High Powered Committee for Integrated Development of the Bagmati Civilization

Kathmandu

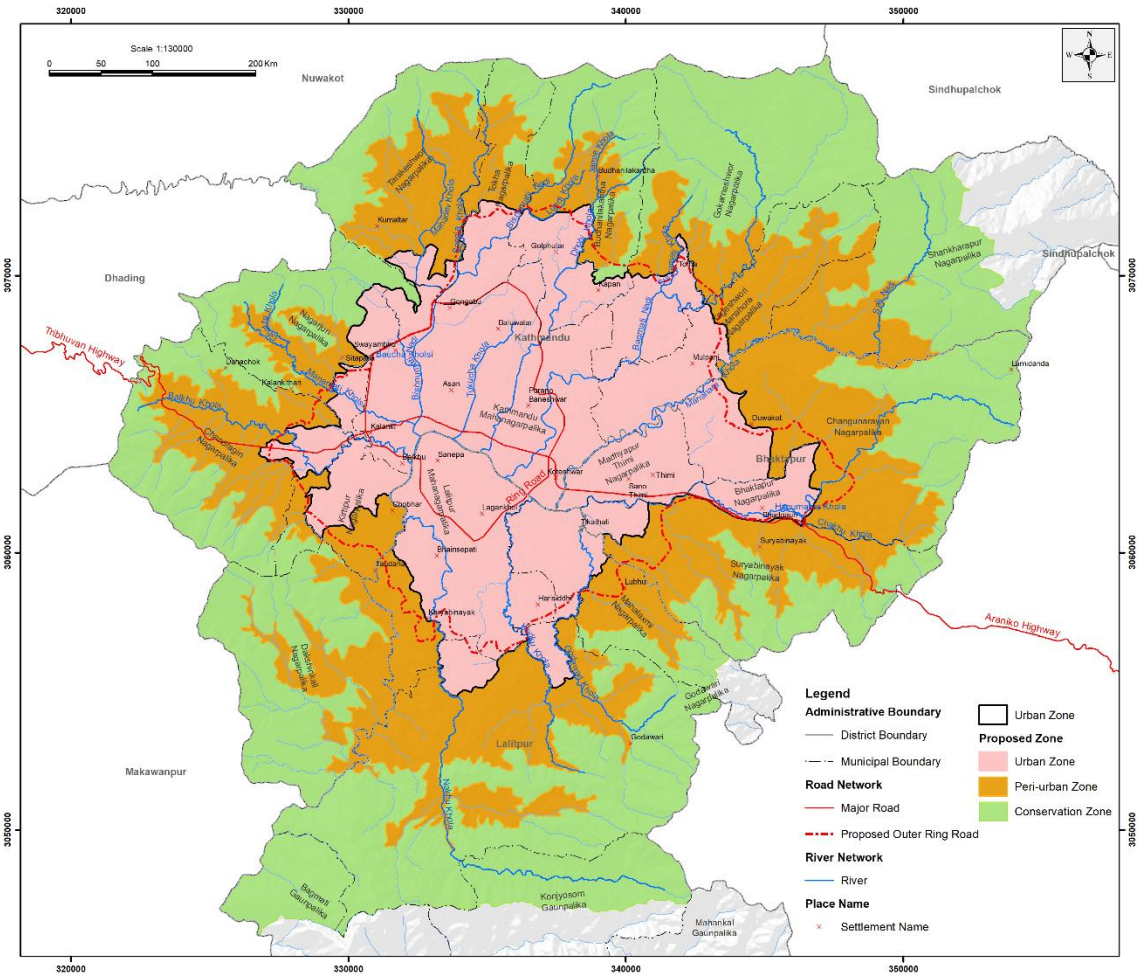
JUNE 2022

FINAL REPORT

for

Preparation of Bagmati Action Plan

Planning Report



Submitted By

JV of GRID Consult (P) Ltd., Rural Infrastructure Developers Consultants (P.) Ltd. & E.I. Maven (P) Ltd.

New Baneshwor, Kathmandu

Tel: 01-5172695, 9851126782

Email: gridconsult.consult@gmail.com

GRID

High Powered Committee for Integrated Development of the Bagmati Civilization

Kathmandu

Preparation of Bagmati Action Plan

Final Report – Planning Report

June, 2022

This document is the Final Report - Planning report for the project "**Preparation of Bagmati Action Plan**" undertaken by High Powered Committee for Integrated Development of the Bagmati Civilization (HPCIDBC), Kathmandu. This document provides methodology, Study Area delineation and introduction of the study area in detail. This document spells out the topography, geology and soil, climate, hydrology, natural hazard, population, infrastructure assets like corridor road, sewer network, waste water treatment plants, river training along with information on cultural heritage and monuments, urban scenario and squatter settlements. The report spells out the key issues related to the river environment and socio-economic issues. It also includes the information on soil pattern and stability, liquefaction and hydrological modeling. The report is the compilation of the existing scenario of Bagmati River System, major issues and challenges, land use zoning, and proposed activities and actions to support the vision for 20 years plan. The report also provides the implementation strategy, monitoring plan and institutional development plan for the implementation of 20 years Bagmati Action Plan.

PROJECT INFORMATION	
Name of the Project	Preparation of Bagmati Action Plan RFP No.: BIP-BAP-01-077/78
Project Executing Agency	High Powered Committee for Integrated Development of the Bagmati Civilization (HPCIDBC) Kathmandu
Implementing Agency	High Powered Committee for Integrated Development of the Bagmati Civilization (HPCIDBC) Kathmandu
Country Project Title	Nepal
Name of the Consultant	JV of GRID Consult (P) Ltd., Rural Infrastructure Developers Consultants (P.) Ltd. & E.I. Maven (P) Ltd. New Baneshwor, Kathmandu Tel: 01-5172695, 9851126782 Email: gridconsult.consult@gmail.com
Project Commencement Date	January 2022
Expected Date of Project Completion	June 2022

SUBMISSION INFORMATION	
Name of the Report	Planning Report
No. of Volume	1 (one)
Volume	I
Supplementary Volume	3 (Three)
Version No	1
Date of First Submission	June 2022
Submission Type	Hard Copy
Copies Produced	For Client : 5 (Five) For Consultant : 1 (One)
Expert Team	Dr. Sudha Shrestha- Team Leader Dr. Padma B. Shahi- Transportation Engineer Ms. Aruna Tandukar - Senior Urban Planner Mr. Madan Singh Khadayat - Economist Mr. Bhaskar Kafle - Sewerage Expert Dr. Madan K. Rimal- Conservationist Mr. Niroj Timalsina - Environmentalist Mr. Sunil Ghaju - Hydrologist Mr. Ishwar Dahal- Hydraulics Engineer Dr. Pradeep Poudyel - Geologist Mr. Hari K. Dhonju - GIS expert Mr. Siraj Kumar Pokharel - Sociologist Mr. Prabhakar Shrestha - Legal Expert Mr. Sandeep Thapa- Geomatics Engineer

	Ms. Sabina Tandukar - Architect Mr. Gagan Ale - Documentation Expert Mr. Smaran Dahal- Geometric Engineer Mr. Angishor Shrestha - Civil Engineer Dr. Bhesh Raj Thapa- Water Resources Expert Mr. Sanish Maharjan- Civil Engineer
Supporting Team	Mr. Ram Sharan Sapkota - Sociologist Mr. Uddab Lal Karki- GIS Officer Ms. Kala Rai- Geographer Ms. Sharmila Rai - Geographer Mr. Roshan Shrestha - Civil Engineer Ms. Sunita Adhikari - Civil Engineer Mr. Suzan Kayastha - Civil Engineer Ms. Rekha Chapagain - Digitization Operator Ms. Roshila Koju - Field Data Collector Ms. Sudha Shrestha - Field Data Collector Ms. Laxmi Bist - Field Data Collector Ms. Bhawana Bajgain - Field Data Collector Ms. Sarmila Shrestha - Field Data Collector Ms. Sarita pancha - Field Data Collector Mr. Rabin Shrestha - Field Data Collector Mr. Sumit Shrestha - Field Data Collector Mr. Roshan Timalsina - Field Data Collector
Checked By	Mr. Angishor Shrestha
Reviewed By	Ms. Aruna Tandukar
Liaison Person	Mr. Angishor Shrestha
Official Stamp	

ACKNOWLEDGEMENTS

We acknowledge our sincere gratitude to Mr. Uddab Prasad Timalsina, Executive Chairperson of HPCIDBC, Er. Nava Raj Pyakurel, Project Manager of BAP, Ar. Ramita Shrestha, Deputy Project Director of BRBIP, Er. Amit Ranjit, SDE of HPCIDBC, Er. Ram Babu Prasad, Engineer of HPCIDBC/BRBIP for their support, cooperation and invaluable suggestions for the project.

We are gratefulness to Peer Reviewer, Mr. Omdharananda Rajupadhaya for their invaluable comments and suggestions for making implementable document.

We also extend our gratitude to respected Mayor of Metropolitan city/Municipality, Chairperson of Rural Municipality, Deputy Mayor of Metropolitan city/Municipality, Deputy Chairperson of Rural Municipality, Chairperson of Ward of Metropolitan city/Municipality/Rural Municipality within Kathmandu Valley, and all the Team Leader, Engineer, Architect and staffs of KVDA, KUKL, DoA, DUDBC, DHM, DSC Consultant, SNP and Metropolitan city/Municipality/Rural Municipality for their invaluable support and kind cooperation that was essential for the development of the project.

We appreciate the efforts of all local representatives of different political parties, different governmental as well as non-governmental institutions, and public of Kathmandu Valley for their cooperation during the field survey & data collection works and their active participation during the field process.

We also thank the project team leader, project advisors, experts, engineers, surveyors, and all the staffs of GRID Consult (P) Ltd., Rural Infrastructure Developers Consultants (P.) Ltd. & E.I. Maven (P) Ltd. for their effort and hard work for the successful completion of this project.

Project team

ABBREVIATION

AQMS	:	Air Quality Monitoring Station
BAP	:	Bagmati Action Plan
CBS	:	Central Bureau of Statistics
CIP	:	Capital Investment Plan
DEM	:	Digital Elevation Model
DEWATS	:	Decentralized wastewater treatment System
DHM	:	Department of Hydrology and Meteorology
DoA	:	Department of Agriculture
DoEnv	:	Department of Environment
DoR	:	Department of Road
DoS	:	Department of Survey
DoTM	:	Department of Transport Management
DUDBC	:	Department of Urban Development and Building Construction
FGD	:	Focus Group Discussions
GESI	:	Gender Equity and Social Inclusion
GIS	:	Geographical Information System
GoN	:	Government of Nepal
HH	:	Household
HPCIDBC	:	High-Powered Committee for Integrated Development of Bagmati Civilization
ICIMOD	:	International Center for Integrated Mountain Development
KII	:	Key Informant Interview
Km	:	Kilometer
KVDA	:	Kathmandu Valley Development Authority
LRMP	:	Land Resource Mapping Project
m	:	meter
MoFE	:	Ministry of Forests and Environment
NDVI	:	Normalized Difference Vegetation Index
NPC	:	National Planning Commission
NTNC	:	National Trust for Nature Conservation
NUDS	:	National Urban Development Strategy
O&M	:	Operation and Maintenance
PRA	:	Participatory Rural Appraisal
RUSLE	:	Revised Universal Soil Loss Equation
Sq. Km.	:	Square Kilometer
SNNP	:	Shivapuri Nagarjun National Park
WECS	:	Water and Energy Commission Secretariat

EXECUTIVE SUMMARY

Background

Bagmati river system with many heritage sites and traditional settlements that are rich with numerous tangible and intangible heritages is collectively termed as 'Bagmati Civilization'. Bagmati river generates at Shivapuri Hills near Baghdwar and flows southward through Gokarna and Pashupati area and ultimately meets Manohara River, Dhobi Khola (Rudramati), Tukucha Khola (Ichhumati), Bishnumati River and Nakhu Khola before it passes through Chobhar George. The sub-tributaries include Hanumante, Godawari, Kodku, Mahadev, Sangla, Bhaucha, Lundi, Jamle, Manamati, Suryamati, Ghatte and Chakhu Khola. Besides, there are other small streams and numerous *kholsis* within the river system.

