the occurrence of loaches, ***Schistura beavani*** **(Günther, 1868)** might have ecological significance as the species has not been reported from such altitudes in Nepalese rivers. However, this is one of the most common species in Nepalese rivers.

The other species, ***Schizothorax richardsonii*** **(Gray 1832),** popularly known as Snow Trout or Asala, which was recorded from the lower sites, may have good future fishery value with potential to substitute the flourishing artificial rearing of exotic Rainbow Trout having considerable economic incentive, provided national park regulations would permit the establishment of hatcheries and distribution of fingerlings for production elsewhere. A healthy congregation of this species in the third site (downstream of the proposed Nagmati dam near the confluence of Bagmati River) again follow the established rule that in fragmented rivers and streams, downstream sites are normally least affected due to river connectivity compared to upstream sites. Therefore, any conservation or developmental work involving rivers and streams must focus on maintaining river connectivity in the lower reaches of Nagmati (near Sundarijal).

12. Potential Impacts of Dam Construction

Apart from the normal disturbances, which can be anticipated during the dam construction phase, the main impact of the dam would be the reduced flow of water downstream. As the downstream reaches of Nagmati River appear to presently have healthy numbers of the above two species of fish, it would be important to maintain certain amount of flow in the river to ensure sustaining the fish populations. Hence, the main mitigation measure to deal with potential impacts to fish would be to maintain minimum flow levels as required.

13. Main Findings of the Study in Relation to Dam Construction:

1. The low numbers and existence of only 2 fish species are more due to natural causes than disturbance. This is due to the physiography, low connectivity and high elevations upstream of proposed dam site, at Nagmati.

2. Some human influences and disturbances are present which are not related to the proposed project, i.e., road crossings, existing dam at Dhap, water diversion to existing reservoir at Sundarijal (downstream of proposed Nagmati dam site) and increasing vehicular and tourist movements.

3. The drilling has a temporary and limited impact only in the immediate vicinity of the dam site.

4. The main impact of dam construction would be reduced flows downstream, which could affect the existing fish populations (healthy in the river stretch near Bagmati confluence).

5. Mitigation measures should establish the minimum flow, required to sustain existing fish populations.

6. Overall impacts of the proposed dams on fish are likely to be minimal in the Nagmati and Dhap sites as there are already low fish numbers and only one or two species present.

14. References

Jha Bibhuti Ranjan. Fish ecological studies and its application in assessing ecological integrity of rivers in Nepal. **PhD thesis. Kathmandu University, Dhulikhel, Nepal, 2006.**

Jha Bibhuti Ranjan, Waidbacher Herwig, Sharma Subodh & Straif Michael. Fish species composition, number and abundance in different rivers and seasons in Nepal and the reevaluation of their threat category for effective conservation and management. **Ecology, Environment & Conservation**, **12 (1): pp. (25-36), 2006.**

Jha B. R. and Sharma C. M. (2012). Spatial and Temporal Distribution of Fish Assemblage in Indrawati Sub-Basin. **WWF, Nepal (Agreement # WL47).**

Maharjan Archana. Ecological Assessment of Bagmati River. Bachelor"s thesis. **Kathmandu University, Dhulikhel, Nepal, 2009.**

Shrestha, J. (1994): Fishes, fishing implements and methods of Nepal. Smt. M.D. Gupta, Lalitpur colony, Lashkar (Gwalior), India.

Shrestha, T. K. (1990): Resource ecology of the Himalayan waters. Curriculum Development Center, Tribhuvan University, Kathmandu, Nepal.

www.fishbase.org (January 10, 2013)

Field Survey Report 6

RIVER WATER QUALITY SURVEY OF THE UPPER BAGMATI RIVER BASIN

DRAFT REPORT

A Report Submitted to:

Aquatic Ecology Centre,
Kathmandu University

Submitted By:

Dr. Subodh Sharma
And
Mrs. Rosha Raut Khadka

Background

In Nepal, surface water, especially river (lotic) water bodies are the major potential resource of water for all the living organisms. Human communities have used surface water for their daily needs including for various purposes like drinking, cooking, cleaning, washing, bathing etc. Apart from these, surface waters are directly used for irrigation, recreation and various industrial operations.

Bagmati River is one of the major rivers of Nepal and is commonly known as a Holy River. A small portion of Bagmati River was considered in this investigation. The river water is also the major source for the people of Kathmandu valley. The river originates in the mountain region and flows through hills to downstream urban settlements. However, the quality of the Bagmati River water is not suitable for using, except near the source area, and its quality continues to deteriorate at the downstream reaches of the river, where river receives a huge amount of unwanted effluents and debris, i.e. solid and liquid wastes.

As per the TOR of the assignment, the main goal of this investigation was to establish the present (baseline) status of Bagmati river water quality, causes of pollution, including known point sources of pollution along the river course from the proposed dam site at Dhap to near Pashupati Nath temple. Altogether 28 water samples were taken from different sites (see Figure A-1 and Table 1 for details of site locations) and analyzed as per the standard methods.

Methods

The samples were collected in pre-washed clean plastic containers, depending upon the parameters as per the requirement. The samples were separated in three different containers. For bacteriological analysis it was collected in sterilized bottles, 200ml samples from different sites were collected in acid washed plastic bottles for heavy metal analysis and preserved immediately after collection with concentrated HNO_3. Similarly, one liter samples were collected in pre-washed clean plastic container for all physico-chemical parameters analysis and kept in ice box with some ice pack and brought to the AEC laboratory, Kathmandu University in Dhulikhel for further analysis.

In the laboratory, bacteriological samples were processed and analyzed as soon as possible and some physico-chemical parameters like pH, temperature, conductivity, alkalinity, ammonia, nitrate, and BOD were also analyzed immediately within the day of collection. Fresh standard solutions were prepared from stock during analysis of each and every parameters and kept at least 3-4 different concentrations standard with blank for calibration. The heavy metals like Fe, Mn, Cu, Zn, Cd, Cr, Ni, Pb, Al and As were analyzed by using Atomic Absorption Spectrometer (AAS). All the sample collection techniques, quality control mechanism and analytical methods were followed by Standard Methods for the Examination of Water and Wastewater (APHA, AWWA & WEF, 1998). The analyzed physico-chemical parameters and their brief test methods are mentioned below in Table 2.

Table 1. Locations and descriptions of water sampling points in the Upper Bagmati River Basin.

S.No.	Sample Code	Site Description	Coordinates/Elev.
1	Nag 01	Northern edge of Dhap reservoir	27˚48.547'N; 85˚27.493'E; 2075m
2	Nag 02	Dhap reservoir at existing dam	27˚48.482'N; 85˚27.509'E; 2069m
3	Nag 03	Proposed Dhap dam site	27˚48.394'N; 85˚27.379'E; 2061m
4	Nag 04	Downstream of proposed Dhap dam	27˚47.755'N; 85˚27.377'E; 1921m
5	Nag 05	Proposed Nagmati dam site	27˚46.993'N; 85˚26.654'E; 1855m
6	Nag 06	Downstream of proposed Nagmati dam site	27˚46.497'N; 85˚26.326'E; 1850m
7	Mul 01	Tap at Mulkharka	27˚46.54'N; 85˚26.08'E; 1840m
8	Sun 01	Tap (stream) above power house at Sundarijal	27.764°N; 85.424°E; 1460m
9	Sun 02	Near foot-bridge opposite Sundarijal powerhouse	27.762˚N; 85.423˚E; 1390m
10	Bag 01	At bridge near Melamchi Gate	27.756˚N; 85.421˚E; 1358m
11	Bag 02	After bridge crossing near Melamchi Gate	27.754˚N; 85.422˚E; 1354m
12	Bag 03	Before tributary near Naya Pati	27.742˚N; 85.413˚E; 1339m
13	Bag 04	After tributary near Naya Pati	27.741˚N; 85.412˚E; 1338m
14	Bag 05	Before Uttar Bahini temple	27.735˚N; 85.398˚E; 1336m
15	Bag 06	After Uttar Bahini temple	27.736˚N; 85.397˚E; 1335m
16	G 01	Before stream confluence near Gokarna	27˚45.62'N; 85˚23.56'E; 1330m
17	G 02	After stream confluence near Gokarna	27˚45.64'N; 85˚23.39'E; 1328m
18	G 03	After Gokarna temple	27˚45.78'N; 85˚23.33E; 1322m
19	G 04	Along straight stretch before Jorpati bridge (1)	27˚45.93'N; 85˚23.30'E; 1321m
20	G 05	Along straight stretch before Jorpati bridge (2)	27˚46.09'N; 85˚23.26'E; 1320m
21	G 06	Along straight stretch before Jorpati bridge (3)	27˚46.30'N; 85˚23.20'E; 1318m
22	G 07	Along straight stretch before Jorpati bridge (4)	27˚46.54'N; 85˚23.14'E; 1317m
23	G 08	At the Jorpati bridge	27˚46.69'N; 85˚23.09'E; 1315m
24	Bag 07	Gothatar (1)	27˚43.20'N; 85˚23.09'E; 1315m
25	Bag 08	Gothatar (2)	27˚43.01'N; 85˚23.05'E;

			1314m
26	Bag 09	Before Guheshwori temple	27˚42.57'N; 85˚21.52'E; 1310m
27	Bag 10	After Guheshwori temple	27˚42.74'N; 85˚21.18'E; 1307m
28	Bag 11	After Pashupati Nath temple	27˚42.36'N; 85˚21.08'E; 1303m

The parameters like mercury, cyanide, oil & grease, phenolic compounds and anionic detergent were tested only for selected sites representing both unpolluted upstream areas (Nag 02 and 05) as well as polluted downstream sites (Bag 2, 4, G 06, 07, and Bag 09). The samples were sent to the CEMAT laboratory for analysis. The water samples were collected as per their instruction and send to CEMAT Water Testing Laboratory in Batishputali, Kathmandu, for necessary processing and analysis on the same day of collection. The analyzed parameters, results, and their respective test methods are mentioned in Table 7.

Table 2. List of analyzed physico-chemical parameters and their testing method/instrument.

Parameters	Units	Test method/Instrument
Physico-chemical parameters		
Water Temperature	^0C	Thermometer
pH	-	pH meter (WTW)
Color	TCU	Platinum Cobalt
Odor and Taste	unobjectionable	Human sensation
Electrical Conductivity	µS/cm	Conductivity meter (WTW)
Turbidity	NTU	Nephalometric (Turbidity meter)
Total Dissolved Solids (TDS)	mgL^{-1}	Gravimetric
Total Solids (TS)	mgL^{-1}	Gravimetric
Total alkalinity as $CaCO_3$	mgL^{-1}	Acid Titration
Fluoride (F)	mgL^{-1}	SPANDS (Spectrophotometric)
Chloride (Cl^-)	mgL^{-1}	Argentrometric
Total Hardness as $CaCO_3$	mgL^{-1}	EDTA Titration
Calcium (Ca^{++})	mgL^{-1}	EDTA Titration
Magnesium (Mg^{++})	mgL^{-1}	EDTA Titration
Ammonia (NH_3)	mgL^{-1}	Nesslerization (Spectrophotometric)
Nitrate (NO_3^{--})	mgL^{-1}	Brucine Absorbity (Spectrophotometric)
Sodium (Na^+)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Potassium (K^+)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Sulphate (SO_4^{--})	mgL^{-1}	Spectrophotometric
Orthophosphorus (PO_4)	mgL^{-1}	Ammonium molybdate ascorbic acid red.^{n}
Dissolved Oxygen (DO)	mgL^{-1}	Multi Parameter Probe
Bio-chemical Oxygen Demand(BOD)	mgL^{-1}	5 days incubation at 20^0C
Chemical Oxygen Demand (COD)	mgL^{-1}	Potassium Permagnate ($KMNO_4$)
Heavy metals		
Iron (Fe)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Manganese (Mn)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Zinc (Zn)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)

Copper (Cu)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Cadmium (Cd)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Chromium (Cr)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Nickel (Ni)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Lead (Pb)	mgL^{-1}	Atomic Absorption Spectrometer (AAS)
Aluminum (Al)	mgL^{-1}	Spectrophotometric (Erichrome Cyanine)
Arsenic (As)	mgL^{-1}	Atomic Absorption Spectrometer (AAS) ((Hydride Generation - vapor)
Bacteriological Parameters		
Total Coliform	CFU/100ml	Membrane filtration
Fecal Coliform	CFU/100ml	Membrane filtration

The results were compared with the **Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem 2065), Nepal Water Quality Guidelines for Recreation, Nepal Water Quality Guidelines for Livestock Watering, Nepal Water Quality Guidelines for Industries** *source: Department of Irrigation, Ground water project (Nepal Gazette Number 10, BS, 2065-03-02*). See Annex Table A-1 through A-5 for the various water quality standard limit values.

Results

Physio-chemical Properties of Water

A clear and expectant trend of the water quality status being generally good at the upper reaches (headwaters) of the Nagmati River and moderate to poor at the heavily populated urban stretches of the Bagmati River from Jorpati to Guheshwori/Pashupati was observed. The physio-chemical properties of the water samples tested mostly followed this trend as can be seen from the values in Table 3. Water temperatures followed the typical pattern of lows (around 11-12 °C) at higher elevations near Dhap and high values, in the range of 15 to 20 °C at lower elevations near Guheshwori.

The electric conductivity (EC), which reflects the concentrations of ions, such as Na, K, Ca and Mg, ranged from less than 5 µS cm^{-1} upstream to 12 µS cm^{-1} at the downstream locations. Correspondingly, the total alkalinity (TA) ranged from a mere 2 mg/L at Nag 01 (Dhap site) to 56 mg/L at Bag 09, i.e., Guheshwori temple. Likewise, turbidity and total dissolved solids (TDS), which reflect the presences of sediment load in the water and other dissolved solids, were also low at Dhap and upper Nagmati (<1 to 1 mg/L) and highest at Bag 11, i.e, the Pashupati temple area, with values of >30 and 452 mg/L, respectively. Thus, the results distinctly indicate a significant increase in sediment, particulate and cation contents at the lower reaches of the river where human influence and discharge of wastes are greather than at the headwaters, which is largely unpopulated.

The properties that showed little variation from Dhap to Guheshwori, however, were pH (which ranged from 6.2 to 7.2), odour, and taste, the latter two being considered unobjectionable. While the pH increased somewhat at the lower reaches, reflecting the increase in cations and alkalinity, odour and taste were not significantly different for all of the sampling sites. This was likely due to the sampling time, that is, shortly after the monsoon season when the water flow was high.

Table 3. Physiochemical parameters of water sampled for the Upper Bagmati River Basin environmental survey.

S.N.	Sample ID	Analyzed Parameters								
		Temp (°C)	pH (-)	EC[a] (µS/cm)	Color (TCU)	Odor[b]	Taste [b]	Turbidity (NTU)	TA[c] (mg/L)	TDS[d] (mg/L)
1	Nag 01	21.8	7.20	12	<5	Unobj	unobj	<1	2	2
2	Nag 02	21.7	6.80	12	10	unobj	unobj	2	4	2
3	Nag 03	21.6	6.40	9	10	unobj	unobj	<1	4	1
4	Nag 04	21.9	6.20	13	10	unobj	unobj	<1	4	3
5	Nag 05	21.8	6.30	13	5	unobj	unobj	<1	6	5
6	Nag 06	21.7	6.30	14	10	unobj	unobj	<1	6	3
7	Mul 1	22.9	6.50	17	<5	unobj	unobj	<1	10	8
8	Sun 01	14.5	6.69	24	<5	unobj	unobj	<5	18	9
9	Sun 02	13.7	6.55	24	<5	unobj	unobj	<5	19	9
10	Bag 01	13.9	6.66	31	<5	unobj	unobj	<5	20	12
11	Bag 02	15.1	6.70	33	<5	unobj	unobj	<5	17	12
12	Bag 03	13.9	6.89	61	<5	unobj	unobj	7	19	26
13	Bag 04	13.9	6.83	68	<5	unobj	unobj	10	28	29
14	Bag 05	17.8	6.84	93	6	unobj	unobj	10	40	41
15	Bag 06	17.3	6.80	94	6	unobj	unobj	12	34	42
16	G 01	12.4	7.02	108	<5	unobj	unobj	7	40	45
17	G 02	11.9	7.04	100	6	unobj	unobj	8	38	42
18	G 03	12.0	7.06	102	7	unobj	unobj	10	42	44
19	G 04	12.0	7.02	165	10	unobj	unobj	15	46	73
20	G 05	12.0	6.99	114	6	unobj	unobj	10	42	50
21	G 06	12.5	6.99	171	12	unobj	unobj	6	56	77
22	G 07	12.4	6.99	145	11	unobj	unobj	10	46	64
23	G 08	12.5	7.00	146	12	unobj	unobj	10	56	64
24	Bag 07	11.7	6.84	142	<5	unobj	unobj	<5	30	63
25	Bag 08	11.6	6.86	189	<5	unobj	unobj	<5	46	84
26	Bag 09	12.1	6.89	176	<5	unobj	unobj	7	56	80
27	Bag 10	12.1	6.90	201	<5	unobj	unobj	12	72	91
28	Bag 11	13.0	6.92	961	10	unobj	unobj	>30	46	452

[a]EC = electric conductivity; [b]Unobj. = unobjectionable; [c]TA = total alkalinity; [d]TDS = total dissolved solids.

Pollution Indicative Water Quality Parameters

The water quality parameters considered to be indicative of general (agricultural and domestic) pollution are: ammonia, nitrate, phosphorus, sulphate, dissolved oxygen, biochemical and chemical oxygen demand and total/fecal coliform bacteria (Table 4). These parameters once again followed a general trend indicating less polluted conditions at the upstream sites near Dhap and Nagmati dam site to moderate to highly polluted conditions at Guheshwori/Pashupatinath temples.

The values of chemical compounds such as ammonia, nitrate and phosphate were low at the upper reaches of Nagmati River, while the highest values were recorded at the Pashupatinath temple. Moderately high values of nitrate at the Nag 02 to Nag 05 sampling sites could be due to organic loading in the river water from livestock and wild animal grazing.

Table 4. Pollution indicator parameters for water samples in the Upper Bagmati River basin.

S.N.	Sample	Analyzed Parameters						
		NH3 (mg/L)	NO3 (mg/L)	PO4 (mg/L)	DO (mg/L)	BOD (mg/L)	Tot. Coli. (cfu/100ml)	Fec. Coli. cfu/100ml)
1	Nag 01	ND (<0.05)	0.28	0.23	10.20	3.50	TNTC	30
2	Nag 02	0.10	12.82	0.13	9.60	1.00	30	2
3	Nag 03	0.12	13.95	0.04	10.20	2.60	50	7
4	Nag 04	0.20	22.41	0.03	10.40	1.60	40	50
5	Nag 05	0.13	12.69	0.29	10.20	4.20	38	2
6	Nag 06	0.07	5.21	0.16	8.60	5.10	56	14
7	Mul 1	0.05	2.40	0.11	10.80	2.90	62	15
8	Sun 01	0.10	14.88	0.22	10.60	3.80	96	64
9	Sun 02	ND (<0.05)	0.82	0.22	11.40	1.40	TNTC	TNTC
10	Bag 01	0.07	3.93	0.39	10.70	2.20	TNTC	TNTC
11	Bag 02	0.80	1.80	0.41	11.31	3.20	TNTC	TNTC
12	Bag 03	0.14	2.78	0.28	12.32	2.00	66	34
13	Bag 04	0.33	6.55	0.41	12.00	3.00	46	30
14	Bag 05	0.99	3.44	1.15	10.51	1.90	TNTC	TNTC
15	Bag 06	0.90	4.25	0.92	12	3.30	98	72
16	G 01	2.18	2.62	0.49	9.92	12.80	TNTC	TNTC
17	G 02	1.20	3.44	0.20	10.24	8	TNTC	TNTC
18	G 03	1.46	1.47	0.24	9.60	12.0	39	16
19	G 04	5.32	4.42	1.38	8.80	12.0	47	26
20	G 05	1.10	3.11	0.29	11.40	13.2	TNTC	TNTC
21	G 06	5.24	1.15	1.21	9.90	16.0	121	42
22	G 07	3.54	2.29	0.72	9.70	10.80	TNTC	62
23	G 08	2.47	1.63	0.72	9.80	16.0	TNTC	73
24	Bag 07	2.54	22.74	0.53	10.50	8.20	TNTC	TNTC
25	Bag 08	4.15	14.47	1.03	9.44	20.0	TNTC	TNTC
26	Bag 09	4.25	10.32	0.57	8.60	12.0	TNTC	TNTC
27	Bag 10	7.62	6.20	0.85	8.80	16.0	TNTC	TNTC
28	Bag 11	74.30	124.0	13.57	1.60	128.0	TNTC	TNTC

NB: ND = Not detected; TNTC = Too numerous to count

Dissolved oxygen (DO) levels followed the opposite trend of high values (10-12 mg/L) at less polluted and rapid water flow sites and lower values at polluted downstream sites where increased microbial (aglae and bacteria) lead to reduced oxygen content in the water. The lowest value of DO, at 1.6 mg/L was observed for Bag 11 site near Pashupatinath temple. Likewise, biochemical oxygen demand (BOD) values were low (1-2 mg/L) at the upstream sites and higher downstream, with the highest value (128 mg/L) recorded at Bag 11.

Total (TC) and fecal coliform (FC) bacterial presence in the river water also revealed a generally increasing trend from the upstream to the downstream sites. At the Nagmati River headwaters, the bacterial colony counts of TC was 30 CFU and FC was a mere 2 CFU, where as, the number of colony forming units were too numerous to count (i.e., greater than 500) at most of the sampling locations downstream of Sundarijal. The presence of 30 CFU of TC and FC at the Nag 01 and 02 sites were likely due to droppings of livestock and other wild animals washing into the impounded wetland at Dhap.

Cations and Anions

The concentrations of cations and anions in the Nagmati River primarily reflect the geology and sediment loads. As the dominant rock types in the SHNP area are sandstone and quartzite, which are acidic in nature and resistant or not easily weathered, the cation concentrations low (ranging from 0.3 to 4.0 mg/L) in the upstream areas down to Sundarijal. Downstream from Sundarijal onwards, their concentrations gradually increase, presumably from anthropogeic sources such as agricultural and domestic runoff, to high values of 22.4, 11.2, 30.1, and 67.6 mg/L of Ca, Mg, Na, and K, repectively (Table 5).

Of the anions analyzed in the river water, fluorine (F^-) concentrations were negligible, ranging from not-detected to 0.87 mg/L. Chloring (Cl^-) and sulphate (SO_4^{2-}) both were low at the upstream reaches and gradually increased downstream to highs of 87 and 47.6 mg/L, respectively at Bag 11 near Pashupati temple. Theses results are corroborated by the water pH values and the total hardness (TH). The TH values, which reflect the concentration of minerals (like calcium and magnesium) in water, steadily increased from 10 mg/L at Nag 02 to 130 mg/L downstream at Pashupatinath temple.

Table 5. Major cations and anions in water samples of the Upper Bagmati River basin.