Bagmati, the holy river and a major source of water for the Kathmandu Valley, has been polluted due to human actions such as settlement along the river, unplanned urbanization in river basin and disposal of untreated sewage and solid waste into the river system. Apart from that, extractions of sand from river bed, construction of public infrastructure in river space and informal squatter settlements along the banks have deteriorated the river environment and the water security. The critical issues of Bagmati River and its tributaries are primarily related to river ecosystem, river side land use change, preservation of culture and heritage and institutional related arrangements.

Several efforts were made in the past for the conservation of Bagmati River and its tributaries. Government of Nepal approved the Bagmati Action Plan (2009-2014) in 2066 B.S with the aim of restoration and conservation in an integrated and coordinated approach. The key issues and challenges identified by BAP 2009-2014 are more or less similar with only variation in their extents due to change in urban context with increased built-up density and land use conversions. Since the scenarios within the valley have changed, the previous action plan might require some updates and additional interventions to achieve the desired outcomes. In this context, HPCIDBC has initiated this assignment to thoroughly revise and update the Action Plan with a planning perspective for next 20 years. This assignment intends to establish GIS based inventory system, prepare hydrological model of the river system and develop new Bagmati Action Plan. It is formulated with the aim to restore and conserve the Bagmati River and its tributaries in an integrated and coordinated approach. The Action Plan covers the Bagmati river system from Shivapuri hill to Katuwal Daha.

Information on the existing infrastructures and services, tangible and intangible heritages, green open spaces and other primary data were collected during field surveys. GIS based inventory system was established based on the field inventory. Environmental studies, socioeconomic studies, geo-technical studies were also performed for the identification of issues related to land, infrastructures, heritages, water ways, hazard risks and vulnerability etc.. Cross section surveys were conducted for hydrological analysis. Series of meetings and discussions were organized with local units, HPCIDBC and its project offices, KVDA, KUKL and other concerned governmental and non-governmental organizations and experts of various thematic areas. Study also critically analyzes previous action plan for the continuation of the priority activities.

Scenario Analysis

Increasing urbanization pressure in the Kathmandu valley has been posing serious environmental consequences in recent years. And most affected environmental function is on river system. Because of contemporary socioeconomic development, rivers have been facing growing threats from several quarters-unsustainable withdrawals, pollution, landuse conversion and habitat deterioration, among others. The land cover change analysis reveal that Kathmandu valley is facing rapid urbanization with 4.56 % annual increment in built-up during last decade which is about four times higher than that of the period from 2000 to 2010. The population has reached to 2,953,731 in 2021 which is increment of 1.90% per year since 2011. Considering the floating population this study

assumes the inhabitant of about 3.7 million in 2022. So, inhabitant of Kathmandu valley in 2032 and 2042 are predicted 4.66 million and 5.89 million. The gross density is expected to reach around 59 ppha in 2042.

Since the formulation of Bagmati Action Plan 2009-2014, various efforts are made in reconstruction/ restoration of monuments and heritage sites, landscaping and river beautification along river corridors, construction and remediation of interceptor and existing sewers, up-gradation/construction of Waste Water Treatment Plants, construction of new sewers in WWTPs service area, river training works, road and green belt along river banks, water storage and increase recharging area like Dhap and Nagmati Dam and others. However, despite several interventions, the Bagmati River and its tributaries remain critically polluted and its space continues to be encroached upon for different purposes. The analysis of water quality shows Dhobi Khola downstream from Ratopul stretch as most polluted river, followed by Mahadev Khola and Bishnumati downstream from Khusibu stretch. Coherently, these areas also receive higher number of sewage discharge, reflecting the main cause of pollution of the Bagmati river system.

Issues

Much of the current undesirable state in rivers can be attributed to disruptive anthropogenic activities. Because of contemporary socioeconomic development, rivers have been facing growing threats from several quarters-unsustainable withdrawals, pollution, landuse conversion and habitat deterioration, among others. The major issues of the Valley Rivers are related to decrease in water discharge and degradation of the river ecosystem. Degradation of water quality and catchment quality, narrowing and deepening of waterway, eroding cultural values, riverside landuse change are the critical issues of Bagmati River system. Degradation of catchment quality is mostly associated with the landuse conversion through settlement expansion, extensive land plotting and unregulated quarries. Decrease in water discharge is the result of water use, mostly tapping of water from the river/streams for drinking, irrigation and industrial uses along with the degradation of catchment quality. Degradation of water quality is associated with the river use, solid waste dumping, direct discharge of sewer and industrial effluents and use of chemical fertilizers and pesticides in agriculture. River encroachment, unplanned construction of embankments, roads and other infrastructures and sand mining in some cases have caused the narrowing and deepening of the waterways. The narrowing of the waterways has resulted in inundation because of narrow passage of river channel. Issues of river bank cutting and river course changing can also be observed in some areas.

The socio-cultural issues among others are associated with the encroachment and deterioration of religious, cultural and historical heritages, restriction in easy access to the rivers due to embankments, roads and other development works, and residential and commercial expansion along the river corridors.

Hydrological Modeling

Hydrological modeling of Bagmati River and its tributaries is used for estimation of basin, sub-basin and river physical characteristics. Peak flood discharge and maximum daily precipitation for 50 years return period at different river basin, junctions and reaches are estimated using hydrological modeling in HEC-HMS followed by calibration and validation of different hydrological parameters. The results from hydrological modeling are used to estimate minimum waterway width required for Bagmati River and its tributaries based on the Lacey's formula as well as model based flood inundation map. As Bagmati River and its tributaries have varying width and depth (cross-section) within small stretches, the results obtained from the model based flood map for waterway width are more precise, accurate and site specific.

The flood hazard maps based on hydrological model have been validated which shows the area around Gokarneshwar and Guheswori along Bagmati river having moderate flood hazard, while

downstream from the confluence of Manohara and Bagmati, the main water course increases to attain deep water level. The high hazard area increases to the downstream from the Bishnumati confluence, where the flood extent seems higher. Moderately hazardous area gradually increases towards downstream and the area near the confluence of Manohara and Kodku Khola falls in high hazard level. Most of the area along the river corridors are covered by low hazard zone, however, parts of the river corridors with small area fall on moderate hazard zone e.g. in Thimi area of Hanumante Khola, Kalimati area of Karakhusi Khola etc. River stretches with narrow section in between wider sections are more vulnerable to the flood risk as they result in increase in water depth and cause large flood inundation area mostly in upstream stretches. Similarly, construction of infrastructures such as bridges, culverts, etc. on river with the traffic operation area (deck level) below high flood level are observed in few bridges and culverts which affect the bridge structures as well as the built-up area on its bank. Uneven banks and river training works in rivers are also observed due to landscape restriction and corridor road mostly in Dhobi Khola stretches which ultimately result the built up area in low flood plain more vulnerable to flood. During flooding, blockage of the sewer lines and drain pipes due to backwater effect and less discharge capacity also increases the vulnerability of many areas.

Zoning

The criticalness of the issues identified varies in different segments of the rivers from upstream to downstream. The issues do not have equal level of significance in upper hills with forests cover and urban area in the valley floor. The hilly forest area surrounding the Kathmandu Valley is the main source of water for Bagmati River and its tributaries. The agricultural lands in the foothills and the valley floor have now converted to urban area and expanding. The urban growth scenario of Kathmandu Valley and new federal system has drastically changed the urban context. In addition, the major urban development projects such as Outer Ring Road, new town concepts have triggered the development outside the core city to periphery. In addition, after the promulgation of new constitution, structure of VDCs and municipalities has been dissolved and the new structure of metropolitan, sub-metropolitan, municipalities and rural municipalities are implemented. In this context, the new zonation concept has been developed on the basis of watershed ecology and urban growth scenario of Kathmandu Valley. They are: i) Conservation Zone, ii) Peri-Urban Zone, and iii) Urban Zone.

The Conservation Zone is the forest area surrounding valley. This area includes the forests of Shivapuri, Phulchowki, Chandragiri and Nagarjun. The Shivapuri Nagarjun National Park lies in this zone. This zone mostly includes forest area which recharges the river system of Valley and needs to be conserved. The central core of the valley has been categorized in Urban Zone area which has the highest population density and high urban growth rate. This area has been delineated within the boundary of proposed Outer Ring Road alignment and is planned for dense urban development with developed urban infrastructure to make Bagmati River clean, green and healthy. The area between Conservation Zone and Urban Zone is categorized as Peri-Urban Zone which has the pressure of urban development but the conservation measures has to be maintained in this zone for water recharge. So, these areas have high responsibility to maintain the river system.

Action Plan

The Action Plan has been prepared with overall vision for restoration and conservation of the Bagmati river system and defined goals, objectives and activities for each of the three zones. The action plan aims to maintain and enhance environmental services in the conservation zone, preserve river ecosystem in peri-urban zone and restoration in urban zone. It also aims in preservation of cultural heritage. The activities and actions are proposed under three broad sectors; River Conservation and Management, Cultural/Civilization Rehabilitation and River/Water Quality and Quantity Improvement. Certain activities which are valid in all the zones are included as

general activities. These activities are either common or associated with knowledge management that will help to build the capacity of HPCIDBC and other agencies and bolster the restoration and conservation of Bagmati River and its tributaries. This action plan has also incorporated the priority activities that have been recommended by previous action plan.

The actions for conservation zone prioritizes ecotourism promotion through cycling/hiking trail; water source conservation; enhance groundwater recharge through rainwater storage/harvesting ponds, water reservoir dams; sustainable landuse management through terrace improvement; promotion of organic farming; relocation of some settlements; gully control and sediment trapping; and reclamation, rehabilitation and preservation of cultural heritages. Similarly, the actions for peri-urban and urban zone prioritize green development with recreational facility along river corridor; implementation of Right of River Way to conserve river area; river training works with bioengineering; development of corridor transport system along rivers; management of Sewerage to prevent direct disposal into river through construction of interceptors and WWTPs; control of direct disposal of solid waste into river by strict law implementation; sustainable landuse management; and reclamation, rehabilitation and preservation of cultural heritages.

Budget

The action plan has been prepared for next twenty year, and the activities/action and budget are divided in four implementation periods viz; short-term (0-5 years), first mid-term (6-10 year), second mid-term (11-15 year) and finally long-term (16-20 year). The implementation of proposed activities require 147,660 million NPR in short term, 66,025 million NPR in first mid-term, 51,431 million NPR in second mid-term and 14,487 million NPR in long-term implementation period. The total tentative budget required for twenty year action plan is 279,605million NPR. Zone-wise implementation of proposed activities requires about 121,934 million NPR for Conservation Zone; 46,132 million NPR for Peri-Urban Zone; 110,421 million NPR for Urban Zone and 1,115 million NPR for general projects.

Implementation Strategy

The long-term stability of the efforts of Bagmati Action Plan can be ensured through planning and implementation but there is also a range of administrative, management and other supporting elements. These includes: policies and laws; institutional arrangements; stakeholder engagement; science, monitoring and research; and tools for giving effect to elements of the action plan's strategy through regulatory controls and other planning systems. For effective implementation of the action plan, the strategies should prioritize; activities and milestones, responsibilities, promotion strategy for private sector and civil society, budget, monitoring and reporting, and strategy review and adaptation. Efforts should be made to strengthen HPCIDBC in terms of technical capacity, financial resources and legal back up. For institutional strengthening this action plan proposes the inclusion of Coordination section to minimize dispute of right between development stakeholders; Environment unit with environmental expert, geological expert and landscape planner and GIS unit or GIS team in IT section in current organizational structure of HPCIDBC. More importantly, the government should ensure adequate resources to ensure effective implementation of action plan in reaching goals and ultimately the vision.

Monitoring Plan

Monitoring against defined and measurable objectives is critical for assessing the effectiveness of the action plan and for guiding adaptive management. The monitoring and evaluation plan should always refer to the overall objectives of the action plan, to specific restoration strategies and to details of specific restoration measures that will be conducted. Regular monitoring is required from the concerned authorities and similarly feedbacks to the implementers. HPCIDBC must take the responsibility for overall monitoring. Besides, a participatory or joint monitoring system can be established where representatives from concerned stakeholders participate and monitor the

programs. This report provides only the means of verification for the activities and actions proposed for Bagmati Action Plan. For effectiveness each implementing agencies have to prepare their own monitoring plans.

सारांस

पृष्ठभूमि

असंख्य मूर्त र अमूर्त सम्पदाहरूले भरिपूर्ण धेरै सम्पदा स्थल र परम्परागत वस्तीहरू भएको वाग्मती नदी प्रणालीलाई सामूहिक रूपमा 'वाग्मती सभ्यता' भनिन्छ। वाग्मती नदी बागद्वार नजिकैको शिवपुरी डाँडाबाट निस्केर गोकर्ण र पशुपति क्षेत्र हुँदै मनोहरा नदी, धोबीखोला (रुद्रमती), टुकुचा खोला (इच्छुमती), विष्णुमती नदी र नख्खु खोलासँग मिसिएर दक्षिणतर्फ चोभार हुँदै काठमाण्डौ उपत्यकाबाट बाहिरिन्छ । उपसहायक नदीहरूमा हनुमन्ते, गोदावरी, कोडकु, महादेव, साङ्गला, भौचा, लुन्डी, जम्ले, मनोमती, सूर्यमती, घट्टे र चाखु खोला पर्दछन् । यसबाहेक नदी प्रणालीभित्र अन्य स-साना खोला र असंख्य खोल्सीहरू छन् ।

काठमाण्डौ उपत्यकाको पवित्र नदी र पानीको प्रमुख श्रोत वाग्मती नदी किनारमा बसोबास, नदी वरपर अव्यवस्थित शहरीकरण र प्रशोधित ढल तथा फोहोरलाई नदी जलाधारमा फाल्ने जस्ता मानवीय कार्यका कारण प्रदूषित भएको छ । त्यस बाहेक खोलाबाट वालुवा उत्खनन, खोला क्षेत्रमा सार्वजनिक पूर्वाधार निर्माण र किनारमा अव्यवस्थित वस्तीले नदीको वातावरणीय सुन्दरता र पानीको स्वच्छतालाई बिगारेको छ । वाग्मती नदी र यसका सहायक नदीहरूका महत्वपूर्ण मुद्दाहरू मुख्यतया नदीको पर्यावरणीय प्रणाली, नदी किनारको भू-उपयोग परिवर्तन, संस्कृति र सम्पदाको संरक्षण र संस्थागत व्यवस्थासँग सम्बन्धित छन् ।

वाग्मती नदी र यसका सहायक नदीहरूको संरक्षणका लागि विगतमा धेरै प्रयासहरू भएका छन् । नेपाल सरकारले एकीकृत र समन्वयात्मक दृष्टिकोणबाट पुनर्स्थापना र संरक्षण गर्ने उद्देश्यले २०६६ सालमा वाग्मती कार्य योजना (ई. २००९-ई.२०१४) स्वीकृत गरेको थियो । उक्त वाग्मती कार्य योजना (Bagmati Action Plan) द्वारा पहिचान गरिएका मुख्य सवाल र चुनौतीहरू बढ्दो निर्मित (Built-up) घनत्व र भू-उपयोग रूपान्तरणको साथ शहरी सन्दर्भमा परिवर्तन पनि एक हो जसका लागि अघिल्लो कार्य योजनामा समय सापेक्ष अद्यावधिक र थप हस्तक्षेपहरू आवश्यक हुन गएको छ । यस सन्दर्भमा, अधिकार सम्पन्न वाग्मती सभ्यता एकीकृत विकास समितिले योजनागत परिपेक्ष्यमा उक्त कार्य योजनालाई सम्पूर्ण रूपमा परिमार्जन र अद्यावधिक गर्दै आगामी २० वर्षको लागि कार्य योजना तर्जुमाको थालनी गरेको छ । यस अध्ययनमा भौगोलिक सूचना प्रणाली (Geographic Information System: GIS) मा आधारित सूची प्रणाली (Inventory System) स्थापना गर्ने, नदी प्रणालीको जल विज्ञान सम्बन्धी (हाइड्रोलोजिकल) मोडेल तयार गर्ने र नयाँ वाग्मती कार्य योजना विकास गर्ने उद्देश्य राखेको छ । वाग्मती नदी र यसका सहायक नदीहरूलाई एकीकृत र समन्वयात्मक दृष्टिकोणले पुनर्स्थापना र संरक्षण गर्ने उद्देश्यका साथ यो कार्य योजना तयार गरिएको हो । कार्य योजनाले शिवपुरी डाँडादेखि कटुवाल दहसम्मको वाग्मती नदी प्रणालीलाई समेटेको छ ।

विद्यमान पूर्वाधार र सेवा, मूर्त र अमूर्त सम्पदा, हरियाली खुला क्षेत्र तथा अन्य प्राथमिक विवरणहरू सम्बन्धी जानकारी फिल्ड सर्वेक्षणबाट सङ्कलन गरिएको छ । सूची प्रणाली (Inventory System) मा आधारित भएर भौगोलिक सूचना प्रणाली (GIS) स्थापना गरियो । जग्गा, पूर्वाधार, सम्पदा, नदी वहाव र प्रकोप जोखिम इत्यादि सम्बन्धी सवालहरूको पहिचान गर्न वातावरणीय अध्ययन, सामाजिक-आर्थिक अध्ययन, भू-प्राविधिक अध्ययन सम्पादन गरियो । जलविज्ञान सम्बन्धी विश्लेषण गर्न क्रस-सेक्सन सर्वेक्षण गरियो । स्थानीय तह, अधिकार सम्पन्न वाग्मती सभ्यता एकीकृत विकास समिति र यसका आयोजना कार्यालयहरू, काठमाण्डौ उपत्यका विकास प्राधिकरण, काठमाण्डौ उपत्यका खानेपानी लिमिटेड, अन्य सरकारी तथा गैर सरकारी संघ संस्थाहरू र विभिन्न विषयगत विज्ञहरूसँग अनेकौं वैठक तथा छलफल

आयोजना गरियो । यस अध्ययनले विगतको कार्य योजनाको महत्वपूर्ण क्रियाकलापलाई निरन्तरता दिन आलोचनात्मक विश्लेषण गरेको छ ।

परिदृश्य विश्लेषण

काठमाण्डौ उपत्यकामा बढ्दो शहरीकरणको दबाबले पछिल्ला वर्षहरूमा गम्भीर वातावरणीय प्रतिकूलता देखिएको छ । सबैभन्दा बढी प्रभावित पर्यावरणीय कार्य नदी प्रणालीमा छ । समसामयिक सामाजिक-आर्थिक विकासका कारण, नदीहरूको वहाव क्षेत्र घट्दो छ जसले गर्दा यस वरपरका क्षेत्रहरूले दिगो निकासी, प्रदूषण, भूउपयोग रूपान्तरण र वासस्थान बिग्रने जस्ता खतराहरूको सामना गरिरहेका छन् । भूउपयोग परिवर्तनको विश्लेषणले काठमाण्डौ उपत्यकाले गत दशकमा ४.५६% वार्षिक निर्मित क्षेत्र वृद्धिका साथ तीव्र शहरीकरणको सामना गरिरहेको देखाएको छ जुन सन् २००० देखि २०१० सम्मको अवधिको तुलनामा करिब चार गुणा बढी हो । सन् २०२१ मा काठमाण्डौ जनसंख्या २९,५३,७३१ पुगेको छ । सन् २०११ देखि प्रतिवर्ष १.९० प्रतिशतको वृद्धि भएको छ। काठमाण्डौ उपत्यकामा चलायमान (Floating) जनसंख्यालाई ध्यानमा राख्दै यस अध्ययनले सन् २०२२ मा करिब ३७ लाख जनसंख्या रहेको अनुमान गरेको छ। त्यसैले सन् २०३२ र २०४२ मा काठमाण्डौ उपत्यकामा क्रमशः ४६ करोड ६० लाख र ५८ करोड ९० लाख बासिन्दा वसोवास गर्ने अनुमान गरिएको छ। कूल जनघनत्व सन् २०४२ मा लगभग ५९ व्यक्ति प्रति हेक्टर पुग्ने अपेक्षा गरिएको छ।

वाग्मती कार्य योजना सन् २००९—२०१४ को तर्जुमा भएदेखि नै स्मारक र सम्पदा स्थलहरूको पुनर्निर्माण, नदी करिडोरमा ल्याण्डस्केपिङ र नदीको सौन्दर्यीकरण, इन्टरसेप्टर सहितको ढल निर्माण, फोहोर पानीको प्रशोधन लगायतका कामहरू भइरहेका छन् । फोहर पानी प्रशोधन केन्द्र, थप क्षेत्रमा नयाँ ढल निर्माण, नदी तटबन्ध कार्य, नदी किनारमा सडक र हरितक्षेत्र, पानी भण्डारण र रिचार्जिंग क्षेत्र वृद्धि जस्तै धाप र नागमती डयाम आदि यसैको प्रतिफलको रुपमा लिन सकिन्छ । तर यति धेरै प्रयासका बाबजुद पनि वाग्मती नदी र यसका सहायक नदीहरू गम्भीर रूपमा प्रदूषित छन् र विभिन्न उद्देश्यका लागि यसको अतिक्रमण भइरहेको छ । पानीको गुणस्तरको विश्लेषणले रातोपुल खण्डबाटको तल्लो भेग धोबीखोला सबैभन्दा प्रदूषित नदीको रूपमा देखाउँछ, त्यसपछि महादेव खोला र खुसिबु खण्डबाट विष्णुमतीको तल्लो भेग देखिन्छ । यी क्षेत्रहरू बढी जनघनत्व भएको तथा वाग्मती नदी प्रणालीको प्रदूषणको मुख्य क्षेत्र भएको देखिन्छ ।

सवालहरू

नदीमा विद्यमान रहेको दयनीय अवस्था मानवजन्य क्रियाकलापबाट सिर्जित भएका हुन् । समसामयिक सामाजिक-आर्थिक विकासका कारण नदीहरूले विभिन्न प्रकारका समस्या व्यहोर्नु परिरहेको छ, जस्तै पानीको अत्यधिक दोहन, प्रदूषण, भूउपयोग रूपान्तरण र वसोवासको विग्रदो अवस्था आदि हुन् । उपत्यकाका नदीहरूका प्रमुख समस्याहरू पानीको वहावमा कमी र नदी प्रणालीमा ह्रासँग सम्बन्धित छन् । पानीको गुणस्तर र जलाधार क्षेत्र (Watershed area) को गुणस्तरमा ह्रास, नदी वहाव क्षेत्र साँघुरो र गहिरो बनाउने, सांस्कृतिक मूल्य मान्यतामा ह्रास, नदी किनारको भूउपयोग परिवर्तन वाग्मती नदी प्रणालीका प्रमुख समस्या हुन्। जलाधार क्षेत्रको गुणस्तरको ह्रास मुख्यतया वस्ती विस्तार, व्यापक जग्गा खण्डीकरण र अनियमित उत्खनन मार्फत भूउपयोग रूपान्तरणसँग सम्बन्धित छ । अत्यधिक पानीको प्रयोग जस्तैः नदी/खोलाबाट खानेपानी, सिँचाई तथा उद्योगका लागि पानी लिने कारण पानीको वहावमा कमी आएको हो । पानीको गुणस्तरमा ह्रासको कारण नदीको प्रयोग, फोहोरमैला नदीमा विसर्जन, ढल तथा औद्योगिक फोहोर बिना प्रशोधन नदीमा मिसाउने र कृषिमा रासायनिक मल र कीटनाशकको प्रयोगसँग सम्बन्धित छ। नदी अतिक्रमण, तटबन्ध, सडक र अन्य पूर्वाधारको अनियोजित निर्माण र कतिपय अवस्थामा वालुवा उत्खननले जलमार्गलाई साँघुरो र गहिरो बनाएको छ । नदीनाला साँघुरो भएकाले