S.N.	Sample ID	Analyzed Parameters							
		TH (mg/L)	Ca^{++} (mg/L)	Mg^{++} (mg/L)	Cl^- (mg/L)	F^- (mg/L)	$SO4^{--}$ (mg/L)	K^+ (mg/L)	Na^+ (mg/L)
1	Nag 01	12	4.01	0.50	3	0.83	<1	0.31	1.31
2	Nag 02	10	3.21	0.50	4	0.85	1.70	0.33	1.06
3	Nag 03	18	2.41	2.0	2	0.86	1.40	0.39	1.13
4	Nag 04	12	4.01	0.50	2	0.87	<1	0.40	1.13
5	Nag 05	12	3.21	0.97	1	0.84	1.90	0.56	1.77

6	Nag 06	20	3.21	2.92	2	0.85	<1	0.57	1.75
7	Mul 1	10	3.21	0.50	2	0.86	<1	0.52	2.05
8	Sun 01	14	3.21	1.46	3	0.14	2.07	0.82	3.76
9	Sun 02	24	6.41	1.94	2	0.06	1.26	0.82	3.76
10	Bag 01	28	8.02	1.94	3	0.19	2.07	1.16	4.13
11	Bag 02	32	7.21	3.40	3	0.14	3.21	1.24	4.22
12	Bag 03	20	4.81	1.94	4	0.10	2.07	2.25	7.91
13	Bag 04	22	5.61	1.94	4	0.10	2.75	2.29	6.22
14	Bag 05	28	8.82	1.46	6	0.10	5.05	4.06	8.94
15	Bag 06	22	6.41	1.46	7	0.10	4.71	4.08	7.98
16	G 01	24	6.41	1.94	11	ND	3.50	3.72	10.29
17	G 02	36	8.82	6.10	12	ND	4.48	3.60	9.53
18	G 03	34	8.82	5.59	14	ND	5.04	3.57	9.66
19	G 04	30	9.62	4.40	16	ND	7.49	6.32	13.46
20	G 05	30	9.62	4.40	10	ND	6.16	3.76	10.66
21	G 06	36	10.42	5.59	16	ND	7.49	8.19	15.20
22	G 07	34	9.62	5.35	14	ND	5.25	5.22	11.45
23	G 08	38	8.82	6.56	14	ND	7.35	5.20	13.96
24	Bag 07	58	10.42	7.78	6	ND	4.25	3.31	10.20
25	Bag 08	56	15.23	9.96	10	ND	7.00	4.56	13.68
26	Bag 09	42	8.02	5.35	9	ND	4.13	3.73	12.41
27	Bag 10	44	8.82	5.35	20	ND	4.02	4.53	14.49
28	Bag 11	130	22.44	11.18	87	ND	47.62	30.10	67.63

NB: ND = Not detected (<0.05); TH = total hardness

Heavy Metals in Water

Table 6. Heavy metals in water samples of the Upper Bagmati River basin.

S.N.	Sample ID	Analyzed Parameters									
		Fe (mg/L)	Mn (mg/L)	Cu (mg/L)	Zn (mg/L)	Ni (mg/L)	Cd (mg/L)	Cr (mg/L)	Pb (mg/L)	As (mg/L)	Al (mg/L)
1	Nag 01	0.99	0.05	0.02	ND (<0.02)	ND (<0.01)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	0.32
2	Nag 02	0.82	ND (<0.05)	0.03	ND (<0.02)	ND (<0.01)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	0.32
3	Nag 03	0.41	ND (<0.05)	0.04	ND (<0.02)	ND (<0.01)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	0.30
4	Nag 04	0.25	ND (<0.05	0.05	ND (<0.	ND (<0.	ND (<0.0	ND (<0.	ND (<0.	ND (<0.0	0.30

			)		02)	01)	03)	02)	01)	05)		
5	Nag 05	0.38	0.06	0.06	ND (<0.02)	ND (<0.01)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	0.27
6	Nag 06	0.08	ND (<0.05)	0.07	ND (<0.02)	ND (<0.01)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	0.40
7	Mul 1	0.19	0.05	0.11	ND (<0.02)	ND (<0.01)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	0.34
8	Sun 01	0.10	ND (<0.05)	ND (<0.02)	0.04	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.65
9	Sun 02	0.09	ND (<0.05)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.10
10	Bag 01	0.10	ND (<0.05)	ND (<0.02)	ND (<0.02)	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.79
11	Bag 02	0.32	ND (<0.05)	ND (<0.02)	0.03	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.79
12	Bag 03	0.47	0.06	0.05	0.02	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.79
13	Bag 04	0.93	0.08	ND (<0.02)	0.03	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	2.20
14	Bag 05	2.87	ND (<0.05)	ND (<0.02)	0.04	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	6.33
15	Bag 06	2.48	0.09	ND (<0.02)	0.05	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	5.64
16	G 01	0.98	0.19	ND (<0.02)	0.04	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	2.75
17	G 02	0.93	0.13	ND (<0.02)	0.03	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	2.06
18	G 03	0.84	0.15	ND (<0.02)	0.02	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	1.93
19	G 04	0.99	0.17	ND (<0.02)	0.04	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	2.89
20	G 05	0.82	0.15	ND (<0.02)	0.03	ND (<0.02)	ND (<0.03)	ND (<0.02)	ND (<0.01)	ND (<0.05)	2.61
21	G 06	0.71	0.17	ND	0.03	ND	ND	ND	ND	ND	3.16

				(<0.02)		(<0.02)	(<0.003)	(<0.02)	(<0.01)	(<0.005)	
22	G 07	0.63	0.13	ND (<0.02)	0.04	ND (<0.02)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	2.48
23	G 08	0.65	0.10	ND (<0.02)	0.03	ND (<0.02)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	2.48
24	Bag 07	0.69	0.09	ND (<0.02)	0.03	ND (<0.02)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	1.38
25	Bag 08	0.85	0.14	ND (<0.02)	0.03	ND (<0.02)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	5.09
26	Bag 09	1.48	0.13	ND (<0.02)	0.02	ND (<0.02)	0.003	ND (<0.02)	ND (<0.01)	ND (<0.005)	3.58
27	Bag 10	2.16	0.18	ND (<0.02)	0.02	ND (<0.02)	ND (<0.003)	ND (<0.02)	ND (<0.01)	ND (<0.005)	4.13
28	Bag 11	1.75	0.22	ND (<0.02)	0.10	ND (<0.02)	0.006	ND (<0.02)	ND (<0.01)	ND (<0.005)	23.38

NB: ND = Not Detected

Heavy metal elements in water occasionally derive from geological sources (rocks and mineral), however, most are introduced from anthropogenic sources such as municipal wastes, chemical dumping and industrial processes. Of the heavy metals analyzed in the river water samples, nickel, cadmium, chromium, lead and arsenic were essentially absent or non-detected. However, metals elements such as iron (Fe), manganese (Mn), copper (Cu), zinc (Zn), and aluminum (Al) all showed increasing trends from the headwaters to the downstream sites of Guheshwori/Pashupati temples. Although the values of these elements were mostly low (ranging from 0.02 for Cu and Zn, 0.1 to 2.48 for Fe and 0.3 to 23. 4 for Al), the values were seen to increase in the stretch from Gokarna to Guheswori. The value of Al (23.4 mg/L) at Bag 11, that is, Pashupatinath temple area exceeded the water quality guidelines standard of 10 mg/L limit for protection of aquatid ecosystems and the 5 mg/L limit for livestock watering (Tables A-1 and A-3 in the Annex).

Table 7. Oil/grease, detergents, phenolic compounds, cyanide, mercury and selenium.

Parameter	**Unit**	**Sample code and results**							**Method**
		Nag 02	**Nag 05**	**Bag 02**	**Bag 04**	**G 06**	**G 07**	**Bag 09**	
Selenium (Se)	µg/L as Se	<1	<1	<1	<1	<1	<1	<1	Atomic Absorption Spectrophotometric (AAS)
Mercury(Hg)	µg/L as Hg	<1	<1	<1	<1	<1	<1	<1	Atomic Absorption Spectrophotometric (AAS), Cold Vapor

Cyanide (CN)	mg/L as CN	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	Spectrophotometric
Phenolic Compounds	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	Gibbs Reaction Method
Anionic Detergent	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	Extraction, Spectrophotometric
Oil & Grease	mg/L	<1	<1	<1	<1	<1	<1	<1	Partition Gravimetric Method

The concentrations of highly toxic compounds and metals, namely, cyanide, mercury and selenium were all below the detection limits of the analytical instruments. Thus, these were well below the water quality statndard limits. Likewise, the presence of oil and grease, phenolic compounds and anionic detergent were all below the detection levels and hence negligible in the water samples analyzed.

Potential Impacts of Dam Construction on Water Resources

The primary impact of dam construction on water resources would be the reduction of flows downstream of the dam site and inundation of areas upstream. As the water quality is good in the upstream stretches of the Nagmati River and downstream sites along the Bagmati River (particulary downstream of the Sundarijal area) are already significantly impacted by human settlements and activities, the damming of the Nagmati River is not expected to have major impacts on river water quality. The polluted downstream sites, especially from Gokarna to Pashupati area are affected mainly by agricultural and domestic effluent discharge (sewage and solid waste). While during the construction phase some disturbance in water quality, mainly sediment loads and irregular flows (discharge volume) can be expected, minimal impacts to water quality are likely to occur after completion of the dams provided minmum flows are maintained. Conversely, flow and flood control may be achieved through regulation of the water discharged from the reservoirs formed by dam construction.

Field Survey Report 7

SOIL TYPES AND STATUS IN THE SHIVAPURI AND ADJACENT AREAS FOR THE PROPOSED BAGMATI RIVER BASIN IMPROVEMENT PROJECT

FINAL REPORT

A Report Submitted to:

Aquatic Ecology Center
Kathmandu University

Submitted by:

Dr. R. M. Bajracharya

1. Background

As per the TOR for the Environmental Study of Upper Bagmati River Basisn Improvement Project (ADB TA 8050 Nep), the purpose of this survey was to establish a baseline status and condition of the soils within and beyond the Shivapuri National Park, specificially within the vicinity of the proposed dam locations at Dhap and Nagmati and the potentially impacted areas downstream. Thus, sampling was done covering several days during the period from October through December 2012, beginning with the upper-most point of sampling at Thulo Dhap near Chisapani. The samples were brought back in clearly labeled polyethleyene bags to the Aquatic Ecology Centre laboratory at Kathmandu University for processing and analyses. This report describes the sampling site locations, sampling methods, analyses performed and interpretation of the results to provide an overall assessment of the status of soils in the study area.

2. Sampling Procedure

The procedure for soil sampling involved random selection of sites within the vicinity of the proposed dam locations at Thulo Dhap and Nagmati River, near Mulkharka, and from Sundarijal to Tilganga (see Figure A-1 in the Annexes for sampling site locations). Sampling spots were randomly selected in view of accessibility, proximity to points of interest and specific location with reference to the water bodies. The soil was sampled from two depth ranges for samples taken within the National Park, namely, at 0-15 cm and 15-30 cm depths, unless bed-rock was encountered above 30 cm. For the samples collected beyond the Park boundaries from Sundarijal to Tilganga, only the surface layer (0-15 cm) was collected as it is presumed that any impacts from dam construction at Nagmati and Dhap inside the National Park would have minimal, if any, impact on soils down stream beyond the park boundaries.

At each sampling location, two types of soil samples were collected: a) A loose sample to the required depth using a soil auger, and b) core samples using a soil corer with steel core rings of 4.7 cm diameter and 6 cm height. The soil cores were used for determining the soil bulk density and moisture content at the time of sampling, while the loose samples were first air-dried, ground and sieved through a 2 mm mesh sieve for all other laboratory analyses. A total of 40 soil samples were collected and analysed.

3. Laboratory Methods

Once the soil samples had been transported to the lab and processed, the following laboratory analyses were carried out on them:

Physical Properties:

1. Soil moisture content (by oven-drying at 105°C; Gardner, 1986)
2. Soil bulk density (by core method; Blake and Hartge, 1986)
3. Soil texture (Bouyoucos Hydrometer method; Gee and Bauder, 1986)
4. Soil colour (using Munsell soil color chart; Munsell, 2000)
5. Electric conductivity (by conductivity meter; modified from NSSC/NRCS/USDA, 1996)

Chemical Properties:

1. Soil reaction (by glass-calomel pH electrode; 1:1 soil:water ratio; McLean, 1982)
2. Total nitrogen (Kjeldahl method; Bremner and Mulvaney, 1982)
3. Available phosphorous (modified Olsen method; Olsen and Sommers, 1982)
4. Exchangeable potassium (Ammonium acetate extraction; Knudsen, Peterson, and Pratt, 1982)
5. Soil organic matter/carbon (dry combustion method; Nelson and Sommers, 1982)

4. Description of the Sites

The sampling sites varied considerably from location to location with grassland dominating in the upper part of the Bagmati River Basin at Thulo Dhap and along stretches of the Nagmati River. Near the Nagmati dam site, Sundarijal and Gokarna, the areas were mostly mixed forest. At Mulkharka, as well as, between Sundarijal and Tilganga, along the Bagmati River, there were considerable areas of farmland (cultivated agricultural lands). A list of the sampling points and site characteristics are provided in Table 1. The sampled locations ranged in elevation from nearly 2,100 meters at Dhap (Nag 01) to a low of about 1,315 meters near the Guheshwori Temple area.

5. Soil Characteristics

Physical Properties

Soil Texture

The sampled locations had predominantly sandy soils with the textural class “sandy loam” (50-80% sand) being most common as shown in Table 2. The next most common soil texture was “loam”, followed by “silt loam”. A few sites had “loamy sand” (Sun 01, Nag 03B) and “sand” textures at Nag 03A near the proposed dam site of Dhap. The high sand textures indicate soils formed on alluvial deposits as the sampling sites were located near the Nagmati River banks. The generally sandy nature of soils in the Shivapuri National Park as such implies high infiltration rates, and hence, good ground water recharging and water harvesting potential for the entire area. Thus, the park area is an important source of water for the residents of the Kathmandu valley.

Table 1. Descriptions and locations of soil sampling sites in the Upper Bagmati River Basin.

S.No.	Sample Code	Site Description	Coordinates/Elev.	Remarks
1	Nag 01	Northern edge of Dhap reservoir; grass land	27˚48.547'N 85˚27.493'E; 2075m	Two soil depths; 0-15, 15-30 cm
2	Nag 02	Dhap reservoir at existing dam; near forest patch	27˚48.482'N 85˚27.509'E; 2069m	Two soil depths; 0-15, 15-30 cm
3	Nag 03	Proposed Dhap dam site; grass land near stream bank	27˚48.394'N 85˚27.379'E; 2061m	Two soil depths; 0-15, 15-30 cm
4	Nag 04	Downstream of proposed Dhap dam; grass land near stream bank	27˚47.755'N 85˚27.377'E; 1921m	Two soil depths; 0-15, 15-30 cm
5	Nag 05	Proposed Nagmati dam site; forest slope	27˚46.993'N 85˚26.654'E; 1855m	Two soil depths; 0-15, 15-30 cm
6	Nag 06	Downstream of proposed Nagmati dam site; grassy stream bank	27˚46.497'N 85˚26.326'E; 1850m	Two soil depths; 0-15, 15-30 cm
7	Mul 01	Farm land (bari) at Mulkharka	27˚46.54'N 85˚26.08'E; 1840m	Two soil depths; 0-15, 15-30 cm
8	Mul 02	Grass land below Mulkharka at existing Sundarijal reservoir	27˚46.34'N 85˚25,74'E; 1620m	Two soil depths; 0-15, 15-30 cm
9	Sun 01	Grassy area above Sundarijal power-house; outside park boundary	27˚45.83'N; 85˚25.50'E; 1460m	Rocky & shallow soil; 0-15 cm only
10	Sun 02	Agricultural field across foot-bridge opposite Sundarijal powerhouse	27˚45.57'N; 85˚25.52'E; 1400m	0-15 cm only
11	Bag 01	Recently harvested paddy field	27˚45.28'N; 85˚25.49'E; 1365m	Right and left bank of Bagmati River (0-15cm)
12	Bag 02	Recently harvested maize field	27˚45.20'N; 85˚25.30'E; 1355m	Right and left bank of Bagmati River (0-15cm)
13	Bag 03	Recently harvested and tilled paddy field	27˚44.49'N; 85˚24.74'E; 1345m	Right and left bank of Bagmati River (0-15cm)
14	Bag 04	Recently harvested paddy field	27˚44.47'N; 85˚24.70'E; 1345m	Right and left bank of Bagmati River (0-15cm)
15	Bag 05	Recently harvested paddy field; forest land (Gokarna) on left bank	27˚44.13'N; 85˚23.87'E; 1340m	Right and left bank of Bagmati River (0-15cm)

16	Bag 06	Recently harvested paddy field; forest land (Gokarna) on left bank	27˚43.11"N; 85˚23.77"E; 1340m	Right and left bank of Bagmati River (0-15cm)
17	Bag 07	Fallow bari (upland agriculture)	27˚43.88"N; 85˚23.08"E; 1330m	Right and left bank of Bagmati River (0-15cm)
18	Bag 08	Maize field (agriculture)	27˚43.02"N; 85˚22.76"E; 1320m	Right and left bank of Bagmati River (0-15cm)
19	Bag 09	Upland field (bari); mustard field (left bank)	27˚42.67"N; 85˚22.29"E; 1320m	Right and left bank of Bagmati River (0-15cm)
20	Bag 10	Ginger field (right bank); recently harvested paddy field (left bank)	27˚42.65"N; 85˚21.56"E; 1320m	Right and left bank of Bagmati River (0-15cm)
21	Bag 11	Forest land (Guheswori temple)	27˚42.58"N; 85˚21.26"E; 1315m	Right and left bank of Bagmati River (0-15cm)
22	Bag 12	Forest land (Guheswori temple)	27˚42.28"N; 85˚21.24"E; 1315m	Right and left bank of Bagmati River (0-15cm)

Soil Colour

The soils at the sampled locations were mostly dark in colour as can be seen from the Munsell Colour notations in Table 2. The most common soil colour was very dark brown (10YR3/2), followed by dark brown (10YR3/3 & 7.5YR3/2) and very dark grayish brown.

Table 2. Soil colour and texture of the soils sampled in the Upper Bagmati River Basin.

S.N.	Site	Soil	Sand	Silt %	Clay %	Soil Textural
1	Sun 01	10YR3/3	79.04	12.56	8.40	Loamy sand
2	Sun 02	10YR4/3	51.42	29.78	18.80	Loam
3	Nag 01 A	10YR3/3	25.66	64.34	10.00	Silt loam
4	Nag 01 B	10YR3/4	38.32	53.08	8.60	Silt loam
5	Nag 02 A	10YR3/3	44.70	45.50	9.80	Loam
6	Nag 02 B	7.5YR3/2	49.46	40.54	10.00	Loam
7	Nag 03 A	10YR3/3	90.38	1.62	8.00	Sand
8	Nag 03 B	10YR3/3	85.80	5.80	8.40	Loamy sand
9	Nag 04 A	10YR2/2	32.00	60.60	7.40	Silt loam
10	Nag 04 B	7.5YR3/2	35.86	56.14	8.00	Silt loam
11	Nag 05 A	10YR3/3	58.44	32.16	9.40	Sandy loam
12	Nag 05 B	10YR4/3	76.42	13.18	10.40	Sandy loam
13	Nag 06 A	7.5YR2.5/2	67.80	25.20	7.00	Sandy loam
14	Nag 06 B	7.5YR3/2	51.30	38.70	10.00	Loam
15	Mul 01 A	10YR3/2	56.66	31.94	11.40	Sandy loam
16	Mul 01 B	10YR3/3	58.18	31.82	10.00	Sandy loam
17	Mul 02 A	10YR4/2	51.64	34.36	14.00	Loam
18	Mul 02 B	10YR4/3	60.98	24.62	14.40	Sandy loam

19	Bag 01	10YR3/2	36.16	49.24	14.60	Loam
20	Bag 01	10YR3/2	48.88	35.32	15.80	Loam
21	Bag 02	10YR3/2	67.00	19.20	13.80	Sandy loam
22	Bag 02	10YR2/2	79.52	8.88	11.60	Sandy loam
23	Bag 03	10YR3/2	41.02	43.78	15.20	Loam
24	Bag 03	10YR3/2	31.26	48.74	20.00	Loam
25	Bag 04	10YR3/1	23.18	57.42	19.40	Silt loam
26	Bag 04	10YR3/1	33.04	50.76	16.20	Silt loam
27	Bag 05	2.5Y3/2	29.68	55.72	14.60	Silt loam
28	Bag 05	10YR3/2	44.92	40.88	14.20	Loam
29	Bag 06	10YR3/2	49.24	40.56	10.20	Loam
30	Bag 06	2.5Y3/2	26.46	55.14	18.40	Silt loam
31	Bag 07	2.5Y3/2	67.72	18.88	13.40	Sandy loam
32	Bag 07	2.5Y3/2	65.84	22.16	12.00	Sandy loam
33	Bag 08	2.5Y3/2	62.48	25.72	11.80	Sandy loam
34	Bag 08	10YR3/1	59.50	28.30	12.20	Sandy loam
35	Bag 09	10YR3/2	66.06	19.94	14.00	Sandy loam
36	Bag 09	10YR3/2	57.56	30.44	12.00	Sandy loam
37	Bag 10	10YR3/2	58.84	25.36	15.80	Sandy loam
38	Bag 10	10YR3/2	77.10	10.30	12.60	Sandy loam
39	Bag 11	10YR3/3	49.46	34.14	16.40	Loam
40	Bag 12	10YR3/3	49.02	34.98	16.00	Loam

*10YR4/3 = brown; 7.5YR3/2 & 10yr3/3 = dark brown; 7.5YR2.5/2, 10YR2/2 & 10YR3/2 = very dark brown; 2.5Y3/2 = very dark grayish brown; 10YR3/1 = very dark gray; 10YR3/4 = dark yellowish brown

(2.5Y3/2). A few instances of brown and yellowish brown or grayish brown soils were also encountered, typically in upper slope areas not adjacent to the river bank. The paddy soils adjacent to the Bagmati river along the stretch from below Sundarijal to Guheshwori were mostly grayish to dark grayish brown in colour, reflecting the frequent water-logging and hence reduced conditions prevalent in the soils.

Soil Bulk Density

The bulk densities of the sampled sites varied considerably, ranging from just under 0.6 g cm^{-3} (0.57) at the forested site of Nag 04 to more than 1.5 g cm^{-3} at the Gokarna forest site. However, the majority of soils had intermediate densities on the order of 1.0 to 1.5 g cm^{-3} as is typical of sandy textured soils that have had some degree of consolidation and compaction. The rather low densities observed for forested or grassed sites near the river bank (such as Nag 01, 02, 04 and 06) was due presumably to the high SOC and water contents as the soils were near saturated. The very high bulk density at the Gokarna site most likely reflected trampled and trafficked conditions along a trail leading to compaction and, therefore, high density. On the other hand, cultivated soils with low amounts of gravel and stones tended to have lower bulk densities in the range of 1.0 to 1.4 g cm^{-3}.

Soil Moisture Content

Most of the sampled sites had high soil water content as the sites were located close to water bodies. One or two locations, however, were very dry with very low water content. Thus, the gravimentric soil moisture percent (on a weight basis) ranged from about 0.5% to over 100%, i.e., saturated.

Electric Conductivity

The electric conductivity (EC) of the soils also varied substantially, ranging from a low of merely 15.3 to a high of 138 µS cm^{-1}. As the EC provides an indication of the concentration of dissolved salts in the soil solution, soils with higher EC values have a greater proportion of exchangeable basic cations such as sodium, potassium, calcium and magnesium. Thus, generally, the soils that are alkaline in reaction tend to have high EC values. Although all of the soils sampled were acidic in reaction, the sites with somewhat higher pH values (in the range of 5 to 6) had typically higher EC values, such as Mul 01, Bag 06, Bag 08 and Bag 09 sites. Overall, however, the soils, particularly within the Shivapuri National Park had low values of EC (sites along the Nagmati River).

Table 3. Selected physical properties of soils sampled in the Upper Bagmati River Basin.