पानीको वहाव क्षेत्र साँघुरो हुन गई डुबान हुने गरेको छ । नदी किनारा क्षयीकरण र नदीको धार परिवर्तनको समस्या पनि केही क्षेत्रमा देख्न सकिन्छ ।

धार्मिक, साँस्कृतिक र ऐतिहासिक सम्पदाको अतिक्रमण र कमजोर अवस्था, तटबन्ध, सडक र अन्य विकास निर्माणका कारण नदीमा पहुँच हुन प्रतिबन्ध, नदी कोरिडोरमा आवासीय तथा व्यावसायिक विस्तार लगायतका सामाजिक–सांस्कृतिक समस्याहरू जोडिएका छन् ।

जलविज्ञान सम्बन्धी (हाइड्रोलोजिकल) मोडलिङ

वाग्मती नदी र यसका सहायक नदीहरूको हाइड्रोलोजिकल मोडेलिङ्ग यी नदीका जलाधार (Basin), उपजलाधार (Sub – basin) र भौतिक विशेषताहरूको अनुमान गर्न प्रयोग गरिन्छ । विभिन्न नदी जलाधार, नदि मिसिने विभिन्न स्थान र खण्डहरूमा ५० वर्षमा पुनरावृति अवधि (Return Period) को लागि उच्च बाढी वहाव र अधिकतम दैनिक वर्षा विभिन्न हाइड्रोलोजिकल मापदण्डहरूको क्यालिब्रेसन र प्रमाणीकरण सहित HEC-HMS मा जलविज्ञान सम्बन्धी मोडलिङ्ग प्रयोग गरी अनुमान गरिएको छ । हाइड्रोलोजिकल मोडलिङबाट प्राप्त नतिजाहरू Lacey's सूत्र र मोडेलमा आधारित भइ बाढी डुबान नक्साको आधारमा वाग्मती नदी र यसका सहायक नदीहरूको लागि आवश्यक न्यूनतम वहाव क्षेत्र अनुमान गरिएको छ । वाग्मती नदी र यसका सहायक नदीहरूको साना खण्डहरूमा फरक-फरक चौडाइ र गहिराई (cross section) भएकाले नदी वहाव चौडाइको मोडेलमा आधारित बाढी नक्साबाट प्राप्त परिणामहरू झन् बढी सटिक, उपयुक्त तथा सम्बन्धित स्थानसँग मिल्दो जुल्दो रहेको छ ।

हाइड्रोलोजिकल मोडलमा आधारित बाढी जोखिम नक्सा प्रमाणीकरण गरिएको छ जसमा वाग्मती नदीको गोकर्णेश्वर र गुहेश्वरी वरपरको क्षेत्र मध्यम बाढीको जोखिम रहेको देखाइएको छ, जबकि मनोहरा र वाग्मतीको संगमबाट तल्लो तटमा पानीको गहिराई प्राप्ति सहित मुख्य जलधारा बढ्न जान्छ । विष्णुमती संगमबाट तल्लो तटमा उच्च जोखिम क्षेत्र बढेको छ, जहाँ बाढीको हद बढी देखिन्छ । मध्यम जोखिमको क्षेत्र क्रमशः तल्लो भेग तर्फ बढ्दै गएको छ र मनोहरा र कोड्कुखोलाको संगम नजिकको क्षेत्र उच्च जोखिममा परेको छ । नदी कोरिडोरको धेरैजसो क्षेत्र न्यून जोखिम क्षेत्रको रूपमा रहेको छ, तर नदी करिडोरका केही सानो खण्डहरू, जस्तै हनुमन्ते खोलाको थिमी क्षेत्र, कारखुसी खोलाको कालीमाटी क्षेत्र इत्यादि मध्यम जोखिममा छन् । फराकिलो खण्डको बीचमा साँघुरो चौडाई भएका खोला खण्डहरू बाढीको लागि बढी जोखिममा छन् किनभने यसले पानीको गहिराइ बढ्छ र धेरैजसो माथिल्लो तटीय क्षेत्रमा ठूलो बाढीले डुबानमा पर्छ । त्यसैगरी, ट्राफिक सञ्चालन क्षेत्र (डेक लेभल) उच्च बाढीको स्तरभन्दा तल रहेको नदीमा पुल, कल्भर्ट जस्ता पूर्वाधार निर्माण गर्दा केही पुल र कल्भर्टहरूमा असर परेको देखिन्छ जसले पुलको संरचना र वरिपरिको निर्मित क्षेत्र (Built-up Area) प्रभावित गर्छ । मुख्यतया धोबीखोलामा ल्याण्डस्केप नियन्त्रण र करिडोर सडकका कारण नदीहरूमा असमान किनाराहरू र नदी तटबन्ध कार्यहरू पनि देखिएका छन्, जसले गर्दा धोबिखोलाका तल्लो भेगका धेरै स्थानहरू बाढीको जोखिममा परेको छ । ढल लाइनहरू र नाली पाइपहरू अवरुद्ध हुँदा बाढीको समयमा पानी फर्कने प्रभाव (Backwater effect) र कम वहाव क्षमताका कारण धेरै क्षेत्रहरूमा जोखिम बढाएको छ ।

क्षेत्र वर्गीकरण

नदीको माथिल्लो तटदेखि तल्लो तटसम्मका विभिन्न खण्डहरूमा पहिचान गरिएका सवालहरूको गाम्भीर्यता बदलिएको पाइन्छ । माथिल्लो पहाडमा जङ्गलले घेरिएको क्षेत्र र उपत्यकाको तल्लो शहरी क्षेत्रमा यी सवालहरूको समान महत्त्व छैन । काठमाण्डौ उपत्यका वरपरको पहाडी वन क्षेत्र वाग्मती नदी र यसका सहायक नदीहरूको पानीको मुख्य श्रोत हो । उपत्यकाको फेदीमा रहेका खेतीयोग्य जमीन अहिले शहरी क्षेत्रमा परिणत भई विस्तार हुँदै गएका छन् । काठमाण्डौ उपत्यकाको शहरी विकास परिदृश्य र नयाँ संघीय प्रणालीले शहरी परिवेशमा आमूल परिवर्तन ल्याएको छ । यसबाहेक,

प्रमुख शहरी विकास परियोजनाहरू जस्तै बाहिरी चक्रपथ र नयाँ शहर अवधारणाहरूले शहरको भित्री भागभन्दा बाहिरतिर विकासलाई बढावा दिएको छ । साथै नयाँ संविधान जारी भएपछि गाविस र नगरपालिकाको संरचना विघटन भई महानगरपालिका, उपमहानगरपालिका, नगरपालिका र गाउँपालिकाको नयाँ संरचना कार्यान्वयनमा आएको छ । यस सन्दर्भमा काठमाण्डौ उपत्यकाको जलाधार पर्यावरण र शहरी वृद्धि परिदृश्यको आधारमा काठमाण्डौ उपत्यकालाई तीन क्षेत्रमा विभाजन गरिएको छ — संरक्षण क्षेत्र, उप-शहरी क्षेत्र र शहरी क्षेत्र ।

संरक्षण क्षेत्र उपत्यका वरपरको वन क्षेत्र हो। यस क्षेत्रमा शिवपुरी, फुलचोकी, चन्द्रागिरि र नागार्जुनको जंगल पर्दछ । शिवपुरी नागार्जुन राष्ट्रिय निकुञ्ज पनि यसै क्षेत्रमा पर्दछ। यस क्षेत्रमा प्रायः वन क्षेत्र समावेश छ जसले उपत्यकाको नदी प्रणालीलाई रिचार्ज गर्दछ र यसलाई संरक्षण गर्न आवश्यक छ। उपत्यकाको केन्द्रीय भागलाई सबैभन्दा बढी जनघनत्व र उच्च सहरी वृद्धि दर भएको सहरी क्षेत्रको क्षेत्रमा वर्गीकरण गरिएको छ। यो क्षेत्र प्रस्तावित बाहिरी चक्रपथ पङ्क्तिबद्धताको सिमाना भित्र चित्रण गरिएको छ र बागमती नदीलाई सफा, हरियाली र स्वस्थ बनाउन विकसित शहरी पूर्वाधारसहित सघन शहरी विकासको योजना छ। संरक्षण क्षेत्र र शहरी क्षेत्र बीचको क्षेत्रलाई उप-शहरी जोनको रूपमा वर्गीकृत गरिएको छ जसमा शहरी विकासको दबाब छ तर पानी रिचार्जको लागि यस क्षेत्रमा संरक्षणका उपायहरू कायम राख्नुपर्छ। तसर्थ, यी क्षेत्रहरूमा नदी प्रणाली कायम राख्न उच्च जिम्मेवारी छ।

कार्य योजना

वाग्मती नदी प्रणालीको पुनर्स्थापना र संरक्षणका लागि समग्र दूरदृष्टिका साथ कार्य योजना तयार गरी तीन क्षेत्रहरूका लागि कार्य योजना तर्जुमा गरिएको छ । कार्य योजनाले मध्य क्षेत्रलाई सबैभन्दा बढी जनघनत्व र उच्च शहरी वृद्धि दर भएको शहरी क्षेत्रमा वर्गीकरण गरिएको छ । अरु चार क्षेत्रहरूमा संरक्षण क्षेत्र र उप-शहरी क्षेत्रमा विभाजन गरिएको छ । हरेक क्षेत्रको संरक्षण क्षेत्रमा वातावरणीय सेवालाई निरन्तरता दिँदै अभिवृद्धि गर्ने तथा उप-शहरी क्षेत्रमा नदी पर्यावरणको संरक्षण र शहरी क्षेत्रमा पुनर्स्थापना गर्ने लक्ष्य राखेको छ । सांस्कृतिक सम्पदाको संरक्षण गर्नु पनि यसको उद्देश्य हो । क्रियाकलाप तथा कार्यक्रमहरू चार खण्डमा प्रस्ताव गरिएको छ - नदी संरक्षण र व्यवस्थापन, सांस्कृतिक/सभ्यता पुनर्स्थापना, नदी/पानी गुणस्तर र परिमाण सुधार । तीन वटै क्षेत्रमा मान्य रहेका केही निश्चित क्रियाकलापहरूलाई सामान्य क्रियाकलापको रूपमा समावेश गरिएको छ । यी क्रियाकलापहरू या त साझा अथवा अधिकार सम्पन्न वाग्मती सभ्यता एकीकृत विकास समिति र अन्य संस्थाको क्षमता अभिवृद्धि गर्दै वाग्मती र यसका सहायक नदीहरूको पुनर्स्थापना तथा संरक्षण गर्ने गरी ज्ञान व्यवस्थापनसँग जोडिएको छ । यस कार्य योजनाले अघिल्लो कार्य योजनाले सिफारिस गरेका प्राथमिकताका गतिविधिहरूलाई पनि समावेश गरेको छ।

संरक्षण क्षेत्रका लागि कार्यहरूले साइकल/हाइकिंग ट्रेल मार्फत पारिस्थितिक पर्यटन प्रवर्द्धनलाई प्राथमिकता दिन्छ, जल श्रोत संरक्षण, वर्षाको पानी भण्डारण / हार्वेस्टिङ पोखरी, जल भण्डार बाँधहरू मार्फत भूमिगत जल रिचार्ज बढाउने, गर्रा खेत सुधार मार्फत दिगो भूउपयोग व्यवस्थापन, जैविक खेतीको प्रचार, केही बस्तीहरूको स्थानान्तरण र सांस्कृतिक सम्पदाहरूको पुन: प्राप्ति, पुनर्स्थापना र संरक्षण आदिमा जोड दिएको देखिन्छ । त्यसैगरी उप-शहरी क्षेत्र र शहरी क्षेत्रका कार्यहरूले नदी करिडोरमा मनोरञ्जन सुविधासहितको हरित विकासलाई प्राथमिकता दिएको छ । नदी क्षेत्र संरक्षण गर्न नदी मार्गको अधिकारको कार्यान्वयन, बायोइन्जिनियरिङले हरित क्षेत्रको विकास, नदी किनारमा करिडोर यातायात प्रणालीको विकास, इन्टरसेप्टर र WWTPs को निर्माण मार्फत नदीमा प्रत्यक्ष विसर्जन रोक्न ढल व्यवस्थापन, कडा कानून कार्यान्वयन गरी नदीमा ठोस फोहोरको प्रत्यक्ष विसर्जनलाई नियन्त्रण गर्ने, दिगो भूउपयोग व्यवस्थापन र सांस्कृतिक सम्पदाहरूको पुन: प्राप्ति, पुनर्स्थापना र संरक्षण गर्ने कार्यहरू पर्दछ ।