S.N.	Site Name	BD, gm/cm3	Water content, %	EC, µS/cm
1	Sun 01	1.27	13.32	68.9
2	Sun 02	1.29	26.21	75.7
3	Nag 01 A	0.75	76.95	30.7
4	Nag 01 B	0.72	80.12	38.5
5	Nag 02 A	0.96	56.21	55.8
6	Nag 02 B	0.82	66.50	33
7	Nag 03 A	1.31	24.97	35.2
8	Nag 03 B	1.37	26.60	24.5
9	Nag 04 A	0.57	79.23	65.9
10	Nag 04 B	0.64	70.44	36.4
11	Nag 05 A	1.15	27.51	15.3
12	Nag 05 B	1.14	18.42	15.4
13	Nag 06 A	0.63	47.86	86
14	Nag 06 B	0.86	40.83	53
15	Mul 01 A	0.82	42.41	133
16	Mul 01 B	1.17	28.28	107.5
17	Mul 02 A	1.24	24.37	28
18	Mul 02 B	1.25	20.00	23.2
19	Bag 01 (L)	1.51	0.48	40.3
20	Bag 01 (R)	1.08	55.93	42
21	Bag 02 (L)	1.37	11.37	48.2
22	Bag 02 (R)	1.31	23.67	42.1
23	Bag 03 (L)	1.08	51.50	33
24	Bag 03 (R)	1.01	49.65	38.5
25	Bag 04 (L)	0.85	87.91	76.2
26	Bag 04 (R)	1.38	17.27	62.2

27	Bag 05 (L)	1.53	38.10	105.6
28	Bag 05 (R)	1.25	37.71	100.2
29	Bag 06 (L)	1.30	5.13	55.7
30	Bag 06 (R)	1.07	45.74	138.1
31	Bag 07 (L)	0.92	94.07	55.4
32	Bag 07 (R)	1.29	40.92	123
33	Bag 08 (L)	0.95	63.25	102
34	Bag 08 (R)	0.85	77.15	71.5
35	Bag 09 (L)	1.13	12.58	127.8
36	Bag 09 (R)	1.37	19.84	123.7
37	Bag 10 (L)	1.10	71.14	107
38	Bag 10 (R)	0.67	106.32	94
39	Bag 11 (L)	1.08	60.52	58
40	Bag 12 (L)	0.96	71.13	56.6

Table 4. Chemical properties of the soils sampled in the Upper Bagmati River Basin.

S.N.	Site Name	pH	TN, mg/kg	Av.P, ppm	Ex.K, ppm	SOM%	SOC%
1	Sun 01	4.45	504	34.5	71.3	1.92	1.11
2	Sun 02	4.47	1624	16	145.4	5.08	2.94
3	Nag 01 A	4.85	1960	11.3	87	9.92	5.75
4	Nag 01 B	4.26	1400	16.2	52.7	9.43	5.47
5	Nag 02 A	3.92	840	9.8	51.5	10.66	6.18
6	Nag 02 B	4.32	1736	8.2	46.1	8.99	5.21
7	Nag 03 A	4.56	560	10.9	40.7	3.86	2.24
8	Nag 03 B	4.04	1736	22	33	3.05	1.77
9	Nag 04 A	4.09	1176	14.7	215	17.98	10.43
10	Nag 04 B	3.91	1008	6.5	119.8	12.40	7.19
11	Nag 05 A	4.26	1232	17.4	42.2	6.36	3.69
12	Nag 05 B	4.32	1288	6.6	30.3	2.81	1.63
13	Nag 06 A	4.13	3976	16.7	274.3	13.22	7.67
14	Nag 06 B	4.17	1288	8	160.4	12.98	7.53
15	Mul 01 A	5.44	3920	126.2	385.9	11.30	6.55
16	Mul 01 B	5.46	1512	139.2	313.4	6.98	4.05
17	Mul 02 A	4.29	952	12.4	79	3.75	2.17
18	Mul 02 B	4.34	1848	15.7	56.8	2.82	1.63
19	Bag 01 (L)	4.05	1848	70.9	50	4.52	2.62
20	Bag 01 (R)	4.22	672	58.6	49.3	2.72	1.58
21	Bag 02 (L)	4.49	1120	44.3	90.7	3.34	1.94
22	Bag 02 (R)	4.06	1288	38	47.2	3.85	2.23
23	Bag 03 (L)	4.16	1400	48.4	75.2	4.06	2.36
24	Bag 03 (R)	4.2	1344	30.1	69.2	4.24	2.46

25	Bag 04 (L)	4.36	1512	24.3	98.4	4.29	2.49
26	Bag 04 (R)	4.31	1288	28.6	76.7	3.70	2.15
27	Bag 05 (L)	4.28	3696	13.7	200.6	8.80	5.10
28	Bag 05 (R)	5.48	896	81	101.4	2.30	1.33
29	Bag 06 (L)	3.99	2128	11.2	100	4.79	2.78
30	Bag 06 (R)	5.58	1512	101	118	3.03	1.76
31	Bag 07 (L)	5.42	1848	48.6	65	2.09	1.21
32	Bag 07 (R)	6.12	1512	66.1	80.3	3.36	1.95
33	Bag 08 (L)	6.45	1008	45.6	57.1	2.14	1.24
34	Bag 08 (R)	6.25	728	34.2	52.6	2.20	1.28
35	Bag 09 (L)	4.46	1344	70	101.6	1.30	0.75
36	Bag 09 (R)	5.41	1512	98.9	75.6	2.26	1.31
37	Bag 10 (L)	4.92	336	24.6	94.9	1.97	1.15
38	Bag 10 (R)	5.23	616	49.4	62.1	2.33	1.35
39	Bag 11 (L)	4.21	1624	16.8	99.4	5.23	3.03
40	Bag 12 (L)	4.26	1456	25.4	65.8	4.53	2.63

6. Chemical Properties

Soil Reaction

As mentioned above, the soils sampled both inside the national park and along the Bagmati River from Sundarijal to Guheshwori were acidic in nature (Table 3). The soil pH values ranged from strongly acidic at 3.91 (Nag 04) to slightly acidic with a value of 6.45 at Bag 08. The majority of soil pH values were in the range of pH 4 to 5, indicating moderate to strongly acidic conditions. Under these conditions, the basic cation concentrations tend to be low.

Major Soil Nutrients

The major soil nutrients analyzed included total nitrogen (TN), available phosphorous (AP) and exchangeable potassium (EK) as shown in Table 3. The TN values were mostly moderate to high ranging from 504 mg kg^{-1} at the Sundarijal site to a high of nearly 4000 mg kg^{-1} at the Nagmati dam site. Most of the soils sampled had moderate levels of TN in the range of 1000 to 2000 mg kg^{-1} as would be expected. However, TN tends to be correlated with soil organic matter levels, hence, sites with high organic matter contents, such as the forested sites of Nag 06 and Bag 05 had the highest TN values. A high value of 3920 mg kg^{-1} observed at Mulkharka was likely due to the application of fertilizers along with farmyard manure and compost on this upland farm terrace.

The available phosphorous levels of the sampled sites were generally moderate to low except in cultivated areas where phosphorous fertilizer (DAP) is presumably applied. In the naturally vegetated sites at Dhap, Nagmati, Sundarijal and Gokarna forest, the values were typically low ranging from 8 to 34.5 ppm. On farm fields, however, the values of AP were considerably more variable, yet higher ranging from 34 to 139 ppm.

Exchangeable potassium in soils tend more to reflect the natural geology of the area and are typically highly variable depending on the presence and weathering state of potassium bearing rocks and minerals. Thus, the EK values of the sampled sites were also highly variable ranging from a low of 33 ppm at Nag 03 to a high of 386 ppm at Mul 01. The high EK values observed for the Mulkharka farm terrace could also be the result of fertilizer application.

Soil Organic Matter and Organic Carbon

The soil organic matter (SOM) and carbon (SOC) status of the soils reflect the vegetative cover abundance and soil type of the area in question, with values ranging from 1.3 to nearly 18% SOM or less than 1 to about 10.4% SOC. As can be clearly seen from the data in Table 3, sites with forest or grass cover and a regular supply of organic litter to the soil had high SOM and SOC contents. This was generally the case for all Nagmati sites as well as Gokarna forest and Guheshwori temple area. The high organic matter status of the Mulkhara farm terrace site once again reflected the application of farmyard manure and compost as organic fertilizer, a common practice on upland farms (bari).

Anticipated Impacts of Dam Construction on Soil Properties

The main impact of dam construction on soils upstream of the dam site would obviously be the inundation and hence saturation of the soils with water. This would affect soils only within the inundation area of the dams, which are expected to be a 36 ha area upstream of the Nagmati dam site, and 11 ha area upstream of the Dhap dam site. As much of the area above the Dhap dam site is already inundated by the existing shallow lake, the area to be affected there would be considerably less than 11 ha. Once flooded, the land under indundation is not expected to support terrestrial plant or animal life, although the sites may eventually be inhabited by aquatic plants and organisms. The the changes in soil physical or chemical properties are likely to be of minor concern. The proposed dams at Dhap and Nagmati and the subsequent reservoirs formed by inundation of the upstream areas do not affect any existing agricultural land or settlement areas directly. Moreover, as the inundated areas (once the proposed dams are constructed) cover less than 1 percent of the total area of the Shivapur National Park and do not include any areas inhabited by local people, the impacts to soil/land resources can be regarded as negligible.

7. References

Blake, G.R., and Hartge, K.H. (1986) Bulk density. *In:* page, A.L. (ed). Methods of soil analysis part 1 (2nd edition) Physical and mineralogical methods agronomy monographs. ASA; SSSA. Maidson. WI, USA, p. 425-442.

Bremner, J.M. and Mulvaney, C.S. (1982) Nitrogen Total. *In:* A. L. Page, R. M. Miller and D. R. Keeney, (eds.) Methods of Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties. American Society Agronomy Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p.595-610.

Gardner, W.H. (1986) Water Content. *In:* A. Klute (ed.) Methods of Soil Analysis, Part 1. (2nd Edition) Physical and Mineralogical Methods-Agronomy Monogram No. 9. American Society of Agronomy- Soil Science Society of America, Madison, WI, USA, p. 493-544.

Gee, G.W. and Bauder, J.W. (1986) Particle Size Analysis. *In:* A. Klute (ed.) Methods of Soil Analysis, Part 1 (2nd edition) Physical and Mineralogical Methods-Agronomy Monogram No. 9 (2nd Edition). American Society of Agronomy- Soil Science Society of America, Madison, WI, USA, p. 383-411.

Knudsen, D., Peterson, G.A. and Pratt, P.F. (1982) Potassium. *In*: A. L., Miller, R. H., Keeney, D.R. (Editors). Methods of Soil Analysis Part 2 (2nd edition), Chemical and Microbiological Properties, ASA/SSSA, In. Madison.USA. 225:246.

McLean, E.O. (1982) Soil pH and lime requirement. Methods of soil analysis Part 2 (2nd edition) Chemical and microbiological properties. American Society of Agronomy. Monograph No. 9. Madison (WI): ASA-SSSA, Inc., Madison, WI, USA, p. 199-224.

Nelson, D.W., and Sommers, L.E. (1982) Total Carbon, Organic Carbon and Organic Matter *In:* A. L. Page, R. M. Miller and D. R. Keeney, eds. Methods of Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties, American Soc. of Agron. Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p. 539-580.

NSSC/NRCS/USDA (1996) Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report No. 42. United States Dept. Agric., Natural Resources Conser. Service, National Soil Survey Center, Washington D.C., USA, 693pp.

Olsen, S.R. and Sommers, L.E. (1982) Phosphorous. *In:* A. L. Page, R. M. Miller and D. R. Keeney, eds. Methods of Soil Analysis Part 2 (2nd edition) Chemical and Microbiological Properties, American Soc. of Agron. Monograph No. 9, ASA-SSSA, Inc., Madison, WI, USA, p.403-416.

Field Survey Report 8

AIR AND NOISE SAMPLING FOR ENVIRONMENTAL STUDY OF THE UPPER BAGMATI RIVER ENVIRONMENT

FINAL REPORT

A Report Submitted to:
Aquatic Ecological Centre,
Kathmandu University
Dhulikhel, Kavre, Nepal

Submitted by:
Water Engineering & Training Centre Pvt. Ltd.
Dillibazar, Kathmandu, Nepal

December, 2012

1. Background

Environmental monitoring of any construction activities have become an inevitable aspect to produce the baseline data thereby developing control mechanism that prevent further degradation of the existing condition and potential hazardous effects to the denizens. Since the air quality and the sound pressure level are most likely to be affected owing to the construction activities in the project area, also the impacts associated with them are often of prime concern. The vehicular movement and other activities in the construction area give rise to increase in sound pressure level as well as suspended particles and particles with aerodynamic diameter less than 10 μm matters in air. At the same time, burning of fuel causes emission of SO_2, NO_2 and heavy metals e. g lead. These air pollutants may induce serious health threats to human beings if early control measures are not taken based on the systematic and regular monitoring. Similarly, sound pressure level also increases and causes sleep disturbances, annoyance, speech interferences and hearing deficiency to the denizens.

So, the current study has helped to identify the negative impacts on the air quality and sound level of the sensitive environment located adjacent to the Upper Bagmati River Basin area, due to New Dam Construction Activity.

An agreement had been made between Aquatic Ecological Centre, Kathmandu University, Dhulikhel, Kavre, Nepal and Water Engineering & Training Centre Pvt. Ltd. (WETC) on 12 November, 2012 to carry out air quality and sound level monitoring along the Bagmati river stretch from Sundarijal area to Tilganga area at five places namely Dhap, Nagmati, Sundarijal, Gokarna and Pashupati - Tilganga. The monitoring was carried out staring from 21 November, 2012 until 26 November 2012 as field work. The collected samples and data were analyzed at the laboratory of WETC to prepare this comprehensive report.

WETC, an environmental consultancy firm along with facility of Nepal Standard accredited analytical laboratory based on ISO 17025, is engaged in environmental monitoring, data generation, water quality management in water supply system and supply and installation of water treatment plants since more than past two decades.

The project was supervised by Dr. Nawaraj Khatiwada and accomplished with team of following and other laboratory personnels.

Bhola Nath Paudyal – Team Leader

Surendra Parajuli – Environmental Monitoring Officer

Raju Neupane – Field and Lab Assistant

2. Scope of the study

The present study includes the Bagmati River stretch from Sundarijal area to Guheshwori – Tilganga for ambient air quality monitoring and sound pressure level measurement. The pin pointed areas are Dhap, Nagmati, Sundarijal, Gokarna and Pahsupati - Tilganga.

3. Objective of the study

The main objectives of the study are to:

I. Carry out 24 hour air sampling for quality monitoring of Suspended Particulate Matter (SPM), Respirable Suspended Particulate Matter (RSPM), Sulphur dioxide (SO_2), Nitrogen Oxides (NOx) and Lead (Pb).

II. Carry out ambient noise monitoring (24 hour on one hour interval) for measurement of L_{max} (dBA), L_{min} (dBA) and L_{eq} (dBA)

4. Air pollutants and its impacts

5) Air pollutants can be in the form of solid particles, liquid droplets, or gases. The pollutants can be classified as either primary or secondary. Primary pollutants are substances directly emitted from a process whereas secondary pollutants are formed in the air when the primary pollutants react or interact. The most common pollutants are Sulphur dioxide (SO2), formed by burning of fossil fuels, Nitrogen Oxides (NO2), formed from natural sources, Suspended Particulate Matters (SPM), emitted from the various man made sources as well as the industrial dust, volcanic eruptions, and vehicles.Major pollutants covered in this study are follows:

Suspended Particulate Matter (SPM):
SPM are abundant in the atmosphere and refers to particles having size from the smallest to a generally acceptable limit up to 50-100 microns in diameter. It is commonly referred as dust particle and cause aesthetic and environmental impacts such as soiling of materials or smothering of vegetation.

They cause health threat to human by means of absorbing toxic and carcinogenic compounds. During breathing it enters into the lungs, which is ultimately harmful to the human health.

Respirable Suspended Particulate Matter (RSPM - PM10)
Particulate matters are originated in the atmosphere by both natural and anthropogenic activities. Natural sources of particulate matters include fine soil and mineral particles, volcanic dust, sea salt spray, biological material such as pollen, spores and bacteria and debris from forest fires. PM_{10} refers to particulate matter that is 10 µm or less in diameter.

The increases in particulate matter have been shown to cause small, reversible decrements in lung function in normal asymptomatic children, and in both adults and children who have some form of pre-existing respiratory condition, particularly asthma. These changes were often accompanied, especially in adults, by increases in symptoms such as chronic bronchitis or cough.

Sulphur dioxide (SO2):
It is a colourless gas with pungent and suffocating smell. The main sources of the gas are combustion of fuels, and various industrial activities. The amount of SO_2 is directly related to the sulphur content of the fuel.

Higher concentration of SO2 causes breathing problem especially asthma to the human being. Similarly, eye irritation, long term heart diseases, other cardiovascular ailments and bronchitis are associated with exposure of the gas. At the same time it also causes environmental effects i.e. formation of $PM_{2.5}$ resulted from the deposition of acid. Thus formed contaminants contribute to the acid rain which upset the ecosystem and environment. Vegetation, especially lichens, can be very sensitive to the SO_2 at relatively low concentrations.

Nitorgen oxide (NOx):
Forest fires are large sources of Nitrogen oxides as it represent the sum of various nitrogen gases found in air of which Nitric oxide (NO) and Nitrogen dioxide (NO_2) are the most dominant. It is mainly formed due to burning of fuel for industrial and commercial purpose as high temperature.

It causes sever respiratory problem, especially in the children. It irritates the lungs and low the immune system. It also causes the acidification and eutrophication harmful to health materials, cultural artifacts, vegetation and corps. Further, in presence of water it forms nitric acid and other toxic nitrates. It is also a main component to form ozone at the surface level.

Lead (Pb):
Lead (Pb) is released into the atmosphere by means of vehicular activities and industrial gases. It is directly inhaled by human during respiration; people living nearest to the highway are at high risk. At the same time deposition of lead on to the food stuffs is ingested by people. Reports have indicated that lead concentration of 1 $\mu g/m^3$ in ambient air results in an increase of about 1-2 μg per decilitre (μg/dl) in blood. Lead poisoning can cause destructive behavioural changes, learning disabilities and permanent brain damage. Children and pregnant women are at greatest risk. Blood levels of 50 – 60 μg/dl are associated with neurobehavioral changes in children.

5. Sound Pressure Level and its impacts

Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes the sensation of hearing through nerves. Sounds produced by all vibrating bodies are not audible. The frequency limits of audibility are from 20 HZ to 20,000 HZ. Sounds of frequencies less than 20 HZ are called infrasonics and greater than 20,0000 HZ are called ultrasonics. Since noise is also a sound, the terms noise and sound are used synonymously. However, the discrimination and differentiation between sound and noise also depends upon the habit and interest of the person/species receiving it, the ambient conditions and impact of the sound generated during that particular duration of time. Noise is defined as unwanted or objectionable sound. Human susceptibility to noise varies in terms of intensity, altitude, timbre of sound, personal sensibility, age, and history of ear disorder. Noise is associated with the air pollution and posses both the auditory and non auditory effect on the exposed population.

The sources of noise may vary according to daily activities. These sources may be domestic (movement of utensils, cutting and peeling of fruits/vegetables etc.) natural (shores, birds/animal shouts, wind movement, sea tide movement, water falls etc.), commercial (vendor shouts, automobiles, aeroplanes, marriages, laboratory, machinery etc.) or, industrial (generator sets, boilers, plant operations, trolley movement, transport vehicles, pumps, motors etc.).

The sound pressure levels covered in this study are as follows:

L_{max} & L_{min} (dBA):

When a source of sound passes by, and recedes to the distance, the sound level reaches a maximum and then fades into the background noise. During the motion of the sound source the maximum sound heard is denoted as Lmax where as the minimum level is denoted as Lmin. dBA is the unit of sound measured in decibel with A weightage.

Leq (dBA):

Leq is the continuous equivalent sound level, defined as the single SPL that, if constant over the stated measurement period, would contain the same sound energy as the actual monitored sound that is fluctuating in level over the measurement period. It is widely uased for most environmental noise assessments. In addition to its simplicity, it is easy to combine with other readings or predictions to derive a total noise level.

High noise levels may cause hearing loss, stress-related illnesses, disrupt sleep, and interrupt activities requiring concentration.

6. Air Quality Standards

Following is the World Health Organization (WHO) guidelines and Nepal Standard for ambient air quality currently being into used.

Contaminant Parameters	WHO Guideline Values 2005	Nepal Standard
PM_{10} (µg/m^3)	50 For 24 hours mean 20 For Annual mean	120 For 24 hours mean
TSP (µg/m^3)		230 For 24 hours mean
NO_2 (µg/m^3)	40 For Annual mean 200 For 1 hour mean	40 For Annual mean 80 For 1 hour mean

SO_2 (µg/m^3)	40 For annual mean 80 For 24 hour mean	20 For 24 hour mean 500 For 10 minutes mean
CO (µg/m^3)	*10,000 For 8 hours** *100,000 For 15 minutes**	10,000 For 8 hours 100,000 For 15 minutes
Lead (µg/m^3)	0.5 For annual	0.5 For annual

Table 17: Air Quality Standards

7. Site description

The sampling points were pre selected by the representatives of the Aquatic Ecology Centre, Kathmandu University.

Pashupati
The sampling was taken at a point inside the Pashupati Area Development Fund and inside the yard of Agnihotri Yagyashala surrounded by the Pashupatinath Temple, Kriyaputri Ghar and Bagmati River. It is nearly 200 meters outside from the ring road, the Gaushala Bust stop. Construction activities were under progress during the monitoring across the sampling area. Vegetation of the area is forest, across the Bagmati River. Vehicular movement was very high giving rise to the dust particles and sound pressure levels. Majority of the vehicles were Buses, Micro Buses, Motor Bikes, Mini Trucks and other vehicles. Due to the interrupted power supply, a generator was used to run monitoring instrument.

Gokarna
Along the Bagmati river, the sampling points were taken at the Barrage of the Bagmati river, near the Gorkarna temple. The high volume air sampler was placed nearly two meter below from the road side inside the yard of Ganesh Temple. The sound pressure level was measured much below, nearly five meters from the road side and at the Barrage. Vegetation of the area is chiefly the forest of Gorkarna reserved forest and mountains. It is also residential area and few number of carpet industries are also in operation across the location. Compared to the Pashupati area vehicular movement is little bit less. Majority of the vehicles are Buses, Micro Buses, Motor Bikes, Mini Trucks and other vehicles. Due to the interrupted power supply, a generator was used to run monitoring instrument.

Sundarijal
The site was located at the North side of the Kathmandu Valley, nearly six kilometers from the Gokarna site along the Bagmati River. The High volume sampler was placed at the Sundarijal Bus Park beside the yard of Sundarijal Hydroelectric Project. The Bagmati is flowing nearly 30 meters below and vegetation is the forest of Shivapuri Wildlife conservation area. Majority of sources of pollution are Mini Bus, Micro Bus and Motor Bikes. Compared to the above sampling locations, the vehicular movement was very less at the site.

Nagmati

This was isolated from the Kathmandu valley and located inside the Shivapuri Wildlife Conservation area, inside the forest. The sampling point was located 50 meters above the Sundarijal water reservoir nearby Karma Hotel and 3 Kilometers far from the Sampling point at Sundarijal. Vehicles mostly found are motor bikes and some mini trucks carrying gravels. Human settlement is not observed nearby the sampling location except some hotels.

Dhap

The sampling site was inside the deep forest and mountains; and 3 kilometers far from the Nagmati site. Vehicular movement is very less; mostly the motorbikes and mini trucks carrying gravels were observed during the monitoring. No human settlement was observed across the sampling points.

8. Methodologies

The sampling points were selected in discussion with Aquatic Ecological Centre and the consultant considering the factors such as air movement, impact position, and permanent reliability of monitoring location up to future monitoring event. Potential types of contaminants were considered as basic criteria for the selection of sampling point.

Following two monitoring instruments were used for the sampling and analysis as per the agreement:

High Volume Air Sampler for Air Quality Monitoring

High volume sampler named Repairable Dust Sampler Modeled No. APM 460 NL, was used in all five places for sampling of PM_{10}, SPM and Lead (Pb). For the sampling of SOx and NOx, Gaseous Sampling Attachment Envirotech APM 411 was used. The instruments were manufactured by Envirotech Instruments Pvt. Ltd., India

<u>Specifications of the instruments are as follows:</u>

Dust Sampler (APM 460 NL)

Flow Rate 0.9 – 1.4 m3 /min free flow

Particle Size Particles of 10 microns & below collec
Filter Paper holder.
SPM bigger than 10 microns collecte
separate sampling bottle under the cy

Sampling Time 28 hours (maximum)

Sampling Time Record 0 to 9999.99 hrs. recorded on a Totalizer.

Automatic Sampling 24 hrs programmable
to automatically shut off the s
after pre set time interval.

Power Requirement Nominal 220 V, Single Phase
AC mains supply.

Size & Weight 430 x 320 x 930mm., 45Kg

Figure 46 : High Volume Air Sampler

Gaseous Sampling Attachment Envirotech APM 411

Flow Rate	0.3 to 3 LPM, accuracy : 2% of span.
Flow Control	Four inlet and one outlet with built in needle valves for flow control of each unit.
Sampling Train	4 Nos. of 35ml Borosilicate glass impingers.
Size	240 x 125 x 350mm.

Figure 47: Gaseous Attachment

Particulate Matters (SPM and PM10), Heavy Metal (Lead) and Gases

For the determination of SPM, PM_{10}, and heavy metal (Pb), samplings were taken with pre-weighted fiber glass filter papers. After sampling the exposed filter papers, the cups were transported safely to the laboratory for the determination of PM_{10} and TSPM. The cups and papers were weighed after dessicating for 24 hours for determination of final weights. For determination of heavy metal (Pb), exposed glass fiber filter papers were digested in Nitric Acid and its concentration was determined by Atomic Absorption Spectrophotometer (AAS).

The sampling was carried out to see the one day cycle that requires running the sampler for 24 hours. However, the air sampler was shut off on the basis of final air suction flow rate so as to minimize the error in calculation. The total sampling time was determined by the rotameter record and average flow rate was measured through the flow meter attached in the air sampler. Calculation of total air volume in normal temperature and pressure was done with respect to average flow rate of air drawn in the run time.

Sulphur Dioxide (SO2) and Nitrogen Dioxide (NO2)

Sampling of SO_2 and NO_2 were done with the help of Indian made Envirotech Instruments, an attachment with the high volume sampler ATM 460 NL - Envirotech. SO_2 and NO_2 were absorbed simultaneously by the suction instrument through the attached gas bubbling impingers. Sodium Tetra-chloromercurate (TCM) solutions and Sodium Arsenite absorbing reagents were used for extracting SO_2 and NO_2 respectively. The collection tubes were kept chilled with ice water to prevent evaporation and to provide greater absorption. Samples were instantly stored and transported to the laboratory under cold condition in an ice box and kept at low temperature till analyses were done to determine the values of the parameters.

Preservation of the samples

The SPM, PM_{10} filters and cups were labeled and packed properly to prevent any loss during transport or storage prior to analysis in the laboratory. The absorbent solutions after the absorption of gas were preserved in polythene bottles maintained at 0 to 4^{o} C during transport and storage. After the sampling of the labeled glass fibre filter paper were kept in air tight boxes to prevent from the moisture and any sample losses during storage and transportation.

Analysis of the samples

Analysis of the different parameters of the air samples were carried out as follows:

SPM and PM10:

The filters, cups and thimbles were conditioned by desiccating for 24 hours in the laboratory, weighed and kept in appropriate labeled envelopes and in a carrying box for safe transport to the field and back. The used filters and cups were conditioned by desiccating for 24 hours and weighed. The levels of the TSP and PM_{10} in working environment were calculated from the weights of the samples with ratio of volume of sample air drawn.

Lead

Lead was estimated after dissolving the PM_{10} residue collected in the filter paper of the corresponding monitoring locations. The glass fiber filter paper for PM_{10} was extracted with a known volume (25ml) of dilute nitric acid (1:5). The content of this metal ion in the extract was determined by Atomic Absorption of Spectrophotometer (AAS).

Sound Pressure Level Meter for Noise Level Monitoring

Sound Pressure level Meter (Monarch 322) was used to measure the noise level for 24 hour on hourly interval, except in Dhap area. Considering the risk of wildlife assailment, fifteen hours data was collected. “A” weighting was used for the entire area, as it is suitable acoustic frequency for human ear response. The “Fast” response was followed equivalent to human ear response with a fraction of time of 0.125 seconds.

The noise data of 10 minutes were directly recorded in the instrument and downloaded to the computer for analysis. The maximum and minimum sound pressure levels were obtained by sorting the data in ascending order; whereas the equivalent sound level was determined by using appropriate formula prescribed by the instrument manual.

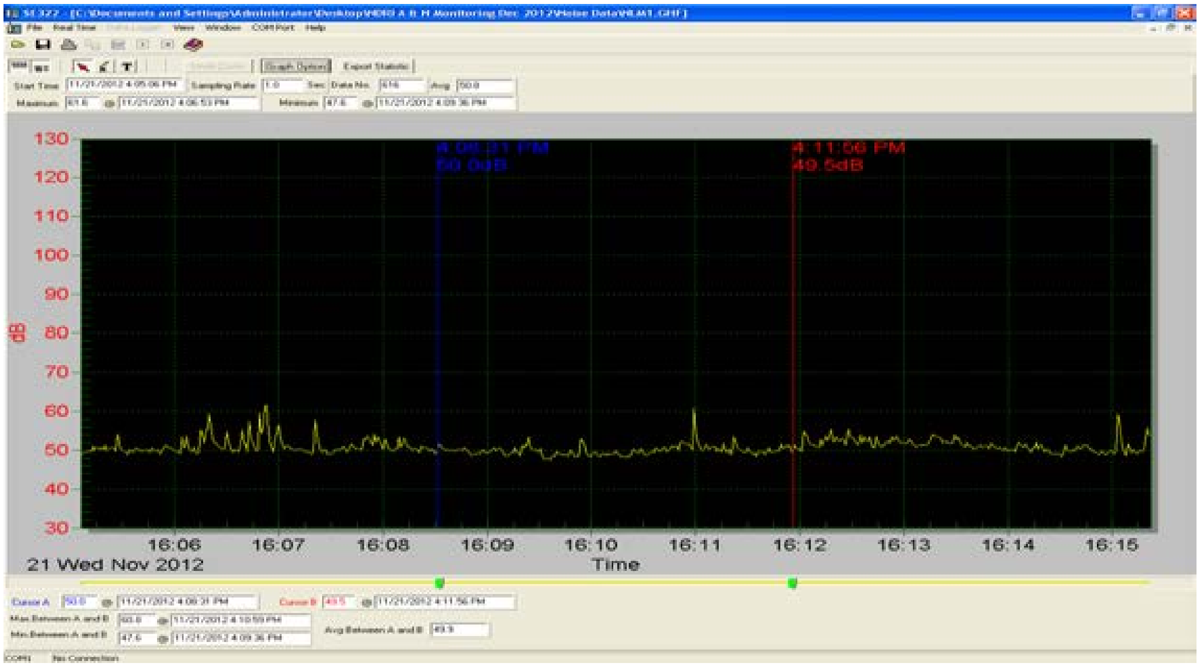


Figure 48: Data Logging of Sound Pressure Level Using Software SE322

Result & Discussion

Air Quality

The observed values were compared with the WHO and Nepal Standard for air quality, presented in the **Table 1**. It was found that the guideline value for the non-respirable particulate matter was not set in both WHO and Nepal Standards. At the same time, not all guideline values were given for one day monitoring cycle (24 hours) in the standard chart. Two parameters, for (respirable particulated matters) PM_{10}, and SO_2 are shown in 24 hour monitoring time while the other two parameters NO_2, and Pb are given in annual/hour, hour/minutes and annual respectively. Therefore, for PM_{10}, and SO_2, straight comparison between the observed values and the standard is possible. However, for parameters NO_2, and Pb logical comparison is necessary as straight calculation is irrelevant.

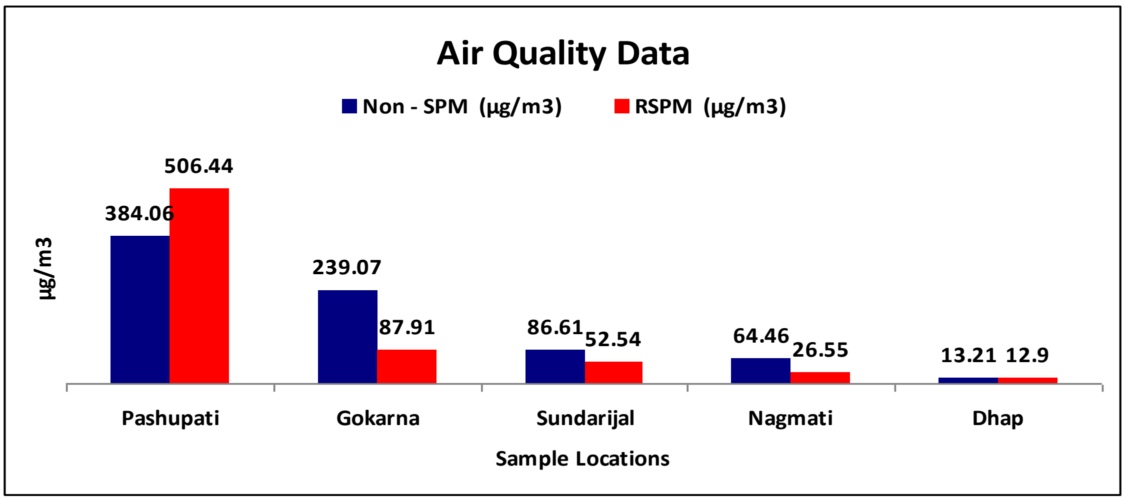
Air Quality Data

Locations	**Average Temperature ^{0}C**	**Non - RSPM (µg/m^3)**	**RSPM – PM_{10} (µg/m^3)**	**SO_X (µg/m^3)**	**NO_X (µg/m^3)**	**Lead (µg/m^3)**
Pashupati	22.6	384.06	506.44	<1.0	<1.0	<0.04
Gokarna	14	239.07	87.91	<1.0	<1.0	<0.04
Sundarijal	18	86.61	52.54	<1.0	<1.0	<0.04
Nagmati	12	64.46	26.55	<1.0	<1.0	<0.04
Dhap	8	13.21	12.9	<1.0	<1.0	<0.04

Table 18: Air Quality Data

Throughout the study area, SO_2, NO_2 and lead was not detected whereas the non-respirable particulate matters were detected significantly at the Pashupati and Gokarna site i.e. 384.06

μg/m^3 and 239.07 μg/m^3 respectively. Based on the guideline value, respirable particulate matter was found much above the standards i.e. 506.44 μg/m^3, whereas the WHO standard is 50 μg/m^3 and Nepal Standard is 120 μg/m^3 for 24 hour mean. Similarly, considering only the WHO standards, the respirable particulate matters at Gokarna and Sundarijal sites were also higher than the prescribed value. It was also remarkable that both the respirable and non-respirable particulate matters were found in decreasing order with respect to increasing altitude. It implies that these parameters were found highest at the Pashupati area while the lowest at the Dhap area. The minimum values detected were 13.2 μg/m^3 and 12.9 μg/m^3 for respirable and non-respirable particulate matter respectively. During the monitoring, it was observed that vehicular and anthropogenic activities were highest at Pashupati area but gradually decreased on moving higher. Upto Sundarijal area, the tracked vehicles were micro bus, trucks, motor bikes. Similarly, other sources of emissions were industries along the Bagmati river, roads under construction. But at the Nagmati and Dhap area these activities were much less as these sites were inside the Sivapuri Conservation Area and surrounded by the forest.



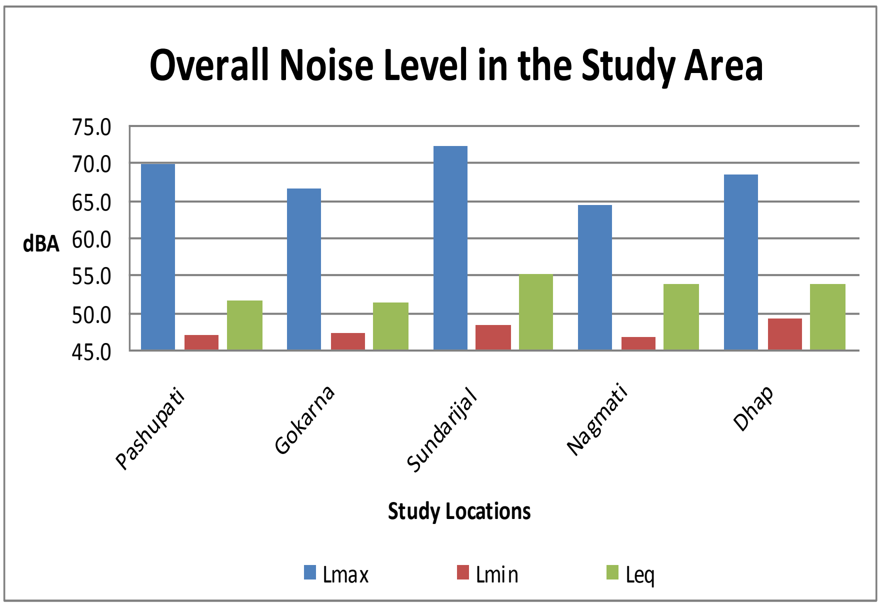
Graph 1: Concentrations of air pollutants in different locations

Sound Pressure Level

Location	Number of observations	Average Sound Pressure Level		
		Lmax	Lmin	Leq
Pashupati	**24**	69.7	46.9	51.5
Gokarna	**24**	66.6	47.1	51.3
Sundarijal	**24**	72.4	48.4	55.2
Nagmati	**24**	64.4	46.8	53.8
Dhap	**15**	68.5	49.0	53.7

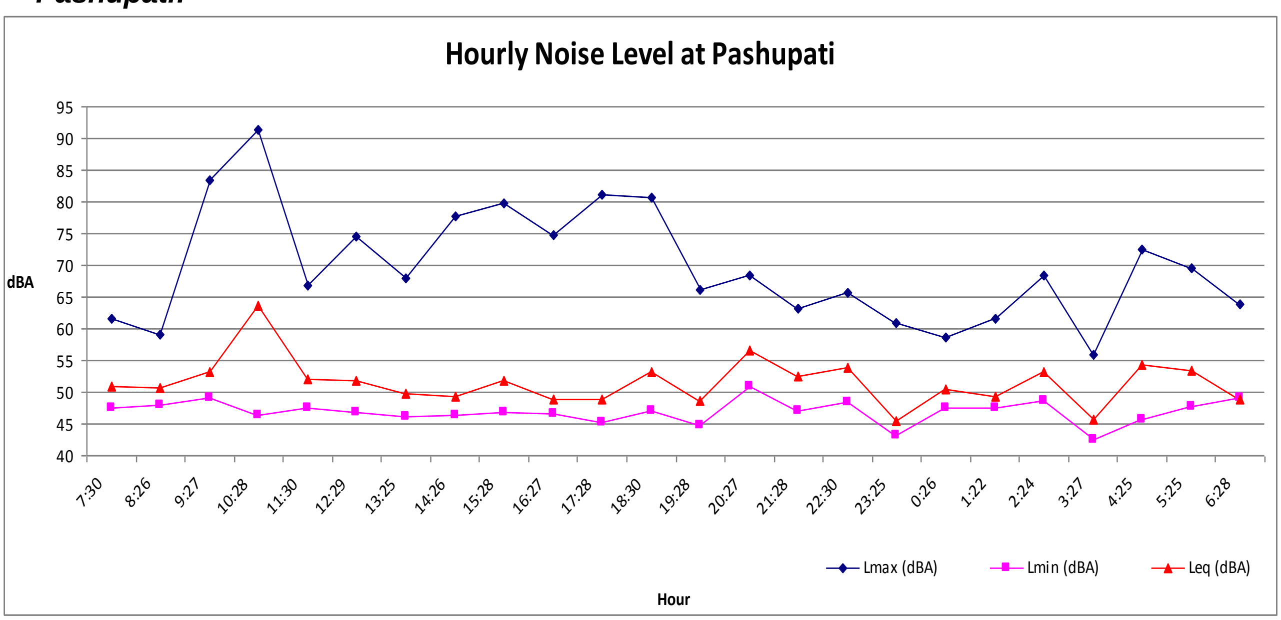
Table 19: Average Noise Level of the Sampling Points

The Average sound pressure level (day and night) of all the five selected points along with number of observations are presented in the Table 3. The maximum (Sundarijal Location) and minimum (Pashupati) noise level recorded are 72.4 dBA and 46.9 dBA respectively. The maximum sound level is attributed to the vehicular movement. Pashupati, Gokarna and Sundarijal sites have maximum vehicular and human movement compared to that of Nagmati and Dhap. As noise level for Nepal has not been set yet, compared to the WHO guideline values, (70 dBA) maximum sound pressure level at the Sundarijal area crossed the prescribed standard, while remaining are within the limits. Several times the noise level were found exceeding the standards on the hourly monitoring, the data of which are presented in **Annex - A**.



Graph 1: Overall Noise Level in the Study Area

Pashupati:

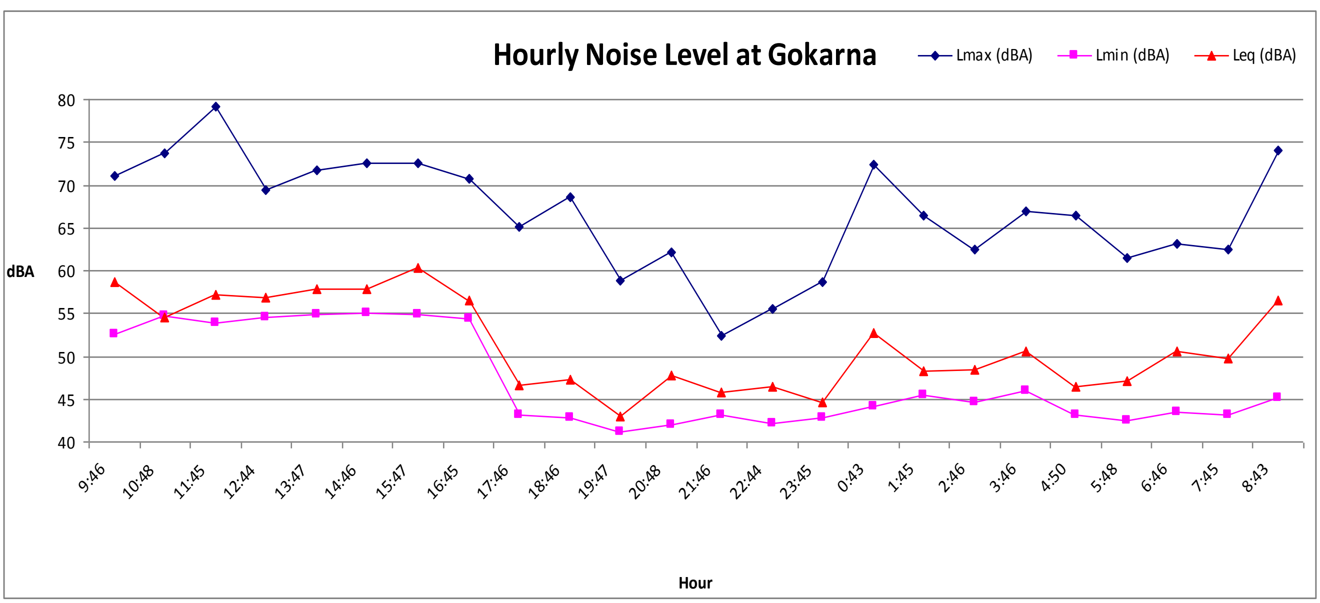


Graph 2: Hourly Noise Level at Pashupati

The graphical data represents the sound pressure level measured from 21 November, 2012, 07:30 to 22 November, 2012, 06:28 on hourly interval. The maximum and minimum sound pressure levels recorded in the site were 91.3 dBA and 42.4 dBA respectively. The equivalent noise level ranged between 45.5 dBA to 63.7 dBA throughout the monitoring period and minimum sound pressure level were found nearly same in most of the hour-recordings. These sound levels were mostly influenced by the noise from the vehicles and randomly produced pressure horns sounds, as the Gaushala Bus stop was located nearly 200 meters far from the sampling point. The higher sound levels were observed during the daytime particularly between 09:00 to 18:00, as the maximum vehicular activities were observed during this period. Similarly, sounds made by the animals around the points had also contributed to raise the sound pressure level.

Gokarna:

The presented data were recorded on 22-23 November, 2012 between 09:46 to 08:43 on hourly interval. The maximum and minimum noise levels recorded during the period were 79.1 dBA and 41.1 dBA respectively. At the same time the equivalent sound pressure level was found to be ranged between 43 dBA to 60.4 dBA. However, this sound level was found nearly same during day time particularly between 08 AM to 05 PM. At the same time the sound pressure level were found significantly decreased in the remaining time. This site was also highly influenced by the activities of vehicles, humans, various animals and sound made by the water current as well, as the sampling point was nearly 3 meter below from the road and at the barrage of Bagmati river.