बजेट

यो कार्य योजना आगामी बीस वर्षको लागि तर्जुमा गरिएको छ । यस कार्य योजनाका लागि योजनाहरू र बजेटलाई चार कार्यान्वयन अवधिमा विभाजन गरिएको छ - छोटो अवधि (०-५ वर्ष), पहिलो मध्यावधि (६-१० वर्ष), दोश्रो मध्यावधि (११-१५ वर्ष) र अन्तमा दीर्घकालीन (१६-२० वर्ष)। प्रस्तावित गतिविधिहरूको कार्यान्वयनका लागि छोटो अवधिमा रू. १ खर्ब ४७ अर्ब ६६ करोड, पहिलो मध्यावधिमा रू. ६६ अर्ब २ करोड ५० लाख, दोश्रो मध्यावधिमा रू. ५१ अर्ब ४३ करोड १० लाख र दीर्घकालीन कार्यान्वयन अवधिमा रू. १४ अर्ब ४८ करोड ७० लाख आवश्यक पर्ने देखिन्छ । बीस वर्षे कार्य योजनाका लागि आवश्यक कूल अनुमानित बजेट रू. २ खर्ब ७९ अर्ब ६० करोड ५० लाख रहेको छ । प्रस्तावित क्रियाकलापहरूको क्षेत्रगत कार्यान्वयनको आधारमा संरक्षण क्षेत्रको लागि लगभग रू. १ खर्ब २१ अर्ब ९३ करोड ४० लाख आवश्यक पर्नेछ, उप-शहरी क्षेत्रका लागि रू. ४६ अर्ब १३ करोड २० लाख, शहरी क्षेत्रका लागि रू. १ खर्ब १० अर्ब ४२ करोड १० लाख र सामान्य परियोजनाहरूको लागि रू. १ अर्ब ११ करोड ५० लाख आवश्यक हुने देखिन्छ ।

कार्यान्वयन रणनीति

वाग्मती कार्य योजनाको प्रयासको दीर्घकालीन स्थायित्व योजना तर्जुमा र यसको कार्यान्वयनबाट सुनिश्चित गर्न सकिन्छ तर यसमा प्रशासनिक, व्यवस्थापकीय र अन्य सहयोगी तत्वहरूको पनि ठूलो भूमिका रहन्छ । यस अन्तर्गत नीति र कानून; संस्थागत व्यवस्था; सरोकारवालाको संलग्नता; विज्ञान, अनुगमन र अनुसन्धान; नियामक नियन्त्रण र अन्य योजना प्रणालीहरू मार्फत कार्य योजनाको रणनीतिका तत्वहरूलाई प्रभाव पार्ने उपकरणहरू समावेश गरिएको छ ।

कार्य योजनाको प्रभावकारी कार्यान्वयनका लागि विभिन्न रणनीतिहरू (क्रियाकलाप र लक्ष्य प्राप्ति, जिम्मेवारी, निजी क्षेत्र र नागरिक समाजको लागि प्रवर्द्धन रणनीति, बजेट, अनुगमन र प्रतिवेदन, र रणनीति समीक्षा र अनुकूलन) लाई प्राथमिकता दिइएको छ । अधिकार सम्पन्न वाग्मती सभ्यता एकीकृत विकास समितिलाई प्राविधिक क्षमता, वित्तीय श्रोत र कानुनी तवरले सुदृढ पार्ने प्रयास गरिएको छ । संस्थागत सुदृढीकरणका लागि यस कार्य योजनामा विकास सरोकारवालाहरूबीचको अधिकारको विवादलाई न्यूनीकरण गर्न समन्वय शाखा, वातावरण विज्ञ सहितको वातावरण शाखा, भूगर्भविद, ल्याण्डस्केप योजनाविद्, सूचना प्रविधि शाखामा भू-सूचना एकाई वा टोली समावेश गर्ने प्रस्ताव गरिएको छ । HPCIDBC को हालको संगठनात्मक संरचनामा भूवैज्ञानिक विशेषज्ञ, Landscape Planner, GIS इकाइ वा GIS टोलीसँगको वातावरण इकाई ब्यबस्थापन गर्ने प्रस्ताव गरिएकोछ । अझ महत्त्वपूर्ण कुरा, सरकारले लक्ष्य र अन्ततः दूरदृष्टि प्राप्त गर्न कार्य योजनाको प्रभावकारी कार्यान्वयन सुनिश्चित गर्न पर्याप्त श्रोत साधनको सुनिश्चितता गर्नुपर्छ ।

अनुगमन योजना

कार्य योजनाको प्रभावकारिताको मूल्याङ्कन गर्दै अनुकूलन व्यवस्थापनलाई निर्देश गर्नका लागि परिभाषित र मापनयोग्य उद्देश्य प्राप्तिको अनुगमन गर्नु महत्वपूर्ण हुन आउँछ । अनुगमन र मूल्याङ्कन योजनाले सदैव कार्य योजनाको सर्वोपरी उद्देश्य प्राप्ति तर्फ, निश्चित पुनर्स्थापना रणनीति तर्फ र कार्यान्वयन गरिने निश्चित पुनर्स्थापनाका प्रयास तर्फ लक्षित हुनु पर्दछ। सम्बन्धित निकायबाट नियमित अनुगमन र त्यसै गरी कार्यान्वयनकर्तालाई नियमित पृष्ठपोषण आवश्यक हुन्छ । अधिकार सम्पन्न वाग्मती सभ्यता एकीकृत विकास समितिले समग्र अनुगमनको जिम्मेवारी लिनुपर्ने हुन्छ । यसका साथै सहभागितात्मक वा संयुक्त अनुगमन प्रणाली बसाल्नु पर्ने हुन्छ, जहाँ सम्बन्धित सरोकारवालाका प्रतिनिधिहरूले सहभागी भएर अनुगमन गर्न सकोस । यो प्रतिवेदनले वाग्मती कार्य योजनाको प्रस्तावित क्रियाकलाप र कार्यहरूलाई प्रमाणित गर्ने

माध्यम पहिल्याएको छ । कार्यान्वयन गर्ने प्रत्येक निकायले प्रभावकारिताका लागि आफ्नो अनगमन योजना तर्जुमा गर्नुपर्ने हुन्छ ।

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

CHAPTER-I

1. INTRODUCTION

1.1. BACKGROUND

Bagmati is the river system in the Kathmandu Valley comprising of 57 rivers and rivulets as its tributaries. There are many heritage sites and traditional settlements on its bank that are rich with numerous tangible and intangible heritages, collectively termed as 'Bagmati Civilization'. One of the significant sites is the Pashupatinath temple area, which is enlisted as a World Heritage site. Bagmati, the holy river of the Hindus and a major source of water for the Kathmandu Valley, has been polluted due to human actions such as settlement along the river, unplanned urbanization in river basin and disposal of untreated sewage and solid waste into the river system. Apart from that, extractions of sand from river bed, construction of public infrastructure in river space and informal squatter settlements along the banks have deteriorated the river environment and the water security.

Joint initiation of citizen and government to make Bagmati a pollution free river resulted in formation of a high-powered Committee for Implementation & Monitoring of Environmental Improvement in Pashupati Area back in 2051 B.S., which is now functioning as High-Powered Committee for Integrated Development of Bagmati Civilization (HPCIDBC). It builds 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. GoN approved the Bagmati Action Plan (2009-2014) in 2066 B.S, which has introduced a concept of zonation of the river system within the Kathmandu valley. It was prepared by HPCIDBC in collaboration with National Trust for Nature Conservation (NTNC). It was established as an important guiding conceptual framework document for scientifically and systematically restoring and conserving the Bagmati River and its tributaries within the Kathmandu valley. It was formulated with the aim to restore and conserve the Bagmati River and its tributaries in an integrated and coordinated approach. The Action Plan covers the Bagmati river system from Shivapuri hill to Katuwal Daha.

Bagmati River is considered as the source of Nepalese civilization and urbanization. It begins at Bagdwar 15km northeast of Kathmandu, exit from Chovar gorge flowing downward through Southern Terai plain of Nepal and merges into mighty Ganges in India. It is holy to both Hindus and Buddhist of Nepal. It is one of the important river systems of Nepal with high cultural and aesthetical values. However, in the absence of planned and coordinated restoration and conservation efforts, environmental degradation and cultural erosion of the Bagmati river system has continued unabated. The critical issues of Bagmati River and its tributaries are primarily related to river ecosystem, river side land use change, preservation of culture and heritage and institutional related arrangements.

Several efforts were made in the past for the conservation of Bagmati River and its tributaries. With the formulation of Bagmati Action Plan 2009-2014, number of its activities have been implemented and is still ongoing till date. Different studies have been conducted; several plans

and programs, projects have been formulated and implemented, several clean up campaigns and awareness programs have been conducted and different policies and acts are promulgated by various agencies for the conservation of the Bagmati River. With the guidance of BAP 2009-2014, various efforts are made in reconstruction/ restoration of monuments and heritage sites, landscaping and river beautification along river corridors, construction and remediation of interceptor and existing sewers, up-gradation/ construction of Waste Water Treatment Plants, construction of new sewers in WWTPs service area, river training works, road and green belt along river banks, water storage and increase recharging area like Dhap and Nagmati Dam and others. Despite several interventions by HPCIDBC, Kathmandu Upatyaka Khanepani Limited (KUKL), Kathmandu Valley Development Authority (KVDA), Local Governments, various NGOs/INGOs and other organizations, the Bagmati River and its tributaries remain critically polluted and its space continues to be encroached upon for different purposes.

The key issues and challenges identified by BAP 2009-2014 are more or less similar with only variation in their extents due to change in urban context with increased built-up density and land use conversions. Since the scenarios within the valley have changed, the previous action plan might require some updates and additional interventions to achieve the desired outcomes. In this context, HPCIDBC has initiated this assignment to thoroughly revise and update the Action Plan with a planning perspective for next 20 years. This assignment intends to establish GIS based inventory system, prepare hydrological model of the river system and develop new Bagmati Action Plan.

1.2. OBJECTIVE OF WORKS

The Consultant's understanding of the project objectives and the Terms of Reference is based on the review of the Terms of reference, HPCIDBC policy documents, other relevant documents such as Bagmati Action Plan (2009-2014), website of HPCIBDC as well as previous experiences of consultant firm in similar projects. The main objective of the current assignment is to review and update the Bagmati Action Plan with a planning perspective for next 20 years and a set vision beyond. More specifically, the objectives of the assignment are to conduct following major activities.

A. Establish GIS based inventory system
B. Prepare hydrological model of the river system.
C. Develop new Bagmati Action Plan

For better understanding of the objectives of the services, the Consultant refered to current Bagmati Action Plan (2009-14) with particular attention to key issues of Bagmati River and its tributaries, zoning of Kathmandu valley river system, action plan, implementation strategies, monitoring plans and budget plans.

The Consultant give due consideration to the various problems and weakness experienced in these already implemented or on-going projects and lessons from them will be effectively and efficiently applied for an appropriate solution in the proposed project. This will be the basic innovative approach, which will be endeavored to make them an exemplary proposition for future reference. Also review of all previous works/projects undertaken by other Consultants made to assess the problems encountered during the implementation of such works/projects. The lesson learned from such experiences are duly acknowledged and accounted for in the present works.

1.3. SCOPE OF WORK

The scope of works to be carried out by consultant for the assignment are described in following activities:

A. Activity 1: Establish GIS based inventory System

- Acquire a high-resolution GIS map of the entire Bagmati river system within the area of HPCIDBC jurisdiction. In addition, the GIS map of other rivers of the Kathmandu Valley need to be acquired and studied also.
- Prepare complete inventory of existing infrastructures, tangible and intangible heritages related to Bagmati river system
- Locate all existing infrastructures, tangible heritages and indicate routes of intangible heritage including festival and crematory procession routes in GIS map.
- Prepare complete land inventory, including type and ownership of land and cadastral details of land within Right of River Ways of Bagmati river system.
- Prepare GIS based land mapping of Bagmati river system and other major rivers of the Kathmandu valley in consultation with the HPCIDBC office.

B. Activity 2: Conduct geo-technical studies and prepare hydrological model of the river system

- Conduct geo-technical studies of HPCIDBC coverage area including soil patterns, measures to ensure soil stability and recommend regulatory remedies for current sand mining practices
- Conduct detail hydrological study of the river system of the Kathmandu Valley covering surface and shallow underground water systems (raj kulo, water sources of stone spouts etc.) within Kathmandu valley
- Prepare digital hydrological 3-D model of the river system with consideration of critical return periods within 50 years.
- Recommend required Right of River ways considering optimum return period and other planning and building by-laws based on the hydrological studies
- Suggest necessary actions to maintain river flow and control flood risk/hazards

C. Activity 3: Develop New Action Plan

- Prepare GIS base map, of appropriate scale, of river system showing current land use and topography, locate all important places/areas of heritage value, green open spaces, all existing physical, social and economic infrastructures and services.
- Identify and assess critical, sensitive and other natural resources including parks, green belts, recreational area, along with strategies for their protection, preservation and stewardship against the adverse impact of future development and land use changes. Show locations and calculate future requirements of such resources.
- Review current Bagmati Action Plan and its implementation status and validate activities undertaken by HPCIDBC post 2014 till date
- Identify constraints and challenges in implementing current BAP
- Identify stakeholders and conduct number of stakeholder meetings to identify current need and course of actions for new BAP
- Review the zoning of Bagmati river system and analyze its significance in present context. Update the zoning to address present and future context
- Set overall vision for restoration and conservation of Bagmati river system with defined goals, objectives and activities in each zone
- Analyze stakeholders contribution potential and propose suitable model for their fair and participatory involvement
- Suggest measures to cope with climate change issues within the river system
- Identify potential development areas and model of land development and develop River side land use (Green land use and Blue land use) with reference to socioeconomic conditions also
- Enlist necessary actions to meet set goals and objectives including phasing (Immediate, medium and long term) of all activities, deliverables, outputs, timelines and budget requirements

- Recommend appropriate plan implementation and monitoring strategy and mechanism
- Prepare budget planning with identification of potential sources and funding arrangements
- Recommend Operation and Maintenance plan of built infrastructures and other Assets Management Plans with due consideration of participatory approach and GESI requirements
- Propose necessary legislative arrangements with appropriate strategies and plans
- Develop an Institutional development plan

1.4. LIMITATION

Bagmati River and its tributaries cover diverse geographical area, including forest, distant settlements, and unhabituated locations. Considering the importance of the action plan maximum possible area affecting flow, health and civilization of Bagmati River area is included in the study. Though for the best outcome, coverage of the study should contain as far as maximum number of socio-economic and environmental issues and the geographical area from the catchment, but hurdles like time frame, resource limitation, priority of the study etc. limits coverage of the study. Followings are some limitation of the study;

- Study does not include all of the Rivers within valley; rather it covers previously studied area and additionally rapidly urbanizing rivers within the valley. Some of the locations with urban expansion which can influence water quality of the river are included in the study. The study is focused on 6^{th} order stream, however, strategic conservation planning is recommended for stream with lower order also.
- Issues regarding household and individual community are concerns of the study, but do not affect plan preparation and implementation in broad scale, so are not included in plan preparation procedure. Instead HH survey and FGD at community level were conducted to collect information and address problem associated with local level.
- Though intangible heritage route are prime concern of the study but study cannot ensure about the inclusion of all existing such intangible assets from the valley.
- As per ToR, Hydrological modelling was done for 50 years return period. If considering lower value of return period, water way required for river system will be lowered.
- Analysis of water quality is based on secondary available information; this study has not conducted primary survey regarding water quality from Bagmati.
- Data related underground structures in valley are included on the basis of acquisition of the data from relevant sources; primary survey of such structure was not possible from the time and resource limitation.
- Issues regarding squatter settlement are handled as per pre-government decision and study does not include such settlement in survey and analysis does not include primary information regarding such settlement.

Gaps and overlapping of land parcels while overlaying the free sheet cadastral. Moreover, some land parcels overlaps in the river areas as a result of river channel migration.

1.5. STRUCTURE OF THE REPORT

The report is organized into planning Report and three Supplementary volumes that address the expected outcomes of the study according to the set objectives and scopes. These volumes are further organized into various chapters, as required, to include the overall aspects of the plan.

- **Planning Report:** describes the methodology, study area delineation and introduction of the study area in detail. This document spells out the topography, geology and soil, climate, hydrology, natural hazard, population, infrastructure assets like corridor road, sewer network, waste water treatment plants, river training along with information on cultural heritage and monuments, urban scenario and squatter settlements. The report spells out the key issues related to the river environment and socio-economic issues. It also includes the information

on soil pattern and stability, liquefaction and hydrological modeling. The report is the compilation of the existing scenario of Bagmati River System, major issues and challenges, land use zoning, and proposed activities and actions to support the vision for 20 years plan. The report also provides the implementation strategy, monitoring plan and institutional development plan for the implementation of 20 years Bagmati Action Plan.

- **Supplementary Volume I - Inventory Report:** describes the baseline information of the existing physical infrastructure, social, economic, environmental infrastructures
- **Supplementary Volume II - Hydrological & Flood Modelling Report:** describes the hydrological modelling of Bagmati basin and recommended the minimum water way of the river with Bagmati basin of Kathmandu Valley
- **Supplementary Volume III (A/B/C/D/E) - Mapping:** presents the base map and other various thematic maps such as location map, existing land use, social infrastructure, road network, culture and tourism map, natural drainage and watershed map, slope elevation, resource map, proposed zoning map and flood inundation map.

CHAPTER-II

2. Methodology

The consultative as well as participatory approach has been adopted for the preparation of Bagmati Action Plan. Field survey and stakeholder consultations were conducted to identify the existing scenario and accordingly the plans and programs are identified to focus onto the development of implementing strategies for Bagmati River System. The action plan covers various aspects of the planning area (**Figure 2-1**).

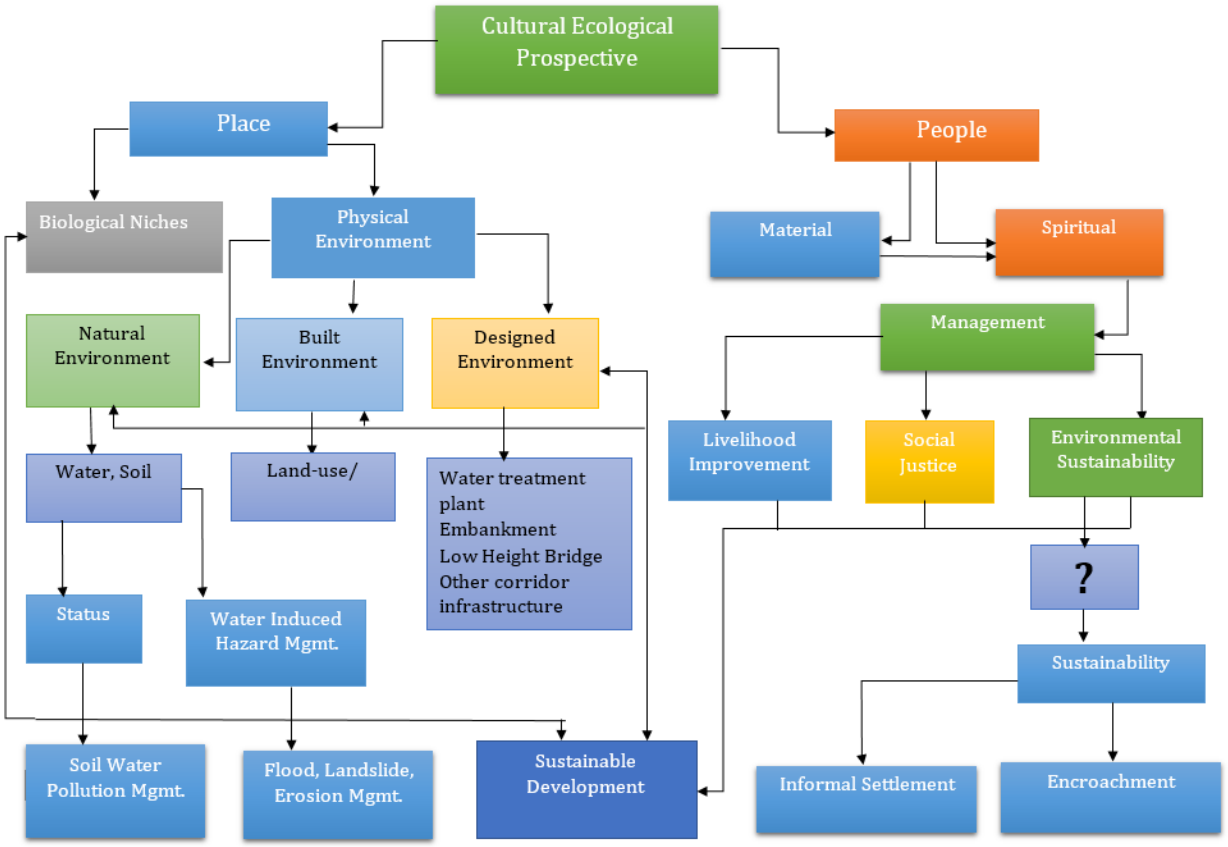


Figure 2-1: Conceptual Framework for Study

The following approaches were adopted for the preparation of Bagmati Action Plan:

a) The foremost step of the planning process was the review of Bagmati Action Plan 2009-2014. Along with this the information about the Kathmandu Valley, Bagmati River and its tributaries available from different sources were reviewed and analyzed. The reports and research papers related to urban development, rivers and water sources, hazard risk analysis, sewerage network and waste water treatment plants, solid waste management, cultural heritage and monuments of Kathmandu valley were reviewed and relevant data and information were collected. Global case studies on river restoration and conservation were also reviewed. Secondary data and information were collected from different agencies

including HPCIDBC, KVDA, KUKL, Water and Energy Commission Secretariat (WECS) and others. Census reports of Central Bureau of Statistics (CBS) were referred for population data. Climate data were obtained from Department of Hydrology and Meteorology (DHM).

b) Digital maps and satellite imageries including topographic maps, aerial photographs, geological maps, land use maps and other relevant thematic maps of the study area were obtained from different sources like Department of Survey (DoS), Department of Mines and Geology (DMG), International Center for Integrated Mountain Development (ICIMOD) and others. The collected maps and photographs were studied and collated with respect to the objectives and deliverables of this assignment. Satellite imagery of 5m resolution was acquired from Planet Earth for preparation of digital base map. Cadastral data maintained by concerned agencies were acquired.
c) Corridor of 100-200m from existing river channel was delineated on both sides for inventory. Questionnaire and checklists were prepared for data/information collection during field survey, key informant interview, focus group discussions (FGD) and stakeholder meetings.
d) Intensive field surveys were conducted along the rivers to collect information on the existing infrastructures and services, tangible and intangible heritages, green open spaces and other primary data. Environmental studies, socioeconomic studies, geo-technical studies were also performed for the identification of issues related to land, infrastructures, heritages, water ways, hazard risks and vulnerability etc.
e) Cross section surveys were conducted using DGPS and Total Station for hydrological analysis.
f) Series of meetings and discussions were organized with local units (municipal and ward level), HPCIDBC and its project offices, KVDA, KUKL and other concerned governmental and non-governmental organizations and experts of various thematic areas. The key issues, challenges and necessary actions were discussed during the meetings.
g) GIS based inventory system was established based on the field inventory.
h) Digital hydrological 3-D model was prepared using Hydrologic Modeling System (HEC-HMS) software with consideration of critical return periods within 50 years. Flood inundation maps were prepared and the required Right of River Ways was recommended.
i) Complete land inventory was prepared with the integration of cadastral details of land within the Right of River Ways of Bagmati River and its tributaries.
j) Zoning of Bagmati River System was updated.
k) Assets Management Plan including Operation and Maintenance plan of built infrastructures was prepared.
l) SWOT analysis, population trend and projections, vulnerability assessments, spatial analysis and needs assessment are done and necessary actions were identified. Investment plan was prepared with phasing of the activities, estimated costs and possible mode of financing.
m) Institutional development plan was prepared and implementation plan, monitoring strategy and mechanisms was recommended.