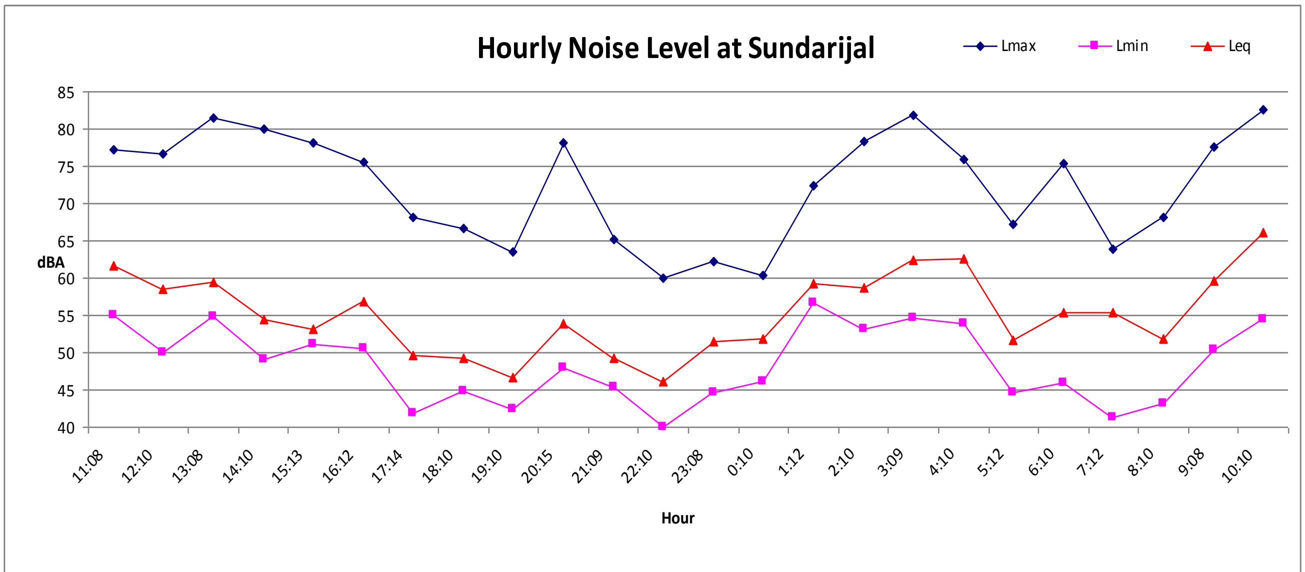


Graph 3: Hourly Noise Level at Gokarna

Sundarijal:

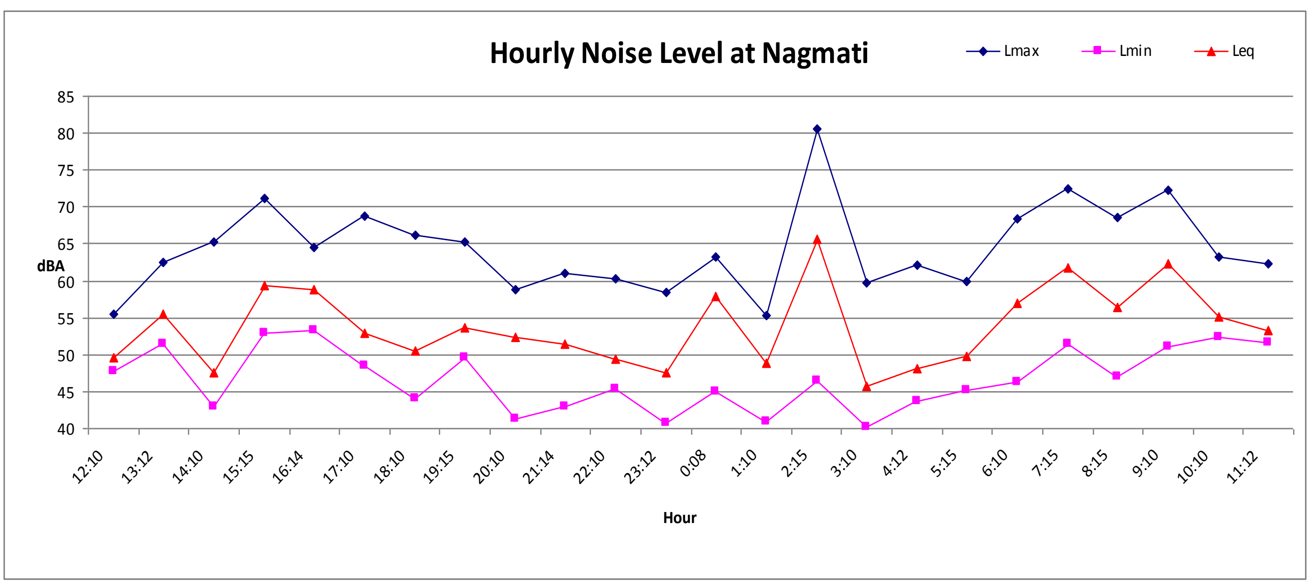
The noise level at this point was found highly fluctuating and highest maximum sound pressure level was also recorded at this point compared to other sites. The data were recorded in this sites on 23-24 November, 2012 between 11: 00 to 10:00 on hourly interval.

The maximum and minimum sound level observed in this sites were 82.5 dBA and 41.3 dBA respectively with equivalent sound level ranging between 46.2 dBA and 66.1 dBA. As the sampling point was at the Sundarijal Bus Park and the Bagmati River was flowing approximately 10 meter below form the road side the sound pressure levels were mostly influenced by the vehicular and human movement along with sound produced by the animals and birds.



Nagmati

Graph 4: Hourly Noise Level at Sundarijal

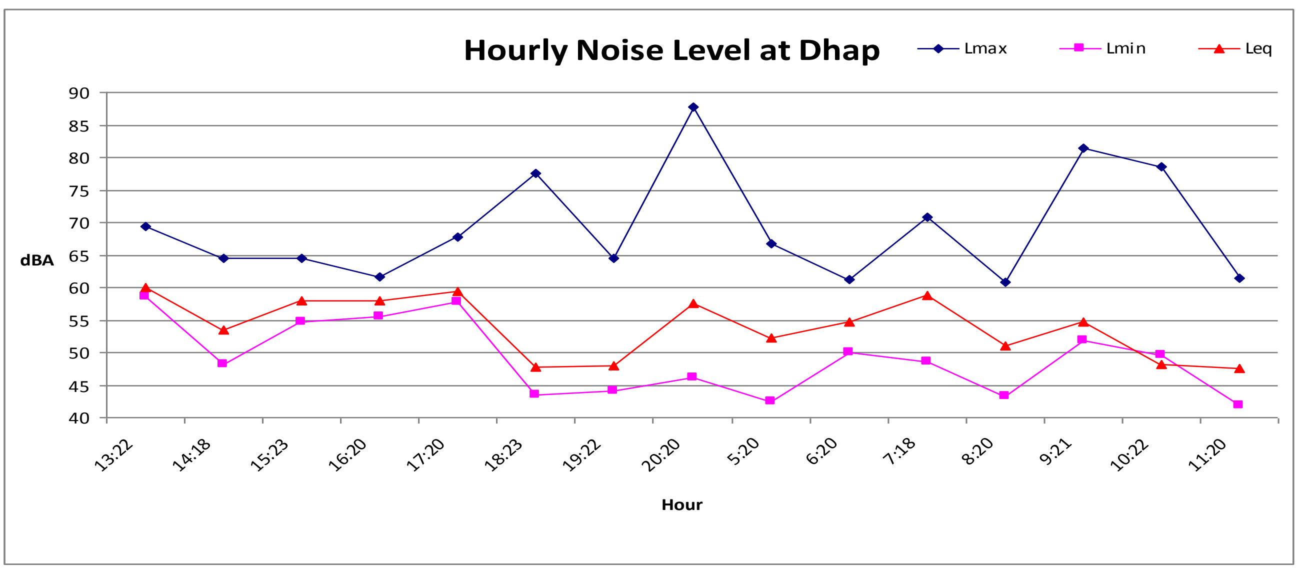


Graph 5: Hourly Noise Level at Nagmati

The graphical representation shows sound pressure level recorded on 24-25 November, 2012, on hourly basis. The maximum and minimum noise levels observed on the day were 80.6 dBA and 40.2 dBA respectively, followed by equivalent noise level ranging 45.7dBA to 65.7 dBA. The sampling point was located above the areas of Sundarijal water reservoir and forest of Shivapuri wild life conservation area. The observed sound pressure levels were mainly contributed by chirping of birds and blowing wind. The vehicular movements were very less compared to above three locations. Motorbike and mini truck carrying gravels were vehicles dominantly found in the area.

Dhap:

The 15 observations of sound pressure level were recorded on hourly interval is shown in the graph that follows. The samplings were taken starting from 13:22 until 20:20 on 25 November, 2012 and 05:20 to 11:20 on 26 November, 2012, considering the security of monitoring team. The place was highly isolated and inside the forest. It was nearly 3 km far from the Nagmati site on the North. The sound pressure level contributed on the site were mainly by the water current of Nagmati river, chirping sounds of birds and very rare vehicular movement i.e. motor bikes and mini trucks carrying gravel. The maximum and minimum noise levels on the sites were 87.7 dBA and 41.8 dBA respectively. Similarly, the equivalent sound pressure levels were found between 60 dBA and 59.4 dBA.



Graph 6: Hourly Noise Level at Dhap

Conclusion

Overall the monitored air quality parameters: respirable and non-respirable parameters including the Sox, NOx and Lead were found within the Nepal Standard at Sundarijal, Nagmati and Dhap area. But respirable particulate matter was found above both the Nepal and WHO Standards at Pashupati area whereas at the Gokarna and Sundarijal site, they were above

WHO Standards but within the Nepal Standards. Although the guideline values of non-respirable particulate matters are not set yet, their concentrations were significantly detected. These dust particles were mainly contributed by the vehicular movements and anthropogenic activities at the Pashupati, Gokarna and Sundarijal sampling sites, whereas in the case of Nagmati and Dhap, it was influenced by natural factors.

On the other hand, noise level was also not in adverse conditions. Regardless of the Lmax value on average of day and night along with hourly interval of all the sites, the sound pressure levels were found within the WHO Standards based on the Leq. The average Lmax, Lmin and Leq of the study area on average of day and night were 68.3 dBA, 47.6 dBA and 53.1 dBA respectively. At the Pashupati, Gokarna and Sundarijal site, the sound pressure was mainly contributed by the vehicular movement along with their pressure horn and some anthropogenic and animal activities. Beside these activities, noise level, due to the current of water was also found increasing at the Gokarna site, whereas at the Nagmati and Dhap, it was mainly natural and caused due to sound made by current of Nagmati river, chirping sound of birds and occasional movement of motor bikes and mini trucks.

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ANNEX A – Field Survey 1 [Vegetation]

Annex 1: General Information of sample plots

Q No	Date	Location	Altitude (m)	Latitude	Longitude	Aspects/slope	Dominant species	Number of trees	Forest Type
Initially proposed Bagmati Damsite									
1	2012.09.12	Sundarijal VDC - 6, Bagmati Damsite	1670	27 46 38	85 25 23	East facing 40	Quercus glauca	29	Oak-Rhododendron forest
2	2012.09.12	Sundarijal VDC - 6, Bagmati Damsite	1655	27 46 38	85 25 23	East facing 25	Quercus glauca Rhododendron arboreum	34	
3	2012.09.12	Sundarijal VDC - 6, Bagmati Damsite	1691	27 46 60	85 25 25	South East 5	Quercus glauca	25	
4	2012.09.12	Sundarijal VDC - 6, Bagmati Damsite	1654	27 46 51	85 25 28	South 10	Quercus glauca	30	
5	2012.09.12	Sundarijal VDC - 6, Bagmati Damsite	1640	27 46 50	85 25 26	South 10	Quercus glauca	18	
Nagmati Damsite									
1	2012.09.12	Sundarijal VDC - 6, Nagmati Damsite	1650	27 46 30	85 26 18	South East 20	Pinus roxburghii	30	Broad leaved forest
2	2012.09.13	Sundarijal VDC - 6, Nagmati Damsite	1933	27 47.281	85 26.913	South 30	Symplocos pyrifolia, Camellia kissi	27	
3	2012.09.13	Sundarijal VDC - 6,	1910	27 47.353	85 27.027	South 5	Symplocos pyrifolia	40	

Q No	Date	Location	Altitude (m)	Latitude	Longitude	Aspects/slope	Dominant species	Number of trees	Forest Type
		Nagmati Damsite							
4	2012.09.13	Sundarijal VDC - 6, Nagmati Damsite	1880	27 46.976	85 26.798	East 10	Rhododendron arboreum	15	
5	2012.09.13	Sundarijal VDC - 6, Nagmati Damsite	1875	27 46 965	85 26 783	South East 20	Rhododendron arboreum	18	
6	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1881	27 46 58.2	85 26 35.86	East facing 15	Rhododendron arboreum, Lyonia ovalifolia	25	
7	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1888	27 46 59.56	85 26 34.74	South East 20	Mixed	33	
8	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1929	27 47 28.5	85 26 59.1	East 20	Mixed	46	
9	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1915	27 47 22.5	85 26 85.3	South East 15	Camellia kissi	33	
10	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1940	27 47'607"	85 27'456"	East facing 15	Quercus lanata	21	
11	2012.09.14	Sundarijal VDC - 6, Nagmati Damsite	1960	27 47'45.1"	85 27'23.43"		Quercus lamellosa	23	
Dhap Damsite									
1	2012.09.16	Sundarijal VDC - 4, Dhap	2100	27 48'31.6"	85 27'26.6"	North 10	Lyonia ovalifolia	12	Temperate mixed

Q No	Date	Location	Altitude (m)	Latitude	Longitude	Aspects/slope	Dominant species	Number of trees	Forest Type
		damsite							broadleaved forest
2	2012.09.16	Sundarijal VDC - 4, Dhap damsite	2094	27 48'26.29"	85 27'24.43"	East 15	Symplocos sumuntia	20	
3	2012.09.16	Sundarijal VDC - 4, Dhap damsite	2093	27 48'22.76"	85 27'21.48"	West 15	Betula alnoides, Symplocos sumuntia	19	
4	2012.09.16	Sundarijal VDC - 4, Dhap damsite	2100	27 48'26.66"	85 27'23.5"	West 20	Symplocos sumuntia, Populus ciliata	10	
5	2012.09.16	Sundarijal VDC - 4, Dhap damsite	2108	27 48'38.2"	85 27'25.6"	North 5	Lyonia ovalifolia	14	
6	2012.09.16	Sundarijal VDC - 4, Dhap damsite (Upstream)	2094	27 48'33.73"	85 27'31.99"	East 15	Symplocos sumuntia	14	
7	2012.09.17	Nuwakot, Dhap Damsite	2103	27 48'31.7"	85 27'42.5"	South West 25	Symplocos sumuntia, Pyrus pashia	16	
8	2012.09.17	Nuwakot, Dhap Damsite	2096	27 48'37.04"	85 27'36.2"	East 30	Daphniphyllum himalense	10	
9	2012.09.17	Nuwakot, Dhap Damsite	2094	27 48'28.2"	85 27'31.33"	West Facing 20	Daphniphyllum himalense	19	
10	**2012.09.17**	**Nuwakot, Dhap Damsite**	**2096**	**27 48'31.1"**	**85 27'36.98"**	**West Facing 20**	**Daphniphyllum himalense**	**20**	

Annex 2: Plant site survey form for tree, shrubs and herbs

PLANT SITE SURVEY FORM (TREE)

Date: Q. No: Q. Size: Latitude: Longitude:

Altitude: VDC: Location: Aspect: Slope: Dominant sp:

S.N	Local/ Scientific Name	DBH (cm)	Height (m)	Crown diameter (m)	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

PLANT SITE SURVEY FORM (SHRUB)

Date: Q. No: Q. Size: Latitude: Longitude:
Altitude: VDC: Location: Aspect: Slope: Dominant sp:

S. N	Local/ Scientific Name	No. of clusters	No. of plants	Av. Height (m)	Coverage (%)	Remarks
1						
2						
3						
4						
5						

PLANT SITE SURVEY FORM (HERB)

Date: Q. No: Q. Size: Latitude: Longitude:
Altitude: VDC: Location: Aspect: Slope: Dominant sp:

S.N	Local/ Scientific Name	No. of plants	Ground cover (%)	Remarks
1				
2				
3				
4				
5				

Annex 3: List of plants recorded along the survey site

SN	Scientific name	Local/ Common name	English name	Family	Life form
1	*Albizia julibrissin var mollis*	Siris		Leguminosae	Tree
2	*Alnus nepalensis*	Uttis	Alder	Betulaceae	Tree
3	*Bauhinia variegata*	Koiralo	Mountain ebony	Leguminosae	Tree
4	*Betula alnoides*	Saur		Betulaceae	Tree
5	*Brassiopsis hainla*	Seto chuletro		Araceae	Tree
6	*Camellia kissi*	Hingua		Theaceae	Tree
7	*Castanopsis indica*	Katush	Nepal chest nut	Fagaceae	Tree
8	*Castanopsis tribuloides*	Musure katush		Fagaceae	Tree
9	*Choerospondias axillaris*	Lapsi	Nepalese hog plum	Anacardiaceae	Tree
10	*Cleyera japonica*	Bakal pate		Theaceae	Tree
11	*Daphniphyllum himalense*	Rachan		Daphniphyllacea e	Tree
12	*Ehretia macrophylla*	Chille	Heliotrope tree	Cordiaceae	Tree
13	*Engelhardia spicata*	Mahuwa		Juglandaceae	Tree
14	*Eriobotrya dubia*	Jure Kafal	Medlar	Rosaceae	Tree
15	*Eurya acuminata*	Jhingane		Theaceae	Tree
16	*Fraxinus floribunda*	Lankuri	Ash	Oleaceae	Tree
17	*Ilex dipyrena*	Seto khasru		Aquifoliaceae	Tree
18	*Juglans regia*	Okhar	Walnut	Juglandaceae	Tree
19	*Lindera pulcherrima*	Phusure		Lauraceae	Tree
20	*Lyonia ovalifolia*	Angeri	Lyonia	Ericaceae	Tree
21	*Myrica esculenta*	Kafal	Bay berry	Myricaceae	Tree
22	*Neolitsea pallens*			Lauraceae	Tree
23	*Persea odoratissima*	Kaulo	Machilus	Lauraceae	Tree
24	*Phyllanthus emblica*	Amala	Emblic myrobolan	Euphorbiaceae	Tree
25	*Pinus roxburghii*	Khote salla	Pine	Pinaceae	Tree
26	*Populus ciliata*	Lekh papal	Himalayan poplar	Salicaceae	Tree
27	*Prunus cerasoides*	Paiyun	Himalayan cherry	Rosaceae	Tree
28	*Pyrus pashia*	Mayal	Wild pear	Rosaceae	Tree
29	*Quercul glauca*	Falat/ Phalat	Oak	Fagaceae	Tree
30	*Quercus lamellosa*	Bajrat	Oak	Fagaceae	Tree
31	*Quercus lanata*	Banjh	Oak	Fagaceae	Tree
32	*Rhododendron*	Guras	Rhododendron	Ericaceae	Tree

SN	Scientific name	Local/ Common name	English name	Family	Life form
	arboretum				
33	*Rhus wallichii*	Bhalayo		Anacardiaceae	Tree
34	*Schima wallichii*	Chilaune	Needle wood	Theaceae	Tree
35	*Symplocos pyrifolia*	Kharane/Kholme		Symplocaceae	Tree
36	*Symplocos sumuntia*	Lodh	Lodh	Symplocaceae	Tree
37	*Taxus wallichiana*	Lauth salla	Himalayan Yew	Taxaceae	Tree
38	*Zizyphus incurva*	Hade bayar	Foothill jujube	Rhamnaceae	Tree
39	*Berberis aristata*	Chutro	Barberry	Berberidaceae	Shrub
40	*Berberis asiatica*	Chutro	Barberry	Berberidaceae	Shrub
41	*Berberis wallichiana*	Chutro	Barberry	Berberidaceae	Shrub
42	*Boehmeria platyphylla*	Gargalo	China grass	Urticaceae	Shrub
43	*Campylotropis speciosa*			Leguminosae	Shrub
44	*Daphne papyracea*	Lokta	Nepali paper plant	Thymeliaceae	Shrub
45	*Drepanostachyum falcatum*	Nigalo	Himalayan bamboo	Gramineae	Shrub
46	*Edgeworthia gardneri*	Argeli	Nepal paper bush	Thymeliaceae	Shrub
47	*Elaeagnus parvifolia*	Gunyelo	Oleaster	Elaeagnaceae	Shrub
48	*Gaultheria fragrantissima*	Dhasingre	Wintergreen	Ericaceae	Shrub
49	*Hypericum sp.*	Areli		Hypericaceae	Shrub
50	*Lonicera sp*	Masino kanike		Caprifoliaceae	Shrub
51	*Mahonia napaulensis*	Jamane manro		Berberidaceae	Shrub
52	*Melastoma normale*	Chulesi		Melastomataceae	Shrub
53	*Osbeckia nepalensis*	Chulesi		Melastomataceae	Shrub
54	*Phyllanthus parvifolius*	Khareto	Broom phyllanthus	Euphorbiaceae	Shrub
55	*Pyracantha crenulata*	Ghangaru	Fire thorn	Rosaceae	Shrub
56	*Rosa macrophylla*	Ban gulaf	Wild rose	Rosaceae	Shrub
57	*Rubia manjith*	Majitho	Madder	Rubiaceae	Shrub
58	*Rubus ellipticus*	Ainselu	Golden evergreen raspberry	Rosaceae	Shrub
59	*Rubus paniculatus*	Ban ainselu		Rosaceae	Shrub

SN	Scientific name	Local/ Common name	English name	Family	Life form
60	*Rubus pentagonous*	Ban ainselu		Rosaceae	Shrub
61	*Viburnum erubescens*	Titekath, Asare		Sambucaceae	Shrub
62	*Wikstroemia canescens*	Furke pat		Thymeliaceae	Shrub
63	*Aconogonum molle*	Thotne	Vegetable smart weed	Polygonaceae	Herb
64	*Acorus calamus*	Bojho	Sweet flag	Araceae	Herb
65	*Arisaema flavum*	Banku	Cobra plant	Araceae	Herb
66	*Artemisia vulgaris*	Titepati	Mug wort	Compositae	Herb
67	*Begonia picta*	Magar kache	Begonia	Begoniaceae	Herb
68	*Calanthe tricarinata*	Sungava	Orchids	Orchidaceae	Herb
69	*Cautleya spicata*	Pani saro		Zingiberaceae	Herb
70	*Centella asisatica*	Ghodtapre	Water pennywort	Umbelliferae	Herb
71	*Chirita urticaefolia*	Akhle ghas		Gesneriaceae	Herb
72	*Chlorophytum nepalense*			Liliaceae	Herb
73	*Colocasia fallax*	Ban karkalo	Coco yam	Araceae	Herb
74	*Cyperus rotundus*	Mothe		Cyperaceae	Herb
75	*Eupatorium adenophorum*	Banmara	Crofton weed	Compositae	Herb
76	*Fragaria nubicola*	Bhuin kafal	Wild strawberry	Rosaceae	Herb
77	*Hedychium spicatum*	Gai saro	Spiked ginger lily	Zingiberaceae	Herb
78	*Impatiens sp*			Balsamaceae	Herb
79	*Inula cappa*	Gai tihare	Golder samphire	Compositae	Herb
80	*Nepeta sp*	Kankarne		Labiateae	Herb
81	*Peperoemia tetraphylla*			Piperaceae	Herb
82	*Persicaria capitata*	Raktanyaule jhar		Polygonaceae	Herb
83	*Pilea glabrima*			Urticaceae	Herb
84	*Potentilla fulgens*	Bajradanti	Silver leaf	Rosaceae	Herb
85	*Roscoaea purpurea*	Bhuisaro		Zingiberaceae	herb
86	*Salvia sp.*			Labiateae	Herb
87	*Satyrium nepalense*	Sungava	Orchids	Orchidaceae	Herb
88	*Spiranthes sinensis*	Sungava	Orchids	Orchidaceae	herb
89	*Taraxacum sp*	Tuki phul	Common dandelion	Compositae	Herb
90	*Dendrophthoe falcata*	Ainjeru	Strap flower	Loranthaceae	Saprophyte

SN	Scientific name	Local/ Common name	English name	Family	Life form
91	*Coccinia grandis*	Gol kankri	Ivy gourd	Cucurbitaceae	Climber
92	*Hedera nepalensis*	Kathe lahero	Ivy climber	Araliaceae	Climber
93	*Raphidophora decursiva*			Araceae	Climber
94	*Smilax sp*	Kurur daino	Green briers	Liliaceae	Climber
95	*Coelogyne cristata*	Sungava	Orchids	Orchidaceae	Ephphytic herb
96	***Coelogyne ovalis***	**Sungava**	**Orchids**	**Orchidaceae**	**Ephphytic herb**

Annex 4: Population parameters along three survey sites

Bagmati

SN	Scientific name	Density	Relative Density	Frequency	Relative Frequency
1	*Quercus glauca*	385	54.23	100	16.67
2	*Rhododendron arboreum*	125	17.61	100	16.67
3	*Schima wallichii*	55	7.75	80	13.33
4	*Cleyera japonica*	40	5.63	60	10.00
5	*Castanopsis indica*	35	4.93	80	13.33
6	*Camellia kissi*	25	3.52	40	6.67
7	*Castanopsis tribuloides*	20	2.82	40	6.67
8	*Lyonia ovalifolia*	15	2.11	60	10.00
9	*Alnus nepalensis*	5	0.70	20	3.33
10	*Pyrus pashia*	5	0.70	20	3.33