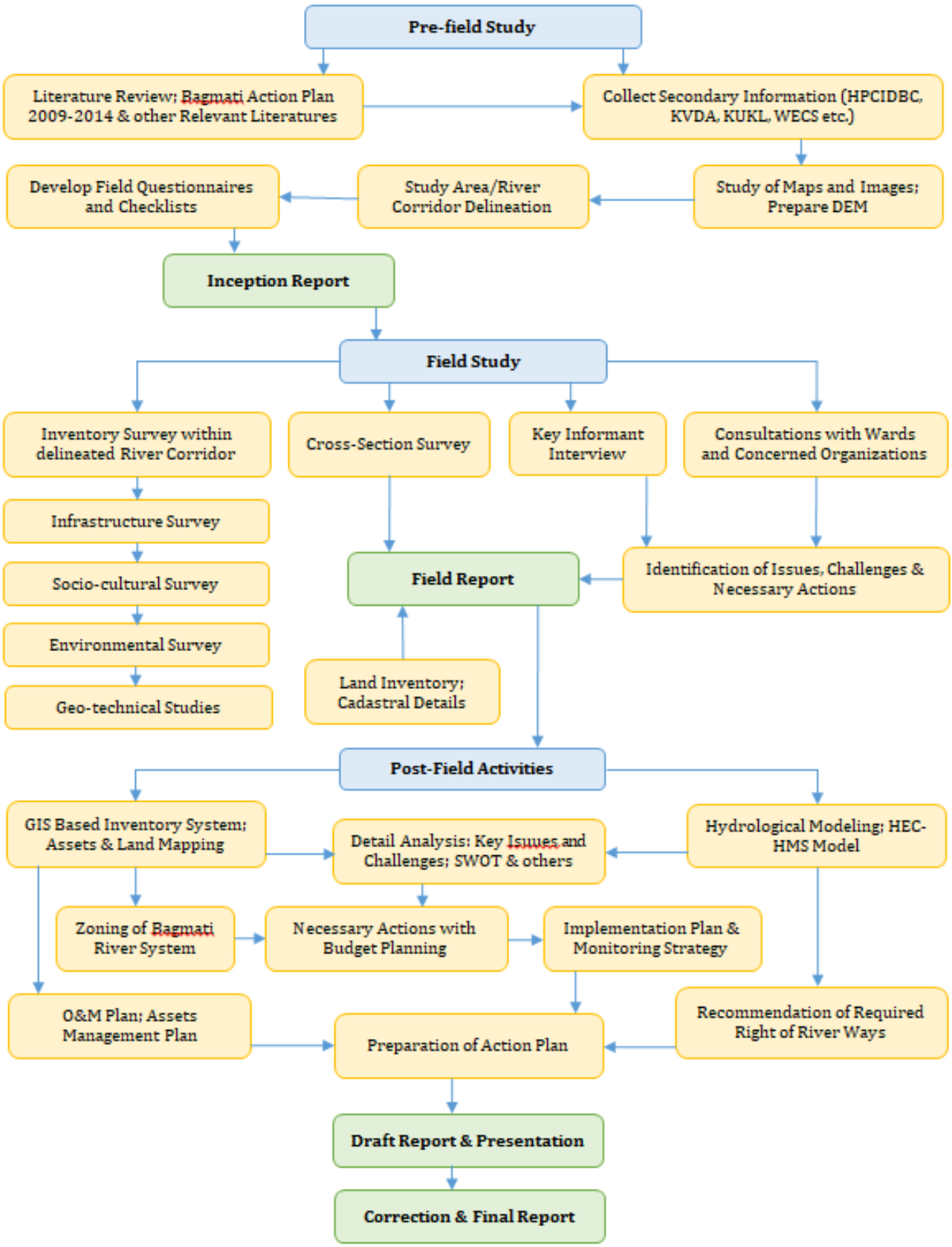


Figure 2-2: Flow chart of the study methodology

CHAPTER-III

3. EXISTING SCENARIO OF STUDY AREA

3.1. BACKGROUND

Kathmandu Valley is situated in Bagmati Province of Nepal. The valley floor is roughly elliptical in shape and is dissected by rivers/streams originating from surrounding mountains. Considering the mountain surrounding valley, it is oval shaped with radius of around 30 Km. The slope of the surrounding mountain ranges from moderate to steep, however, valley floor normally is flat land except the river edge. The southern and south-west hill-slope of the valley has higher slope. The elevation ranges from 1203 m to 2737 m with an average of 1548 m.

The Kathmandu Valley has mild climate most of the year. The annual mean temperature ranges between 12.36°C to 19.03°C. The annual precipitation ranges from minimum of 1546 mm to maximum of 2121 mm.

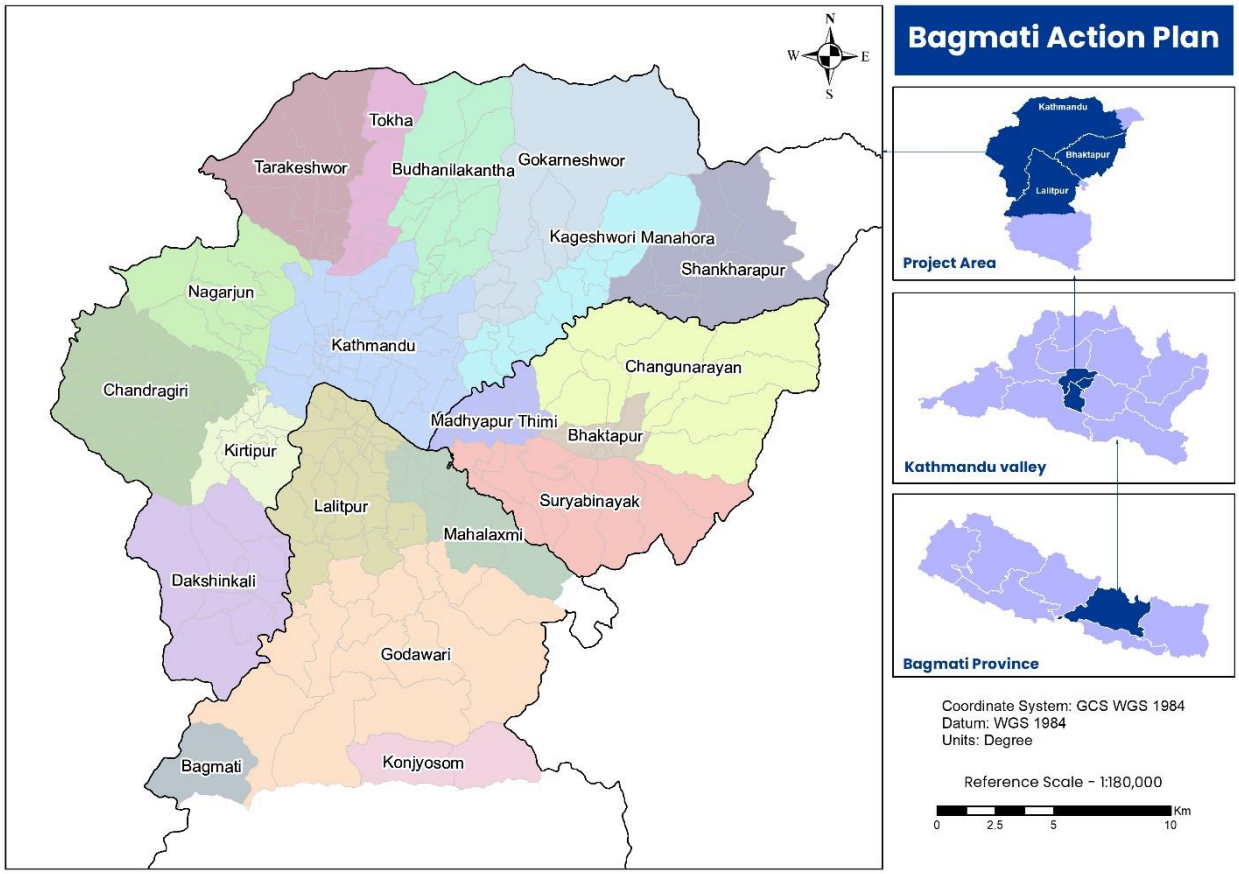


Figure 3-1: Location map of study area

Administrative Division

Kathmandu valley comprises of 2 metropolitan cities - Kathmandu and Lalitpur, 16 municipalities- Bhaktapur, Budhanilakantha, Chandragiri, Changunarayan, Dakshinkali,

Godawari, Gokarneshwor, Kageshwori Manahora, Kirtipur, Lalitpur, Madhyapur Thimi, Mahalaxmi, Nagarjun, Shankharapur, Surya Binayak, Tarakeshwor and Tokha and 2 rural municipalities- Bagmati and Konjyosom.

Historical Background of Kathmandu Valley

The myth has it that Kathmandu valley was once a lake surrounded by hills and that in Satyayuga Vipashwi, the first of the seven mortal Buddhas came to Nepal, took abode in Jamacho hill and sowed the seed in the great lake of the serpents during full moon day of April. A lotus flower appeared from that seed which was later known as "Swayambhu" – the self-existent. This happened on the full moon day of October. People still climb Jamacho on April full moon day to mark the sowing of the seed and on October people throng Swayambhu. In the following era of Tretayuga, Vishvabhu Buddha, who took up abode in Pucva Mountain and offered one lakh flowers to Swayambhu, predicted the drain of lake. Then came Manjushree from China who drained the lake by slashing the rock hill in Chobar by his Pragyakhadga, the sword of wisdom. It is believed that the lake was home to great serpents and with the draining, many left the valley, however Manjushree persuaded Karkotaka (the king of serpents) to reside in a pond known as Tau daha in Chobar and to ensure the prosperity of the valley. Then came Karkuchanda Buddha to take up abode on Sipucva mountain but he did not find water to consecrate his disciples so he thrust his thumb into the rock and there flowed the river Bagmati on the day of vernal equinox. After consecrating his disciples he threw up their hair and where it fell a stream came forth which was called Keshavati, the stream of hair (Bagmati, 1995).

The geographical study of the valley do suggest that it was once a lake and most probably due to the cleavage created to the surrounding mountain caused by the earthquake, the water was slowly drained out creating a habitable space. The fertile soil gave way to lush green grasslands and the cowherd form the higher slopes descended down to feed their cows and thus slowly the valley was inhabited. With time the trade routes developed through the valley connecting southern plains with the northern high plateau of Tibet. This movement was of tremendous importance in the development of culture, art, architecture, literature to name the few.

It is clear that the early settlers settled near the river banks. Of all the rivers Bagmati, Bishnumati and Hanumante are of major importance because it's on their banks that the historic settlements of Patan, Kathmandu and Bhaktapur developed. Bagmati and Bishnumati flowing in the Kathmandu Valley are regarded as the holiest of all by Nepalese society. In "Nepal Mahatmaya" Bagmati has been depicted as the holiest river – one gets fruit of Bajpey and Ashwamegh Yagya if one takes dip in their stretch. Likewise, in "Pashupati Puran" it has been said that one gets spiritual, physical and divine power and gets rid of drudgery just by taking bath in Bagmati River. Similary, Bishnumati has been described as being emanating from the feet of Lord Vishnu is purest of pure. Likewise, "Nepal Mahatmaya" states that one is granted for Vishnu Lok after taking holy dip in Bishnumati (S. Amatya, 2003). The river edges are long understood as places to attain salvation and the dying to would desire to die in one of the tirthas in the lure to attain moksa. As such the river edges and mainly confluences of the valley sees many tirthas, temples and ghat development.