Nagmati

SN	Scientific name	Density	Relative Density	Frequency	Relative Frequency
1	*Symplocos pyrifolia*	152.27	20.24	90.91	12.35
2	*Quercus glauca*	102.27	13.60	63.64	8.64
3	*Rhododendron arboreum*	90.91	12.08	72.73	9.88
4	*Pinus roxburghii*	84.09	11.18	18.18	2.47
5	*Lyonia ovalifolia*	70.45	9.37	54.55	7.41
6	*Camellia kissi*	56.82	7.55	63.64	8.64
7	*Cleyera japonica*	45.45	6.04	36.36	4.94
8	*Quercus lamellosa*	25.00	3.32	27.27	3.70
9	*Persea odoratissima*	22.73	3.02	36.36	4.94
10	*Pyrus pashia*	20.45	2.72	45.45	6.17
11	*Lindera pulcherrima*	15.91	2.11	36.36	4.94
12	*Fraxinus floribunda*	11.36	1.51	27.27	3.70

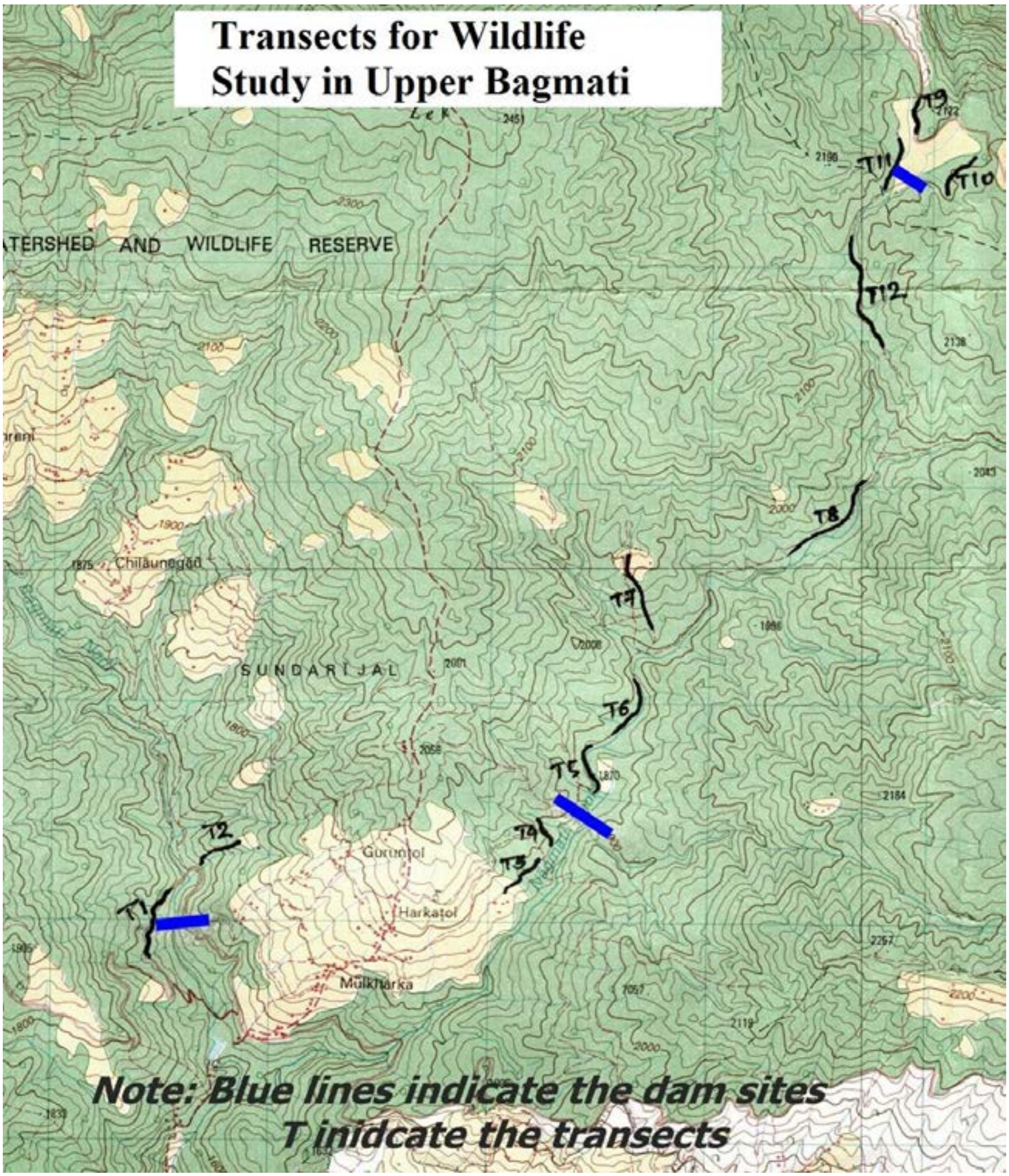
13	*Daphniphyllum himalanse*	11.36	1.51	18.18	2.47
14	*Eurya acuminata*	9.09	1.21	27.27	3.70
15	*Myrica esculenta*	9.09	1.21	27.27	3.70
16	*Daphniphyllum himalense*	4.55	0.60	18.18	2.47
17	*Schima wallichii*	4.55	0.60	18.18	2.47
18	*Quercus lanata*	4.55	0.60	9.09	1.23
19	*Albizia julibrissin* var. *mollis*	2.27	0.30	9.09	1.23
20	*Alnus nepalensis*	2.27	0.30	9.09	1.23
21	*Berberis asiatica*	2.27	0.30	9.09	1.23
22	*Ehretia macrophylla*	2.27	0.30	9.09	1.23
23	*Mahonia napaulensis*	2.27	0.30	9.09	1.23

Dhap

SN	**Scientific name**	**Density**	**Relative Density**	**Frequency**	**Relative Frequency**
1	*Symplocos sumuntia*	100	22.60	100	13.70
2	*Lyonia ovalifolia*	62.5	14.12	60	8.22
3	*Daphniphyllum himalense*	55	12.43	90	12.33
4	*Pyrus pashia*	45	10.17	100	13.70
5	*Camellia kissi*	42.5	9.60	70	9.59
6	*Betula alnoides*	42.5	9.60	50	6.85
7	*Quercus glauca*	22.5	5.08	50	6.85
8	*Rhododendron arboreum*	15	3.39	40	5.48
9	*Alnus nepalensis*	10	2.26	30	4.11
10	*Ilex dipyrena*	10	2.26	30	4.11
11	*Rhus wallichii*	10	2.26	30	4.11
12	*Berberis asiatica*	7.5	1.69	20	2.74
13	*Populus ciliata*	7.5	1.69	20	2.74
14	*Symplocos pyrifolia*	5	1.13	20	2.74
15	*Edgeworthia gardneri*	5	1.13	10	1.37
16	*Mahonia napaulensis*	2.5	0.56	10	1.37

ANNEX B: Field Survey 2 [Wildlife]

Annex 1: Topographic Map of the Study Area



Annex 2: Glimpses from the field

Annex 3: Transects Details and Wildlife Species Recorded along the Transects

Transects Details and Wildlife Species Recorded along the Transects

Transect No.: 1
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Mulkharka
Location: Bagmati Bridge, Downstream of proposed damsite at Bagmati
Starting Point (GPS Coordinates): Latitude $27^0$46.749" N, Longitude $85^0$25.618" E, Elevation: 1622m, GPS Accuracy:+/- 6m
Ending Point: (GPS Coordinates): Latitude $27^0$46.549" N, Longitude $85^0$25.502" E, Elevation: 1669m, GPS Accuracy:+/- 6m
Transect Length: 560 m

Transect No.: 2
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Mulkharka
Location: Bagmati Bridge, Upstream of proposed damsite at Bagmati
Starting Point (GPS Coordinates): Latitude $27^0$46.917" N, Longitude $85^0$25.611" E, Elevation: 1694m, GPS Accuracy:+/- 5m
Ending Point: (GPS Coordinates): Latitude $27^0$46.849" N, Longitude $85^0$25.601" E, Elevation: 1657m, GPS Accuracy:+/- 6m
Transect Length: 470 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Pellet	Transect trail in the forest	$27^0$46.861" N $85^0$25.626" E	1667 m	SE	86%	Querqus glauca, Rhododendron arboreum, Thea sp., etc.	20 m	Barking Deer	Fresh pellet recently casted

Transect No.: 3
Date: 2012-09-12
District: Kathmandu VDC: Sundarijal Village: Harkatol
Location: Downstream of proposed damsite at Nagmati
Starting Point (GPS Coordinates): Latitude $27^0$46.513" N, Longitude $85^0$26.361" E, Elevation: 1833m, GPS Accuracy:+/- 4m
Ending Point: (GPS Coordinates): Latitude $27^0$46.691" N, Longitude $85^0$26.512" E, Elevation: 1851m, GPS Accuracy:+/- 5m
Transect Length:700 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Scat	Rt. Bank of river, left	$27^0$46.586" N $85^0$26.461" E	1841 m	SE	Open	Pinus roxburghii, Rhododendron	100 m from Nagmati	Jungle Cat (????)	Relic disintegrated scat

		side of main road					arboreum, Myrica esculenta, etc.			
Transect No.: 4 Date: 2012-09-14 District: Kathmandu VDC: Sundarijal Village: Harkatol Location: Downstream of proposed damsite at Nagmati Starting Point (GPS Coordinates): Latitude 27^{0}46.694" N, Longitude 85^{0}26.530" E, Elevation: 1850m, GPS Accuracy:+/- 7m Ending Point: (GPS Coordinates): Latitude 27^{0}46.732" N, Longitude 85^{0}26.609" E, Elevation: 1857m, GPS Accuracy:+/- 5m Transect Length: 358 m										
S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Scat	Rt. Bank of river, transect trail	27^{0}46.696" N 85^{0}26.561" E	1861 m	E	17%	Pinus roxburghii, Rhododendron arboreum, Myrica esculenta, etc.	30 m	Unidentified	With grass and insect carapaces
2	Scat	Rt. Bank of river, transect trail	27^{0}46.696" N 85^{0}26.561" E	1856 m	E	4%	Pinus roxburghii, Pyrus pashia, Quercus galauca, Gultheria fragrantisima, Phyllanthus niruri, etc.	20 m	Leopard Cat	
Transect No.: 5 Date: 2012-09-14 District: Kathmandu VDC: Sundarijal Village: Harkatol Location: Downstream of proposed damsite at Nagmati Starting Point (GPS Coordinates): Latitude 27^{0}46.874" N, Longitude 85^{0}26.622" E, Elevation: 1891m, GPS Accuracy:+/- 6m Ending Point: (GPS Coordinates): Latitude 27^{0}46.958" N, Longitude 85^{0}26.777" E, Elevation: 1866m, GPS Accuracy:+/- 5m Transect Length: 450 m										
Transect No.: 6 Date: 2012-09-14 District: Kathmandu VDC: Sundarijal Village: Sano Dhap										

Location: Upstream of proposed damsite at Nagmati (Inundation Area)
Starting Point (GPS Coordinates): Latitude 27^{0}47.291‟ N, Longitude 85^{0}26.869‟ E, Elevation: 1904m, GPS Accuracy:+/- 6m
Ending Point: (GPS Coordinates): Latitude 27^{0}47.384‟ N, Longitude 85^{0}26.863‟ E, Elevation: 1955m, GPS Accuracy:+/- 8m
Transect Length: 650 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Scat	Rt. Bank of river, transect trail	27^{0}47.373‟ N 85^{0}26.824‟ E	1921 m	E	28%	Rhododendron arboreum, Quercus sps, Thea sps, Mahonia nepalensis, Myrica esculenta, etc.	20 m	Leopard Cat	With grass and insect carapaces

Transect No.: 7
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Sano Dhap Area
Location: Upstream of proposed damsite at Nagmati (Inundation Area)
Starting Point (GPS Coordinates): Latitude 27^{0}47.400‟ N, Longitude 85^{0}27.085‟ E, Elevation: 1905m, GPS Accuracy:+/- 6m
Ending Point: (GPS Coordinates): Latitude 27^{0}47.569‟ N, Longitude 85^{0}27.388‟ E, Elevation: 1935m, GPS Accuracy:+/- 7m
Transect Length: 480 m

Transect No.: 8
Date: 2012-09-15
District: Kathmandu VDC: Sundarijal Village: Sano Dhap Area
Location: Upstream of proposed damsite at Nagmati, right bank (Inundation Area)
Starting Point (GPS Coordinates): Latitude 27^{0}47.682‟ N, Longitude 85^{0}27.487‟ E, Elevation: 1935m, GPS Accuracy:+/- 7m
Ending Point: (GPS Coordinates): Latitude 27^{0}47.569‟ N, Longitude 85^{0}27.388‟ E, Elevation: 1935m, GPS Accuracy:+/- 7m
Transect Length: 620 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Scent	Transect trail, right bank of Nagm	27^{0}47.801‟ N 85^{0}27.561‟ E	1977 m	Ridge, S	85%	Pyrus pashia, Thea sps, Myrica esculenta, etc.	50 m	Large Civet	

		ati								

Transect No.: 9
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Chisapani, Dhap
Location: Upstream of proposed damsite at Dhap, right bank
Starting Point (GPS Coordinates): Latitude 27^{0}48.633" N, Longitude 85^{0}27.635" E, Elevation: 2080m, GPS Accuracy:+/- 5m
Ending Point: (GPS Coordinates): Latitude 27^{0}48.623" N, Longitude 85^{0}27.762" E, Elevation: 2087m, GPS Accuracy:+/- 5m
Transect Length: 418 m

S N.	Sign Type	Locati on	GPS Coordin ates	Elevat ion	Asp ect	Cro wn Cov er	Dominant Tree Species	Dista nce from Water	Remark s	Addition al Comme nts
1	Scat	Trans ect trail, right side of the road	27^{0}48.6 00" N 85^{0}27.6 35" E	2088 m	N	1%	Lyonia ovalifolia, Pyrus pashia, Euria acuminata , Berberis aristata, Daphniph yllum sps etc.	25 m	Unidenti fied Civet?? ?	
2	Diggi ng	Trans ect trail, left side of the road	27^{0}48.5 87" N 85^{0}27.7 24" E	2085 m	S	47%	Lyonia ovalifolia, Pyrus pashia, Euria acuminata , Berberis aristata, Daphniph yllum sps etc.	35 m	Wild boar	
3	Diggi ng	Trans ect trail, left side of the road	27^{0}48.6 23" N 85^{0}27.7 62" E	2087 m	S	48%	Lyonia ovalifolia, Pyrus pashia, Euria acuminata , Berberis aristata, Daphniph yllum sps etc.	35 m	Wild boar	Numero us

Transect No.: 10
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Chisapani, Dhap

Location: Upstream of proposed damsite at Dhap, right bank
Starting Point (GPS Coordinates): Latitude $27^0$48.532" N, Longitude $85^0$27.771" E, Elevation: 2084m, GPS Accuracy:+/- 4m
Ending Point: (GPS Coordinates): Latitude $27^0$48.459" N, Longitude $85^0$27.729" E, Elevation: 2089m, GPS Accuracy:+/- 5m
Transect Length: 529 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Digging	Transect trail, left of Dhap	$27^0$48.532" N $85^0$27.771" E	2084 m	N	81%	Lyonia ovalifolia, Pyrus pashia, Daphniphyllum sps etc.	1 m	Wild Boar	Digging present all along the transect
2	Scent	Transact trail, left side of Dhap	$27^0$48.459" N $85^0$27.729" E	2089 m	NW	73%	Lyonia ovalifolia, Pyrus pashia, Berberis aristata, Daphniphyllum sps etc.	5 m	Large Civet	

Transect No.: 11
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Chisapani, Dhap
Location: Upstream of proposed damsite at Dhap, right bank, Inundation Area
Starting Point (GPS Coordinates): Latitude $27^0$48.475" N, Longitude $85^0$27.579" E, Elevation: 2084m, GPS Accuracy:+/- 5m
Ending Point: (GPS Coordinates): Latitude $27^0$48.243" N, Longitude $85^0$27.491" E, Elevation: 2069m, GPS Accuracy:+/- 5m
Transect Length: 720 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Pellets	On trail	Few meters around starting point	2084 m	SE	25%	Lyonia ovalifolia, Pyrus pashia, Berberis aristata, Daphniphyllum sps etc.	5 m	Barking Deer	
2	Pug Mark	On trail	Few meters	2084 m	SE	25%	Lyonia ovalifolia,	5 m	Yellow-throated	Later live

	with Claw Scratch		around starting point				Pyrus pashia, Berberis aristata, Daphniphyllum sps etc.		Marten	animal sighted in the territory
3	Scat	On trail	27^{0}48.246‟ N 85^{0}27.464‟ E	2062 m	Plain	2%	Alnus nepalensis, Rhododendron arboreum, Lyonia ovalifolia, Berberis aristata, etc.	< 1 m	Leopard Cat	

Transect No.: 12
Date: 2012-09-14
District: Kathmandu VDC: Sundarijal Village: Chisapani, Dhap
Location: Downstream of proposed damsite at Dhap, Left bank
Starting Point (GPS Coordinates): Latitude 27^{0}48.193‟ N, Longitude 85^{0}27.487‟ E, Elevation: 2084m, GPS Accuracy:+/- 5m
Ending Point: (GPS Coordinates): Latitude 27^{0}47.975‟ N, Longitude 85^{0}27.595‟ E, Elevation: 2069m, GPS Accuracy:+/- 5m
Transect Length: 560 m

S N.	Sign Type	Location	GPS Coordinates	Elevation	Aspect	Crown Cover	Dominant Tree Species	Distance from Water	Remarks	Additional Comments
1	Digging	On trail	27^{0}48.193‟ N 85^{0}27.487‟ E	2077 m	SE	56%	Alnus nepalensis, Lyonia ovalifolia.	10 m	Wild boar	

Annex 4: Wildlife details of the area

SN	Common/Scientific Names	Order	Family	Identification
1	Orange-bellied Himalayan Squirrel (*Dremomys lokriah*)	Rodentia	Scuridae	V
2	Rhesus Macaque (*Macaca mulata*)	Primates	Cercopithecidae	V
3	Barking Deer (*Munitacus muntjak*)	Artiodactyla	Cervidae	P, V
4	Large Hare (*Lepus nigricollis*)	Lagomorpha	Laporidae	V
5	Yellow-throated Marten (*Martes flavigula*)	Carnivora	Mustelidae	F, V
6	Leopard Cat (*Prionailurus bengalensis*)	Carnivora	Felidae	S
7	Jungle Cat (*Felis chaus*)	Carnivora	Felidae	S
8	Common Leopard (*Panthera pardus*)	Carnivora	Felidae	S
9	Large Civet (*Viverra zibetha*)	Carnivora	Viverridae	Sc
10	Masked Palm Civet (*Paguma larvata*)	Carnivora	Viverridae	
11	Crab Eating Mongoose	Carnivora	Herpestidae	
12	Wild Boar (*Sus scrofa*)	Artiodactyla	Suidae	D
13	Great Roundleaf bat (*Hipposideros armiger*)	Chiroptera	Hipposideridae	
14	Greater False Vampire Bat (*Megaderma lyra*)	Chiroptera	Megadermatidae	
15	LittleTube–Nosed Bat (*Murina aurata*)	Chiroptera	Vespertilionidae	
16	Common bent wing bat (*Miniopterus schreibersii*)	Chiroptera	Vespertilionidae	
17	Intermediate horse shoe bat (*Rhinolophus affinis*)	Chiroptera	Rhinolophidae	
18	Greater horse-shoe bat (*Rhinolophus ferrumequinum*)	Chiroptera	Rhinolophidae	
19	Big-eared Horseshoe Bat (*Rhinolophus macrotis*)	Chiroptera	Rhinolophidae	
20	Least Horseshoe Bat (*Rhinolophus pusillus*)	Chiroptera	Rhinolophidae	

ANNEX C: Field Survey 3 [Avifauna]

Annex 1: Bird List from Shivapuri – Nagarjuna National Park taken from secondary source and found in different transects

Order	Family	English name	Scientific Name	Status	Survey Obs.	1st Tran.	2nd Tran.	3rd Tran.	4rth Tran.	5th Tran.	6th Tran.	7th Tran.	8th Tran.	9th Tran.	10th Tran.	11th Tran.	12th Tran.
BARBETS	Megalaimidae	Blue Throated Barbet	*Megalaima asiatica*	r2	√	√	√							√			
		Golden Throated Barbet	*Megalaima franklinii*	r3	√									√			
		Great Barbet	*Megalaima virens*	r?4	√									√			
BEE EATERS	Meropidae	Blue-bearded Bee-eater	*Nyctornis athertoni*	s5													
		Chestnut-headed Bee-eater	*Merops leschenaulti*	s3													
BROADBILL	Eurylaimidae	Long-tailed Broadbill	*Psarisomus dalhousiae*	r5													
BULBULS	Pycnonotidae	Black Bulbul	*Hypsipetes leucocephalus*	r1	√	√		√									
		Black-crested Bulbul	*Pycnonotus melanicterus*	r4													
		Himalayan Bulbul	*Pycnonotus leucogenys*	r2	√			√						√			
		Mountain Bulbul	*Hypsipetes mcclellandii*	r2	√								√				
		Red-vented Bulbul	*Pycnonotus cafer*	r1	√												√
		Striated Bulbul	*Pycnonotus striatus*	r4													
BUTTONQUIL	Turnicidae	Barred Buttonquail	*Turnix suscitator*	r3													
CUCKOOS	Cuculidae	Asian Koel	*Eudynamys scolopacea*	r3													
		Banded Bay Cuckoo	*Cacomantis sonneratii*	s5													
		Chestnut-winged Cuckoo	*Clamator coromandus*	s5													

		Common Hawk Cuckoo	*Hierococcyx varius*	s5													
		Drongo Cuckoo	*Surniculus lugubris*	s5													
		Eurasian Cuckoo	*Cuculus canorus*	s2													
		Green-billed Malkoha	*Phaenicophaeus tristis*	r3													
		Grey-bellied Cuckoo	*Cacomantis passerinus*	s4													
		Indian Cuckoo	*Cuculus micropterus*	s3													
		Large Hawk Cuckoo	*Hierococcyx spaverioides*	s2													
		Lesser Cuckoo	*Cuculus poliocephalus*	s2													
		Oriental Cuckoo	*Cuculus saturatus*	s2													
		Pied Cuckoo	*Clamator jacobinus*	s5													
		Plaintive Cuckoo	*Cacomantis merulinus*	s5													
DIPPER	Cinclidae	Brown Dipper	*Cinclus pallasii*	r4	√	√											
EGRET AND HERON	Ardeidae	Cattle Egret	*Bubulcus ibis*	r1													
		Indian Pond Heron	*Ardeola grayii*	r1													
FALCONS	Falconidae	Amur Falcon	*Falco amurensis*	m4													
		Common Kestrel	*Falco tinnunculus*	r3	√		√										
		Eurasian Hobby	*Falco subbuteo*	s4													
		Lesser Kestrel	*Falco naumanni*	m5	√		√										
		Common Kestrel	*Falco tinnunculus*														
		Oriental Hobby	*Falco severus*	s5													
		Peregrine Falcon	*Falco peregrinus*	r4													

		Saker Falcon	*Falso cherrug*	w5*													
FLOWERPECKERS AND SUNBIRDS	Nectariniidae	Black-throated Sunbird	*Aethopyga saturata*	r2													
		Crimson Sunbird	*Aethopyga siparaja*	r3													
		Fire-breasted Flowerpecker	*Dicaeum ignipectus*	r1													
		Fire-tailed Sunbird	*Aethopygaignicauda*	r3													
		Green-tailed Sunbird	*Aethopyga nipalensis*	r1													
		Mrs Gould's Sunbird	*Aethopyga gouldiae*	r4													
		Purple Sunbird	*Nectarinia asiatica*	r2													
		Thick-bellied Flowerpecker	*Dicaeum agile*	s4													
		Yellow-bellied Flowerpecker	*Dicaeum melanoxanthum*	r4													
FRANCOLIN, PHEASANT AND PARTRIDGES	Phasianidae	Black Francolin	*Francolinus francolinus*	r4													
		Chukar	*Alectoris chukar*	r?4													
		Hill Partridge	*Arborophila torqueola*	r1	√												
		Kalij Pheasant	*Lophura leucomelanos*	r1													
GOLDCREST	Regulidae	Goldcrest	*Regulus regulas*	w3													
HOOPOE	Upupidae	Common Hoopoe	*Upupa epops*	m3	√				√							√	

KINGFISHERS	Alcedinidae	Common Kingfisher	*Alcedo atthis*	r2													
	Dacelonidae	White-throated Kingfisher	*Halcyon smyrnensis*	r2													
KITES, EAGLES AND VULTURES	Accipitridae	Besra	*Accipter virgatus*	r4													
		Black Eagle	*Ictinaetus malayensis*	r3	√												
		Black Kite	*Milvus migrans*	r2	√	√											
		Bonelli's Eagle	*Hieraaetus pennatus*	w3													
		Booted Eagle	*Hieraaetus pennatus*	w3													
		Cinereous Vulture	*Aegypius monachus*	w4													
		Common Buzzard	*Buteo buteo*	w3													
		Crested Serpentine Eagle	*Spilornis cheela*	r2	√												
		Egyptian Vulture	*Neophron percnopterus*	r4													
		Eurasian Griffon	*Gyps fulvus*	m5													
		Eurasian Sparrowhawk	*Accipter nisus*	w3													
		Golden Eagle	*Aquila chrysaetos*	V													
		Greater Spotted Eagle	*Aquila clanga*	w4*													
		Hen harrier	*Circus cyaneus*	w4													
		Himalayan Griffon	*Gyps himalayensis*	w3													
		Lammergeier	*Gypaetus barbatus*	V													
		Long-legged Buzzard	*Buteo rufinus*	w4													

		Montagu's Harrier	*Circus pygargus*	m5													
		Mountain Hawk eagle	*Spizaetus nipalensis*	r3													
		Northern Goshawk	*Accipiter gentilis*	w4													
		Shikra	*Accipter badius*	r3	√			√									
		Steppe Eagle	*Aquila nipalensis*	w2													
		Upland Buzzard	*Buteo hemilasius*	w4													
		White-rumped Vulture	*Gyps bengalensis*	r5*													
LEAFBIRD	Irenidae	Orange-bellied Leafbird	*Chloropsis hardwickii*	r2													
MAGPIE, STREEPIE AND CROWS	Corvidae	Ashy Drongo	*Dicrurus leucophaeus*	r3													
		Asian Paradise Flycatcher	*Terpsiphone paradisi*	s4													
		Bar-winged Flycatcher-shrike	*Hemipus picatus*	r3													
		Black Drongo	*Dicrurus macrocercus*	r1	√	√											
		Black-headed Jay	*Garrulus lanceolatus*	r4													
		Black-winged Cuckooshrike	*Coracina melaschistos*	r3													
		Bronzed Drongo	*Dicrurus aeneus*	r3													
		Eurasian Golden Oriole	*Oriolus oriolus*	s3													
		Eurasian Jay	*Garrulus glandarius*	r3													

		Eurasian Blackbird	*Turduus merula*	A	√												
		Grey Treepie	*Dendrocitta formosae*	r1	√			√	√		√		√				
		Grey-chinned Minivet	*Pericrocotus solaris*	r4													
		House Crow	*Corvus splendis*	r1	√												
		Large -billed Crow	*Corvus macrorhynchos*	r1	√												
		Large Cuckooshrike	*Coracina macei*	r2													
		Lesser Racket-tailed Drongo	*Dicrurus remifer*	r3													
		Long-tailed Minivet	*Pericrocotus ethologus*	r2													
		Scarlet Minivet	*Pericrocotus flammeus*	r1	√												
		Short-billed Minivet	*Pericrocotus brevirostris*	r4													
		Maroon Oriole	*Oriolus traillii*	r2													
		Red-billed Blue Magpie	*Urocissa erythrorhyncha*	r1	√												
		Rufous Treepie	*Dendrocitta vagabunda*	r3	√												
		Spangled Drongo	*Dicrurus hottentottus*	r4													
		Spotted Nutcracker	*Nucifraga caryocatactes*	r5													
		White-throated Fantail	*Rhipidura albicollis*	r3													
		Yellow-bellied Fantail	*Rhipidura hypoxantha*	r2													
		Yellow-billed Blue Magpie	*Urocissa flavirostris*	r5	√									√		√	

MARTINS AND SWALLOWS	Hirundinidae	Barn Swallow	*Hirundo rustica*	r3	√	√											
		Eurasian Crag Martin	*Hirindo rupestris*	w4													
		Nepal House Martin	*Delichon nipalensis*	w4													
		Northern House Martin	*Delichon urbica*	w3													
		Plain Martin	*Riparia paludicola*	r2													
		Red-rumped Swallow	*Hirundo daurica*	r3													
		Sand Martin	*Riparia riparia*	A	√												
MYNAS	Sturnidae	Common Myna	*Acridotheres tristis*	r1	√												
		Jungle Myna	*Acridotheres fuscus*	r2													
NEEDLETAILS AND SWIFTS	Apodidae	Alpine Swift	*Tachymarptis melba*	w3													
		Fork-tailed Swift	*Apus pacifus*	r1													
		Himalayan Swiftlet	*Collocalia brevirostris*	w3	√									√			
		House Swift	*Apus affinis*	r1													
		White-throated Needletail	*Hirundapus caudacutus*	w4													
NIGHTJARS	Caprimulgidae	Grey Nightjar	*Caprimulgus indicus*	r4													
		Large-tailed Nightjar	*Caprimulgus macrurus*	w4													
NUTHATCHES	Sittidae	Chestnut-bellied Nuthatch	*Sitta castanea*	r2									√				
		Velvet-fronted Nuthatch	*Sitta frontalis*	r2													
		Wallcreeper	*Tichodroma*	w4													

			muraria														
		White-tailed Nuthatch	*Sitta himalayensis*	r1	√				√	√				√			
OWLS	Strigidae	Asian Barred Owlet	*Glaucidium cuculoides*	r2													
		Brown Wood Owl	*Strix leptogrammica*	r3													
		Collared Owlet	*Glaucidium brodiei*	r2													
		Eurasian Eagle Owl	*Bubo bubo*	r4													
		Mountain Scoops Owl	*Otus sunia*	r3													
		Spot-bellied Eagle Owl	*Bubo nepalensis*	r5													
		Spotted Owlet	*Athene brama*	r2													
PARAKEETS	Psittacidae	Rose-ringed Parakeet	*Psittacula krameri*	r4													
		Slaty-headed Parakeet	*Psittacula himalayana*	r5													
PIGEONS AND DOVES	Columbidae	Ashy Wood Pigeon	*Columba pulchricollis*	r3													
		Barred Cuckoo Dove	*Macropygia unchall*	r4													
		Eurasian Collared Dove	*Streptopelia decaocta*	r3													
		Oriental Turtle Dove	*Streptopilia orientalis*	r3	√			√						√			
		Rock Pigeon	*Columba livia*	r2	√												
		Speckled Wood Pigeon	*Columba hodgsonii*	r3													
		Spotted Dove	*Streptopelia chinensis*	r2	√	√											
		Wedge-tailed Green	*Treron sphenura*	r3	√									√			

		Pigeon															
PRINIA AND WHITE EYE	Cisticolidae	Striated Prinia	*Prinia criniger*	r2													
	Zosteropidae	Oriental White-eye	*Zosterops palpebrosus*	r2	√												
ROSEFINCHES AND BUNTINGS	Fringillidae	Brown Bullfinch	*Pyrrhula nipalensis*	r3													
		Common Rosefinch	*Carpodacus erythrinus*	w3													
		Crested Bunting	*Melophus lathami*	r3													
		Crimson -browed Finch	*Pinicola subhimachalus*	w4													
		Dark-breasted Rosefinch	*Carpodacus nipalensis*	w3													
		Gold-naped Finch	*Pyrrhoplectes epauletta*	w4													
		Little Bunting	*Emberiza pusilla*	w4													
		Pink-browed Rosefinch	*Carpodacus rodochrous*	w4													
		Plain Mountain Finch	*Leucosticte nemoricola*	w4													
		Red-headed Bullfinch	*Pyrrhula erythrocephala*	r4													
		Scarlet Finch	*Haematospiza sipahi*	w5													
		Spot-winged Grosbeak	*Mycerobas melanozanthos*	r3													
		Tibetan Siskin	*Carduelis thibetana*	w5													
		White-browed Rosefinch	*Carpodacus thura*	w4													
		White-	*Mycerobas*	w4													

		winged Grosbeak	*carniceps*														
		Yellow-breasted Greenfinch	*Carduelis spinoides*	r2	√								√				
SHRIKES	Lannidea	Brown Shrike	*Lanius cristatus*	w2													
		Grey-backed Shrike	*Lanius tephronotus*	r3													
		Long-tailed Shrike	*Lanius schach*	r2													
SNIPES AND SANDPIPER	Scolopacidae	Common Snipe	*Gallinago gallinago*	r2													
		Eurasian Woodcock	*Scolopax rusticola*	w3													
		Green Sandpiper	*Tringa ochropus*	w3													
		Solitary Snipe	*Gallinago solitaria*	w5													
SPARROWS, PIPPETS, WAGTAILS, ACCENTORS AND MUNIAS	Passeridae	Eurasian Tree Sparrow	*Passer montanus*	r1	√												
		Grey Wagtail	*Motacilla cinerea*	w2	√												
		House Sparrow	*Passer domesticus*	r1	√	√											
		Maroon-backed Accenter	*Prunella immaculata*	w4													
		Olive-backed Pipit	*Anthus hodgsoni*	r1				?									
		Rosy Pipit	*Anthus roseatus*	w3													
		Rufous - breasted Accenter	*Priunella strophiata*	w3													

		Russet Sparrow	*Passer rutilans*	r4													
		Scaly-breatsed Munia	*Lonchura punctulata*	r2													
		Upland Pipit	*Anthus sylvanus*	r5													
		White Wagtail	*Motacilla alba*	w2	√							√					
		White-rumped Munia	*Lonchura striata*	r3													
THRUSHES AND FLYCATCHERS	Muscicapidae	Black Redstart	*Phoenicurus coeruleocephalus*	w4													
		Black-backed Forktail	*Enicurus immaculatus*	s5													
		Blue Rock Thrush	*Monticola solitarius*	s3													
		Blue Whistling Thrush	*Myophonus caeruleus*	r1	√	√											
		Blue-capped Redstart	*Phoenicurus ochruris*	w3													
		Blue-capped Rock Thrush	*Monticola cinclorhynchus*	s3													
		Blue-fronted Redstart	*Phoenicurus frontalis*	w2													
		Blue-throated Flycatcher	*Cyornis rubeculoides*	r2													
		Chestnut Thrush	*Turdus ruficollis*	w2													
		Chestnut-bellied Rock Thrush	*Monticola rufiventris*	s3													
		Common Stonechat	*Saxicola torquata*	r1	√												
		Dark-sided Flycathcher	*Muscicapa sibrica*	s1													

		Dark-throated Thrush	*Turdus ruficollis*	w2													
		Ferruginous Flycatcher	*Muscicapa ferruginea*	s4													
		Golden Bush Robin	*Tarsiger chrysaeus*	w3													
		Grey Bushchat	*Saxicola ferrea*	r3	√									√			
		Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	r1													
		Grey-winged Blackbird	*Turdus boulboul*	r2													
		Hill Blue Flycatcher	*Cyornis banyumas*	r?5													
		Hodgson's Bushchat	*Saxicola insignis*	m5*													
		Hodgson's Redstart	*Phoenicurus frontalis*	w2													
		Indian Blue Robin	*Luscinia brunnea*	s2													
		Kashmir Flycatcher	*Ficedula suburba*		√												
		Large Niltava	*Niltava grandis*	r5													
		Little Forktail	*Enicurus scouleri*	r3													
		Little-pied Flycatcher	*Ficedula westermanii*	s3													
		Long-billed Thrush	*Zoothera monticola*	w4													
		Long-tailed Thrush	*Zoothera dixoni*	w4													
		Orange-flanked Bush Robin	*Tarsiger cyanurus*	w3													
		Orange-headed Thrush	*Zoothera citrina*	s4													
		Oriental Magpie Robin	*Tarsiger saularis*	w3													

		Pied Bushchat	*Saxicola caprata*	r2													
		Pied Thrush	*Zoothera wardii*	s4													
		Plain-backed Thrush	*Zoothera mollissima*	w4													
		Plumbeous Water Redstart	*Rhyacornius phaenicuroides*	w4	√												
		Purple Cochoa	*Cochoa purpurea*	s5													
		Pygmy Blue Flycatcher	*Muscicapella hodgsoni*	r?5													
		Red-throated Flycatcher	*Ficedula parva*	w3													
		Rufous-bellied Niltava	*Niltava sundara*	r2	√								√		√		
		Rufous-gorgeted Flycatcher	*Ficedula strophiata*	r2													
		Rusty-tailed Flycatcher	*Muscicapa ruficauda*	s3													
		Scaly Thrush	*Zoothera dauma*	w3													
		Slaty-backed Flycatcher	*Ficedula hodgsonii*														
		Slaty-backed Forktail	*Enicurus schistaceus*	r3													
		Slaty-blue Flycatcher	*Ficedula tricolor*	r3													
		Small Niltava	*Niltava macgrigoriae*	r2													
		Snowy-browed Flycatcher	*Ficedula hyperythra*	s3													
		Spotted Forktail	*Enicurus maculatus*	r3													
		Tickell's Thrush	*Turdus unicolor*	s3													

		Ultramarine Flycatcher	*Ficedula superciliaris*	r2													
		Verditer Flycatcher	*Eumyias thalassina*	r2	√									√			
		White-bellied Redstart	*Hodgsonius phaenicuroides*	w4													
		White-browed Bush Robin	*Tarsiger indicus*	w3													
		White-browed Shortwing	*Brachypteryx montana*	w5													
		White-capped Water Redstart	*Chaimarrornis leucocephalus*	r2													
		White-collared Blackbird	*Turdus albocinctus*	w2													
		White-gorgeted Flycatcher	*Ficedula monileger*	w5													
		White-tailed Robin	*Myiomela leucura*	r3	√												
		White-tailed Stonechat	*Saxicola leucura*	A	√								√				
TITMICE	Paridae	Black-lored Tit	*Parus xanthogenys*	r1	√												
		Black-throated Tit	*Aegithalos concinnus*	A	√												
		Coal Tit	*Parus ater*	r4													
		Fire-capped Tit	*Cephalopyrus flammiceps*	r5													
		Great Tit	*Parus major*	r1	√												
		Green-backed Tit	*Parus monticolus*	r1	√									√			
		Yellow-browed Tit	*Sylviparus modestus*	r3													
TREECREEPERS AND WREN	Certhiidae	Brown-throated Tree-creeper	*Certhia discolor*	r3													

		Rusty-flanked Tree-Creeper	*Certhia nipalensis*	r4													
		Winter Wren	*Troglodytes troglodytes*	w2													
WARBLERS	Sylviidae	Aberrant Bush Warbler	*Cettia flavolivacea*	r4													
		Ashy-throated Warbler	*Phylloscopus inornatus*	w3	√												
		Black-chinned Babbler	*Stachyris pyrrhops*	r2													
		Black-eared Shrike Babbler	*Pteruthius melanotis*	r3													
		Black-faced Warbler	*Abroscopus schisticeps*	r2													
		Black-headed Shrike Babbler	*Pteruthius xanthochlorus*	r3													
		Black-throated Parrotbill	*Paradoxornis nipalensis*	r4													
		Blue-winged Laughingthrush	*Garrulax squamatus*	r5													
		Blue-winged Minla	*Minla cyanouroptera*	r3													
		Blyth's Leaf Warbler	*Phylloscopus reguloides*	w2													
		Blyth's Reed Warbler	*Acrocephalus dumetorum*	w3													
		Buff-barred Warbler	*Phylloscopus pulcher*	w1													
		Chestnut-crowned Laughingthrush	*Garrulax erythrocephalus*	r1													
		Chestnut-	*Seicercus*	r2													

		crowned Warbler	*castaniceps*														
		Chestnut-headed Tesia	*Tesia castaneocoronata*	r3													
		Chestnut-tailed Minla	*Minla strigula*	r2													
		Common Tailorbird	*Orthotomus sutorius*	r2													
		Cutia	*Cutia nipalensis*	r4													
		Dusky Warbler	*Phylloscopus fuscatus*	w4													
		Golden-spectacled Warbler	*Seicercus burkii*	r2	√												
		Green Shrike Babbler	*Pteruthius melanotis*	r3													
		Greenish Warbler	*Phylloscopus trochiloides*	w2													
		Grey-bellied Tesia	*Tesia cyaniventer*	r3													
		Grey-hooded Warbler	*Seicercus xanthoschistos*	r1	√			√						√			√
		Grey-sided Bush Warbler	*Cettia brunnifrons*	w3													
		Grey-sided Laughingthrush	*Garrulax caerulatus*	r4													
		Grey-throated Babbler	*Stachyris nigriceps*	r2													
		Hoary-throated Barwing	*Actinodura nipalensis*	r3	√			√									
		Hume's Warbler	*Phylloscopus humei*	w2													
		Large-bellied Leaf Warbler	*Phylloscopus magnirostris*	w4													

		Lemon-rumped Warbler	*Phylloscopus chloronotus*	w2													
		Nepal Fulvetta	*Alcippe nipalensis*	r2													
		Nepal Wren Babbler	*Pnoepyga immaculata*	w5													
		Puff-throated Babbler	*Pellorneum ruficeps*	s3													
		Pygmy Wren Babbler	*Pnoepyga pusilla*	r3													
		Red-billed Leiothrix	*Leiothrix lutea*	r2													
		Red-tailed Minla	*Minla ignotincta*	r4													
		Rufous Sibia	*Heterophasia capistrata*	r1	√									√		√	
		Rufous-chinned Laughingthrush	*Garrulax rufogularis*	r1													
		Rufous-vented Yuhina	*Yuhina occipitalis*	r3													
		Rufous-winged Fulvetta	*Alcippe vinipectus*	r2													
		Rusty-cheeked Scimitar Babbler	*Pomatorhinus erythrogenys*	r1													
		Scaly - brested Wren Babbler	*Pnoepyga pusilla*	r3													
		Scaly Laughingthrush	*Garrulax subunicolor*	A	√									√			
		Slender-billed Scimitar Babbler	*Xiphirhynchus superciliaris*	r5													
		Spiny	*Turdoides*	r3													

		Babbler	*nipalensis*														
		Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*	r2													
		Streaked Laughingthrush	*Garrulax lineatus*	r2													
		Striated Laughingthrush	*Garrulax striatus*	r1	√				√					√	√	√	
		Stripe-throated Yuhina	*Yuhina gularis*	r2													
		Tickell's Leaf Warbler	*Phylloscopus affinis*	w3													
		Western Crowned Warbler	*Phylloscopus aoccipitalis*	w5													
		Whiskered Yuhina	*Yuhina flavicollis*	r2	√												
		Whistler's Warbler	*Seicercus whistleri*	w3													
		White-bellied Yuhina	*Yuhina zantholeuca*	r3													
		White-browed Fulvetta	*Alcippe nipalensis*	r2													
		White-browed Scimitar Babbler	*Pomatorhinus schisticeps*	r4													
		White-browed Shrike Babbler	*Pteruthius flaviscapis*	r3													
		White-crested Laughingthrush	*Garrulax leucolophus*	r1	√												
		White-throated Laughingthr	*Garrulax albogularis*	r1	√									√		√	

		ush															
		Yellow-browed Warbler	*Phylloscopus inornatus*	w3													
		Yellowish-bellied Bush Warbler	*Cettia acanthizoides*	w4													
WATERHEN	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	A	√												
WOODPECKERS	Picidae	Bay Woodpecker	*Blythipicus pyrrhotis*	r4													
		Brown-fronted Woodpecker	*Dendrocopos auriceps*	r3													
		Crimson-breasted Woodpecker	*Dendrocopos cathpharius*	r3													
		Darjeeling Woodpecker	*Dendrocopos darjellensis*	r3													
		Eurasian Wryneck	*Jynx torquilla*	w3													
		Fulvous-breasted woodpecker	*Dendrocopos macei*	r3													
		Greater Yellownape	*Picus flavinucha*	r3													
		Lesser Yellownape	*Picus chlorolophus*	r2													
		Rufous Woodpecker	*Celeus brachyurus*	r5													
		Rufous-bellied Wodpecker	*Dendrocopos hyperythrus*	r2													
		Speckled Piculet	*Picumnus innominatus*	r3													

ANNEX D: Field Survey 5 [Fishes]

Annex 1: Field protocol (Fish base)

1. Place: 2. Run: 3. Fishing time: 4. Fished distance

No	Species	Length	Weight	Sex/dev	No	Species	Length	Weight	Sex/dev
1					26				
2					27				
3					28				
4					29				
5					30				
6					31				
7					32				
8					33				
9					34				
10					35				
11					36				
12					37				
13					38				
14					39				
15					40				
16					41				
17					42				
18					43				
19					44				
20					45				
21					46				
22					47				
23					48				
24					49				
25					50				

Annex 2: Field protocol

GENERAL

Name of the water body	Locality	Date	Time	Weather
River order	River length	Stretch code	Stretch length	Width
Depth	Latitude	Longitude	Altitude	Impact
Season				

PHYSICO-CHEMICAL

Temperature	Dissolved Oxygen	Ph	Conductivity	Velocity
Discharge				

MORPHOLOGY

1. SUBSTRATE

Rock	Boulder	Cobbles	Pebbles	Gravels	Sand	Silt

2. RIVER BANK

RIGHT

Natural	Artificial	Eroded	Planted
Bare	Overhanging branches	Woody Debris	

LEFT

Natural	Artificial	Eroded	Planted
Bare	Overhanging branches	Woody Debris	

Table A-1. Data of fish sampling at the three sites within the Shivapuri National Park.

Nagmati - Dhap

run	Schistura beavani (CPUE)
1	1.5
2	0.5
average	1
Nagmati Dam Site	
run	Schizothorax richardsonii (CPUE)
1	0
2	0.66
average	0.33
Confluence of Bagmati	
run	Schizothorax richardsonii (CPUE)
1	14
2	20
average	17

Annex 3: Table A-2. Raw data of the fish sampling survey at Dhap, Nagmati Dam site and near the confluence of Bagmati River.

No.	River	Place	Date	Season	Run	Fishing time (min)	River width (m)	Fished distance (m)	Genus	Species	Common Name	Total length (mm)	Total weight (g)	CPUE
1	Nagmati/stream	Dhap	15.12.12	Winter	1	20	1	200	Schistura	beavani	Pate	90	8	0.50
1	Nagmati/stream	Dhap	15.12.12	Winter	1	20	1	200	Schistura	beavani	Pate	60	3	0.50
1	Nagmati/stream	Dhap	15.12.12	Winter	1	20	1	200	Schistura	beavani	Pate	50	2	0.50
2	Nagmati/pond	Dhap	15.12.12	Winter	2	20		150	Schistura	beavani	Pate	60	3	0.50
3	Nagmati	Dam Site	29.01.13	Winter	1	18		125	0	0	0			0.00
4	Nagmati	Dam Site	29.01.13	Winter	2	15		100	Schizothorax	richardsonii	Asala	190	54	0.67
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	110	12	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90	6	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90	7	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	100	10	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	85	4	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	85		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	110	17	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	70		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	100		0.50

5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	70		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90	6	0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	70		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	80		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	70		0.50
5	Nagmati	confluence of Bagmati	29.01.13	Winter	1	20	6	75	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	260	158	0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	150	23	0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	155	30	0.50

6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	160	35	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	150	23	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	150	30	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	120	14	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	120	17	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	100		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	110	11	0.50

6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	120	15	0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	100		0.50
6	Nagmati	confluence of Bagmati	29.01.13	winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	70		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	100		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	100		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	90		0.50
6	Nagmati	confluence of Bagmati	29.01.13	Winter	2	20	8	100	Schizothorax	richardsonii	Asala	80		0.50

ANNEX D: Field Survey 6 [Water Analysis]

Annex 1: Topographic Map of the Study Area

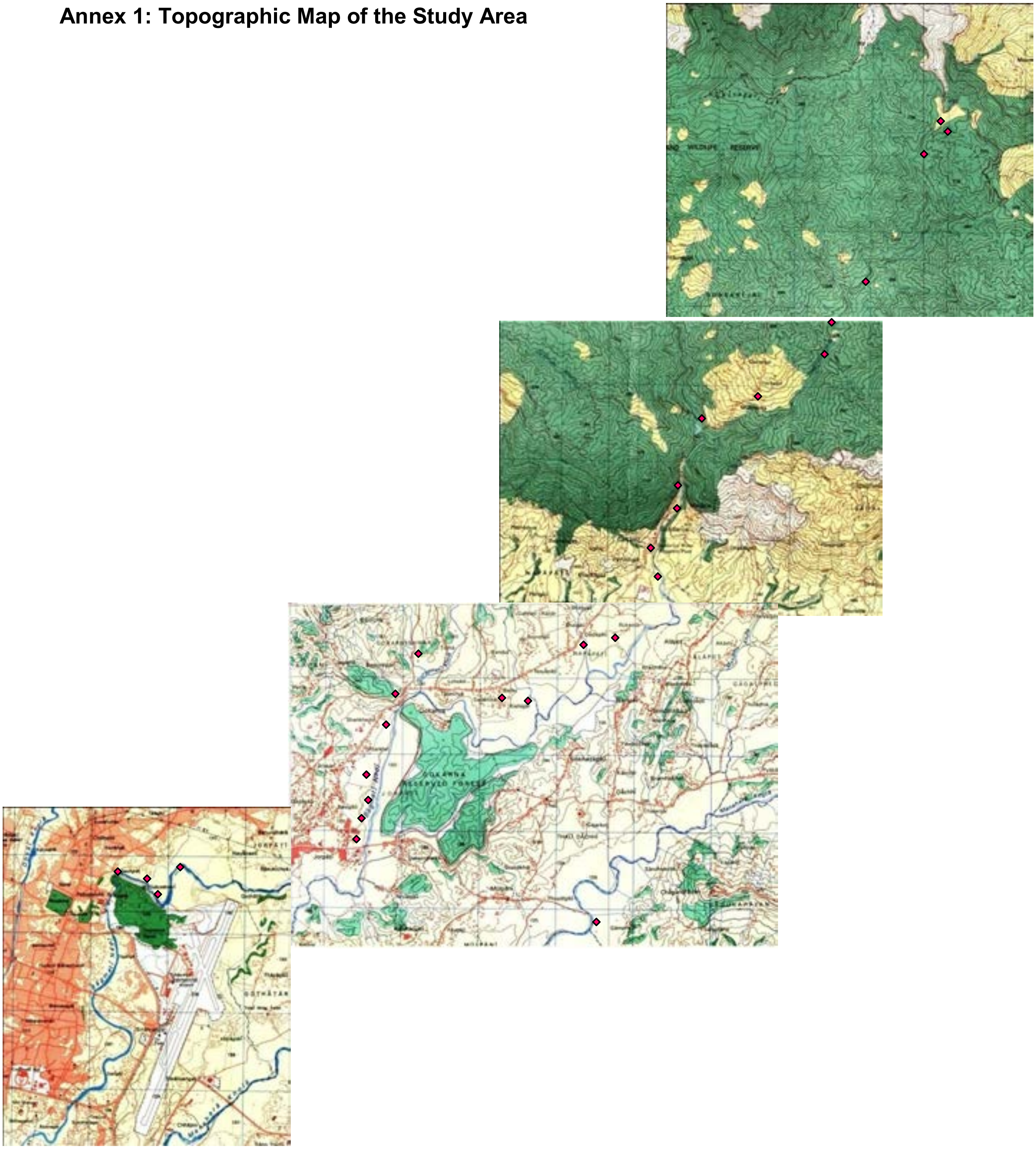


Figure A-1. Map showing the soil and water sampling locations from Dhap to Guheshwori-Tilganga.

Annex 2: Some Photos of the Sampling Site

Figure A-2. Upper Dhap site (Nag 01).

Figure A-3. The Dhap lake with existing dam in view.

Figure A-4. Soil profiles at the Dhap lake (a), Nagmati site grass/shrub land (b), and grass land near the exisiting Sundarijal reservoir.

Figure A-5. The reservoir at Sundarijal below Mulkharka.

Figure A-6. Nagmati River near road crossing below propsed dam site.

Annex 3: Table A-1. Nepal Water Quality Guidelines for the Protection of Aquatic Ecosystem

S.N.	Parameters name		Target Water Quality Range	Chronic Effect Value	Aquatic Effect Value
1	Aluminium (mg/l)		At pH <6.5:5	10	100
			At pH <6.5:10	20	150
2	Ammonia (µg/l)		<7	< 15	< 100
3	Arsenic (µg/l)		<10	< 20	< 130
4	Atrazine (µg/l)		<10	< 19	< 100
5	Cadmium				
	Soft water	(60 mg/l $CaCO_3$)	<0.15	0.3	3
	Medium water	60-119 mg/l	<0.25	0.5	6
	Hard water	120-180mg/l	<0.35	0.7	10
	Very hard water	>180mg/l	<0.40	0.8	13
6	Chlorine (Residual) µg/L		<0.2	0.35	5
7	Chromium (VI) µg/L		7	10	200
8	Chromium (III) µg/L		<12	24	340
9	Copper µg/L				
	Soft water	(60 mg/l $CaCO_3$)	< 0.3	0.53	1.6
	Medium water	60-119 mg/l	< 0.8	1.5	4.6
	Hard water	120-180mg/l	< 1.20	2.4	7.5
	Very hard water	>180mg/l	<1.40	2.8	12
10	Cyanide (µg/L)		1	4	110
11	Dissolved Oxygen (% saturation)		80-120	> 60	> 40
12	Endosulphan (µg/L)		< 0.01	0.02	0.2
13	Fluoride (µg/L)		< 750	1500	2540
14	Iron (µg/L)		The iron concentration should not be allowed to vary by more than 10% of the background dissolved iron concentration for a particular site or case, at specific time.		
15	Lead (ug/l)				
	Soft water	(60 mg/l $CaCO_3$)	< 0.2	0.5	4
	Medium water	60-119 mg/l	<0.5	1.0	7
	Hard water	120-180mg/l	< 1.0	2.0	13
	Very hard water	>180mg/l	< 1.2	2.4	16
16	Manganese (µg/L)		< 180	370	1300
17	Mercury (µg/L)		< 0.04	0.08	1.7

18	Nitrogen (inorganic)	Inorganic nitrogen concentrations should not be changed by more than 15% from that of the water body under local unimpacted condition at any time of the year; The trophic status of the water body should not increase above its present level, though a decrease in trophic status is permissible (see effect): The amplitude and frequency of natural cycles in inorganic nitrogen concentrations should not be changed		
19	pH All aquatic ecosystems	pH values could not be allowed to vary from the range of the background pH values for a specific site and time of day, by > 0.5 of a pH unit, or by > 5% and should be assessed by whichever estimate is more conservative.		
20	Phenols (µg/L)	< 30	60	500
21	Phosphorus (inorganic) All surface waters	Inorganic phosphorus concentration should not be changed by > 15% from that of the water body under local, unimpacted conditions at any time of the year. The trophic status of the water body should not increased above its present level, though a decrease in trophic status is permissible (see effect) The amplitude and frequency of natural cycle in inorganic phosphorus concentration should not be changed		
22	Selenium (µg/L)	< 2	5	30
23	Temperature (All aquatic ecosystem)	Water temperature should not be allowed to vary from the background average daily water temperature considered to be normal for that specific site and time of day, by > 2 ^{0}C or by 10% whichever estimate is the more conservative.		
24	Total Dissolved Solids (All inland water)	TDS concentrations should not be changed by > 15% from the normal cycle of the water body under unimpacted conditions at any time of the year The amplitude and frequency of natural cycles in TDS conc^{n} should not be changed.		
25	Total Suspended Solids (All inland waters)	Any increase in TSS concentrations must be limited to < 10 % of the background TSS concentrations at a specific site and time		
26	Zinc (µg/L)	< 2	3.6	36

Source: Department of Irrigation: Ground Water Project (Nepal Gazette (Number 10, BS, 2065-03-02).

Annex 4: Table A-2. Nepal Water Quality Guidelines for Recreation

S.N.	Parameters name	Full contact	Partial contact	Non Contact
1	Biological Parameters: Algae, macrophytes, phytoplankton scum, etc	Should not be present in excessive amount		
	Indicator Organism			
	Faecal coliform	< 130 count/100ml	< 1000 count/100ml	No target value
	Escherichia coli	< 130 count/100ml	No target value	No target value

	Entero cocci Faecal Streptococci	< 30 count/100ml	0-230 count/100ml	No target value
	Coliphase	< 20 count/100ml	No target value	No target value
	Schistosoma/Bilharzia	No snails capable of acting as the intermediate host of the bilharzias parasite	No snails capable of acting as the intermediate host of the bilharzias parasite	No target value
	Nuisance Plants	Swimmer should not be entangled	Boats should not be entangled	
2	Chemical Irritant			
	The Criteria are qualitative and no specific irritant and quantitative measures are given			
3	Chemical Parameters			
	pH	6.5-8.5	6.5-8.5	No target value
4	Physical Parameters			
	Clarity	> 1.6 (Sechchi disc depth Metres)	No target value	No target value
	Colour	100 Pt-Co units	100 Pt-Co units	No target value
	Floating Matter and refuse	Free of floating or submerged debris	No target value	No target value
	Odour	No objectionable or unpleasant odour	No objectionable or unpleasant odour	No objectionable or unpleasant odour
	Residual Chlorine	0.1 mg/l	No target value	No target value
	Surface films	Should not be noticeable	Should not be noticeable	Should not be noticeable
	Turbidity	0.5 NTU		

Source: Department of Irrigation: Ground Water Project (Nepal Gazette (Number 10, BS, 2065-03-02).

Annex 5: Table A-3. Nepal Water Quality Guidelines for Livestock Watering

S.N.	Constituent	Proposed Concentration
1	Algae	No visible blue-green scum
2	Aluminium	< 5 mg/l
3	Arsenic	< 0.2 mg/l
4	Berylium	< 0.1 mg/l
5	Boron	< 5 mg/
6	Cadmium	< 0.01 mg/l
7	Calcium	< 1000 mg/l
8	Chloride	
9	Chromium (VI)	< 1 mg/l
10	Cobalt	< 1 mg/l
11	Copper	< 0.5 mg/l
12	Electrical conductivity	< 1.5 mg/l
13	Fluoride	< 2 mg/l
14	pH	6.5-8.5
15	Iron	Not toxic
16	Lead	< 0.1 mg/l
17	Magnesium	< 500 mg/l
18	Manganese	< 10 mg/l
19	Mercury	< 10 µg/l
20	Molybdenum	< 0.01 mg/l
21	Nickel	< 1 mg/l
22	Nitrate/Nitrite	< 100 mg/l as nitrate
23	Nitrite-N	< 10 mg/l
24	Selenium	< 0.05 mg/l
25	Sodium	< 2000 mg/l
26	Sulphate	< 1000 mg/l
27	Total Dissolved Solids	
	Dairy Cattle	< 7100 mg/l
	Sheep	< 12800 mg/l
	Horse	< 6400 mg/l
	Pigs	< 4300 mg/l
	Poultry	<2800 mg/l
28	Vanadium	< 0.1 mg/l (FAO)
29	Zinc	< 24 mg/l (FAO)
	Pathogens;	
30	Faecal Coliform count	< 200 count/100 ml
		< 100 count for < 20 % of the samples
	Pesticides: Guidelines applicable for human beings	
	Chlorinated Hydrocarbons: Guidelines for human beings apply	

Source: Department of Irrigation: Ground Water Project (Nepal Gazette (Number 10, BS, 2065-03-02).

Annex 6: Table A-4. Nepal Water Quality Guidelines for Industries

S.N.	Parameter	Recommended Value			
		Category 1	**Category 2**	**Category 3**	**Category 4**
1	BOD	< 50 mg/l	< 120 mg/l	< 300 mg/l	< 1200 mg/l
2	COD	< 10 mg/l	< 15 mg/l	< 30 mg/l	< 75 mg/l
3	Chloride	< 20 mg/l	< 40 mg/l	< 100 mg/l	< 500 mg/l
4	Iron	< 0.1 mg/l	< 0.2 mg/l	< 0.3 mg/l	< 10 mg/l
5	Manganese	< 0.01 mg/l	< 0.1 mg/l	< 0.2 mg/l	< 10 mg/l
6	pH	7.0-8.0	6.5-8.0	6.5-8.0	5.0-10.0
7	Silica	< 5 mg/l	0-10 mg/l	< 20 mg/l	< 150 mg/l
8	Sulphate	< 30 mg/l	< 80 mg/l	< 200 mg/l	< 500 mg/l
9	Suspended solids	< 3 mg/l	< 5 mg/l	< 5 mg/l	< 25 mg/l
10	Total Dissolved Solids	TDS: < 100 mg/l EC: < 15 mS/m	TDS: < 200 mg/l EC: < 30 mS/m	TDS: < 450 mg/l EC: < 70 mS/m	TDS: < 1600 mg/l EC: < 250 mS/m
11	Total Hardness	< 50 mg/l as $CaCO_3$	< 100 mg/l as $CaCO_3$	< 250 mg/l as $CaCO_3$	< 100 mg/l as $CaCO_3$

Source: Department of Irrigation: Ground Water Project (Nepal Gazette (Number 10, BS, 2065-03-02).

Annex 7: Table A-5. Nepal Drinking Water Quality Standard

Group	Parameters	Unit	Maximum Concentration Limits
Physical	Turbidity	NTU	5 (10)**
	pH	-	6.5-8.5*
	Color	TCU	5 (15)**
	Taste & Odor	Would not be objectionable	
	Total Dissolved Solids	mg/l	1000
	Electrical Conductivity	µs/cm	1500
	Iron	mg/l	03 (3)*
	Manganese	mg/l	0.2
	Arsenic	mg/l	0.05
	Cadmium	mg/l	0.003
	Chromium	mg/l	0.05
	Cyanide	mg/l	0.07
	Fluoride	mg/l	0.5-1.5
	Lead	mg/l	0.01
	Ammonia	mg/l	1.5
Chemical	Chloride	mg/l	250
	Sulphate	mg/l	250
	Nitrate	mg/l	50
	Copper	mg/l	1
	Total Hardness	mg/l	500
	Calcium	mg/l	200
	Zinc	mg/l	3
	Mercury	mg/l	0.001
	Aluminum	mg/l	0.2
	Residual Chlorine	mg/l	0.1-0.2*
Micro Germs	E-Coli	MPN/100ml	0
	Total Coli form	MPN/100ml	95% in sample

Note: *These standards indicate the maximum and minimum limits.
( ) Figures in parenthesis are upper range of the standard recommended.

Source: Ministry of Physical Planning (Nepal Gazette; B.S. 2063/03/12).

ANNEX F: Field Survey 8 [Air and Noise Monitoring]

Annex 1: Hourly averaged Sound Pressure Level at Pashuapti

Date	Time	Sound Pressure Level		
		Lmax (dBA)	Lmin (dBA)	Leq (dBA)
11/21/2012	7:30	61.6	47.6	50.8
11/21/2012	8:26	59.1	47.9	50.7
11/21/2012	9:27	83.4	49.0	53.2
11/21/2012	10:28	91.3	46.4	63.7
11/21/2012	11:30	66.9	47.5	52.0
11/21/2012	12:29	74.6	46.9	51.8
11/21/2012	13:25	67.9	46.1	49.8
11/21/2012	14:26	77.7	46.4	49.4
11/21/2012	15:28	79.8	46.8	51.8
11/21/2012	16:27	74.7	46.6	48.8
11/21/2012	17:28	81.1	45.3	48.8
11/21/2012	18:30	80.7	47.0	53.2
11/21/2012	19:28	66.1	44.8	48.6
11/21/2012	20:27	68.4	50.8	56.5
11/21/2012	21:28	63.2	47.0	52.5
11/21/2012	22:30	65.7	48.3	53.8
11/21/2012	23:25	61.0	43.2	45.5
11/21/2012	0:26	58.6	47.5	50.4
11/22/2012	1:22	61.5	47.5	49.4
11/22/2012	2:24	68.4	48.6	53.1
11/22/2012	3:27	55.9	42.4	45.7
11/22/2012	4:25	72.5	45.6	54.3
11/22/2012	5:25	69.5	47.8	53.3
11/22/2012	6:28	63.9	49.0	48.9
Average		**69.7**	**46.9**	**51.5**

Annex 2: Hourly averaged Sound Pressure Level at Gokarna

Date	Time	Sound Pressure Level		
		Lmax (dBA)	**Lmin (dBA)**	**Leq (dBA)**
11/22/2012	9:46	71.1	52.6	58.7
11/22/2012	10:48	73.8	54.7	54.5
11/22/2012	11:45	79.1	53.9	57.2
11/22/2012	12:44	69.5	54.6	56.9
11/22/2012	13:47	71.7	54.8	57.9
11/22/2012	14:46	72.5	55.1	57.8
11/22/2012	15:47	72.6	54.9	60.4
11/22/2012	16:45	70.7	54.3	56.5
11/22/2012	17:46	65.2	43.2	46.6
11/22/2012	18:46	68.6	42.8	47.2
11/22/2012	19:47	58.8	41.1	43.0
11/22/2012	20:48	62.1	42.0	47.7
11/22/2012	21:46	52.4	43.2	45.8
11/22/2012	22:44	55.6	42.2	46.4
11/22/2012	23:45	58.7	42.8	44.6
11/22/2012	0:43	72.4	44.2	52.8
11/23/2012	1:45	66.5	45.5	48.2
11/23/2012	2:46	62.4	44.7	48.4
11/23/2012	3:46	66.9	46.0	50.6
11/23/2012	4:50	66.5	43.1	46.5
11/23/2012	5:48	61.5	42.4	47.1
11/23/2012	6:46	63.2	43.5	50.5
11/23/2012	7:45	62.5	43.1	49.8
11/23/2012	8:43	74.1	45.2	56.6
Average		**66.6**	**47.1**	**51.3**

Annex 3: Hourly averaged Sound Pressure Level at Sundarijal

Date	Time	Lmax	Lmin	Leq
11/23/2012	11:08	77.2	55	61.7
11/23/2012	12:10	76.6	50	58.5
11/23/2012	13:08	81.5	54.8	59.4
11/23/2012	14:10	80.0	49.0	54.4
11/23/2012	15:13	78.2	51.1	53.2
11/23/2012	16:12	75.6	50.5	56.8
11/23/2012	17:14	68.2	41.8	49.7
11/23/2012	18:10	66.6	44.8	49.3
11/23/2012	19:10	63.5	42.5	46.7
11/23/2012	20:15	78.2	48.0	53.9
11/23/2012	21:09	65.2	45.3	49.3
11/23/2012	22:10	60.0	40.0	46.2
11/23/2012	23:08	62.3	44.6	51.4
11/23/2012	0:10	60.3	46.1	51.8
11/24/2012	1:12	72.4	56.6	59.2
11/24/2012	2:10	78.3	53.2	58.7
11/24/2012	3:09	81.8	54.7	62.4
11/24/2012	4:10	75.9	53.9	62.6
11/24/2012	5:12	67.2	44.6	51.7
11/24/2012	6:10	75.4	45.9	55.3
11/24/2012	7:12	63.8	41.3	55.3
11/24/2012	8:10	68.1	43.2	51.8
11/24/2012	9:08	77.6	50.3	59.7
11/24/2012	10:10	82.5	54.4	66.1
Average		**72.4**	**48.4**	**55.2**

Annex 4: Hourly averaged Sound Pressure Level at Nagmati

Date	Time	Lmax	Lmin	Leq
11/24/2012	12:10	55.5	47.7	49.5
11/24/2012	13:12	62.5	51.4	55.4
11/24/2012	14:10	65.2	43.0	47.6
11/24/2012	15:15	71.1	53.0	59.3
11/24/2012	16:14	64.6	53.3	58.8
11/24/2012	17:10	68.7	48.5	52.9
11/24/2012	18:10	66.1	44.1	50.6
11/24/2012	19:15	65.2	49.5	53.7
11/24/2012	20:10	58.8	41.3	52.4
11/24/2012	21:14	61.1	42.9	51.4
11/24/2012	22:10	60.3	45.4	49.4
11/24/2012	23:12	58.4	40.8	47.5
11/24/2012	0:08	63.2	44.9	57.8
11/25/2012	1:10	55.3	41.0	48.8
11/25/2012	2:15	80.6	46.5	65.7
11/25/2012	3:10	59.8	40.2	45.7
11/25/2012	4:12	62.1	43.7	48.1
11/25/2012	5:15	60.0	45.1	49.7
11/25/2012	6:10	68.4	46.2	56.9
11/25/2012	7:15	72.4	51.4	61.8
11/25/2012	8:15	68.6	47.1	56.5
11/25/2012	9:10	72.3	51.0	62.4
11/25/2012	10:10	63.2	52.4	55.2
11/25/2012	11:12	62.3	51.6	53.2
Average		**64.4**	**46.8**	**53.8**

Annex 5: Hourly (15 hour) averaged Sound Pressure Level at Dhap

Date	Time	Lmax	Lmin	Leq
11/25/2012	13:22	69.3	58.6	60.0
11/25/2012	14:18	64.5	48.2	53.5
11/25/2012	15:23	64.4	54.7	57.9
11/25/2012	16:20	61.6	55.5	58.0
11/25/2012	17:20	67.8	57.8	59.4
11/25/2012	18:23	77.5	43.4	47.8
11/25/2012	19:22	64.4	44.1	48.0
11/25/2012	20:20	87.7	46.2	57.6
11/26/2012	5:20	66.8	42.4	52.2
11/26/2012	6:20	61.2	50.1	54.7
11/26/2012	7:18	70.8	48.6	58.7
11/26/2012	8:20	60.9	43.3	51.1
11/26/2012	9:21	81.4	51.8	54.6
11/26/2012	10:22	78.5	49.6	48.2
11/26/2012	11:20	61.4	41.8	47.5
Average		**69.2**	**49.1**	**53.9**