There are numerous lakes and ponds in the valley like Indra daha of Dahachowk, Matatirtha daha, Manichuda daha, Mahadev Pokhari, Tau daha to name the few which are natural formations to hold water. As for the manmade ponds, excavation in Satyanarayan temple in Handigaon mentions that there used to be ponds in the area and this could probably date before the Lichavis arrived here. The art of constructing the pond was continued through Lichhavi to Malla and numerous such ponds were created. For example, Rani Pokhari with Balgopaleshwara temple at its center is probably the largest pond constructed in Malla period.

The earliest settlers of the Kathmandnu valley are known as Gopalas or cowherd followed by Kiratas, after which Lichhavis from Vaishali ruled the valley from 1st cent. A.D. to 8th cent. A.D. The Lichhavi era is of importance because of their contribution in the development of pit conduit water supply system. Although historians agree that the word "Tilamaka" is non-sanskrit word and was probably a Kirat word whose meaning is similar to water canal or a water way which suggest that system of bringing water for far away source to the city was probably in use already in the valley before the Lichhavis arrived. But it is during the Lichhavi period that that system flourished and numerous pit conduits and extensive water canal projects were carried on by the Kings and their future heirs. The oldest inscription relating to the water conduit comes from Manga hiti dated 570 AD by Bharbi, grandson of King Mandeva. These pit conduits mark the cross roads and major public spaces of the town. The pranali or canal systems developed to bring water to these conduits are technical genius of that time. For instance the Raj kulo bringing water from as far as Lele river of Lembatigrama were under the royal jurisdiction as mentioned in the Tanga hiti inscription of Jayadeva II. This canal brought the water which fed the saptapatal pukhu situated around the Lagan thur to the south of ancient Patan city. From this pond the water was channelized through local underground terracotta canals to feed the pit conduits were the water were allowed to flow through a stone spout. Such raj kulos are to be found in all major settlements of the valley. Within the city of Patan the celebration of rain god Bunga dya or Rato machindranath is closely associated with the water supply system. The myth relates that the god was brought to Nepal from Assam by the King Narendradeva, tantric Bandhudatta and a Rathachakra Jyapu to end the twelve year drought in the valley. Tiwari, 2015 mentions that with the start of the Jatra it was originally mandated that the pukhu in Pulchowk be fully filled and that the water kept running at Patan Sundhara indicating the system of repair and maintenance of these canal systems.

The biggest festival related to water culture is that of Janai purnima, on this day almost all of the residents of the valley irrespective of their caste or creed visit the holy ponds or rivers to take a dip or pay homage to the god. It is the major festival of Gosaikunda tirtha. SImialarly another major festival relating to water culture is that of sithi nakha which falls on Jestha shukla sasthi. During this day the newars of the valley clean the water sources like ponds, Jaldronis, pit conduits, wells followed by ritual worship and feasting of delicacies made of lentils. There are environment aspects associated to this festival too as during summers diseases would spread rapidly and mosquitoes would breed in stagnant water and by cleaning them with the advent of summer such misfortunes are prohibited. The rivers, water sources and water culture are the soul and spirituality of the valley as such they demand respect and culture sensitive protections and interventions only.

KVDA has covered the area of KVDA jurisdiction as 721 sq.km. covering the entire Kathmandu and Bhaktapur Districts and approximately 50% land area of Lalitpur districts. Geographically the valley extends from 27°49'4" to 27°31'42" latitude and from 85°11'19" to 85°33'57" longitude in the mid-mountain physiographic region of Nepal. (KVDA)

In this study, the river system of Bagmati within Kathmandu Valley is the catchment area or influence area of the project which is 672.34 sq.km and for the detail study total administrative area of ward is considered within study area, so the area of study area is 714.20 sq.km.The detail study area covers of following local units.

Table 3-1: Local unit of study area

S. N.	Local Units	Type	Total Number of Wards	Number of Wards Included in the Study Area	Area of Local Unit (sqkm)	Study area of Local Unit (sqkm)
1	Kathmandu	Metro city	32	32	49.45	49.45
2	Kirtipur	Municipality	10	10	14.76	14.76
3	Dakshinkali		9	9	42.68	42.68

S. N.	Local Units	Type	Total Number of Wards	Number of Wards Included in the Study Area	Area of Local Unit (sqkm)	Study area of Local Unit (sqkm)
4	Chandragiri		15	15	43.92	43.92
5	Nagarjun		10	10	29.85	29.85
6	Tarakeshwor		11	11	54.95	54.95
7	Tokha		11	11	17.11	17.11
8	Budhanilkantha		13	13	34.80	34.80
9	Gokarneshwor		9	9	58.50	58.50
10	Kageshwori Manahora		9	9	27.38	27.38
11	Shankharapur		9	7 (except ward 1 & 2)	60.21	60.21
12	Bhaktapur		10	10	6.89	6.89
13	Surya Binayak		10	10	42.45	42.45
14	Madhyapur Thimi		9	9	11.47	11.47
15	Changunarayan		9	9	62.98	62.98
16	Lalitpur	Metro city	29	29	36.12	36.12
17	Mahalaxmi	Municipality	10	9 (except ward 10)	26.51	26.51
18	Godawari	Municipality	14	14	96.11	96.11
19	Konjyosom	Rural Municipality	5	2 (except ward 1-3)	44.16	44.16
20	Bagmati		7	1 (except ward 2-6)	111.49	10.84

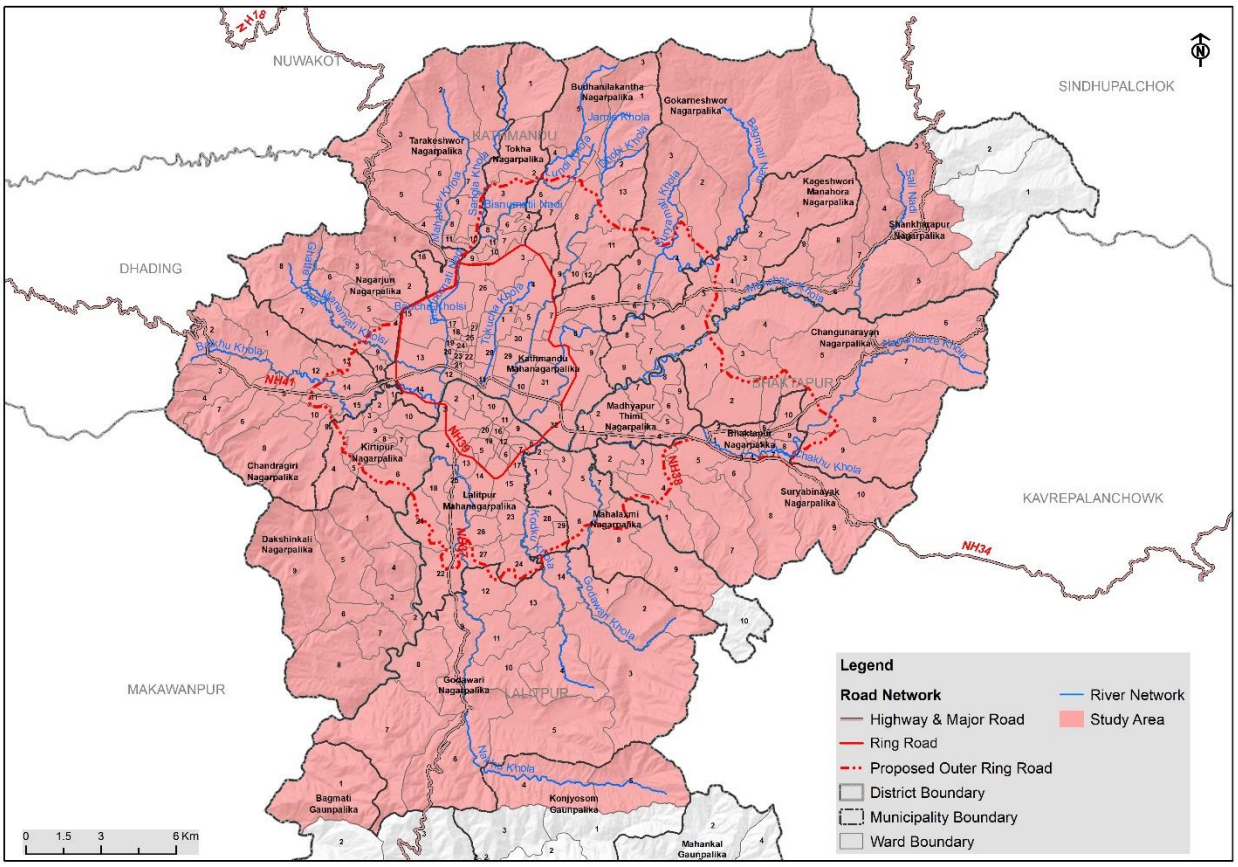


Figure 3-2: Study area Map for BAP

3.2. GEOPHYSICAL CONTEXT

3.2.1. Geology and Soil

Kathmandu Valley is an intermontane basin, which comprises unconsolidated sedimentary deposits in central part and is surrounded by bedrocks in the periphery. Thus, the geology of the valley can be broadly classified into two categories: hard basement rocks and soft sedimentary sequences. The peripheral hilly area of the valley comprises low to medium grade metamorphic rocks and intrusive rocks belonging to Lesser Himalayas as well as sedimentary rocks equivalent to Tibetan Tethys Zone (Stocklin &Bhattarai, 1977). Stratigraphically, these bedrocks can be divided into two groups namely, the Bhimphedi Group and Phulchauki Group of the Kathmandu Complex (Stocklin &Bhattarai, 1977; Stocklin, 1980). Underlying Precambrian metamorphic rock sequences are transitionally changed to middle Palaeozoic sedimentary rocks that are equivalent to the Tibetan-Tethys Zone on the upper part (Joran Stöcklin, 1980) in this area. As in the peripheral hills of Kathmandu Valley, bedrocks are also exposed in the form of small isolated hillocks within the soft sediment of basin such as in Balkhu, Swoyambhu, Gokarna, and Pasupatinath. The stratigraphy of basement rocks with main composition is presented in Table 3-2.

Table 3-2: Stratigraphic subdivisions of the hard rock (Stocklin & Bhattarai, 1977; Stocklin, 1980)

Rock unit	Group	Formation	Thickness (m)	Main Lithology	Age
Kathmandu Complex	PHULCHAUKI GROUP	Godavari Limestone	300	Limestone, dolomite	Devonian
		Chitlang Formation	1000	Slate	Silurian
		Chandragiri Limestone	2000	Limestone	Ordovician
		Sopyang Formation	200	Slate, Calc-phyllite	Cambrian
		Tistung Formation	3000	Metasandstone	
	T R A N S I T I O N				
	BHIMPHEDI GROUP	Markhu Formation	1000	Marble, Schist	Precambrian
		Kulikhani Formation	2000	Quartzite, Schist	

Source: Stocklin & Bhattarai (1977); Stocklin (1980)

The central basin part of the valley is filled with soft sedimentary deposit that comprises semi-consolidated fluvio-lacustrine sediments. The depth of valley sediments is more than 650 m. at the central part of the valley, under Baneshwor, which gradually decreases towards the marginal ends (Moribayashi & Maruo, 1980). The oldest sediments found in the basin are reported of Plio-Pleistocene age (~5 to 2.5 million years ago), while the youngest sequence was deposited in about 11,000 years ago. The unconsolidated layers of sediments are distributed in the central part of the valley covering about half (~49.4%) of the entire Kathmandu Valley. The valley sediments can be categorized into three units based on their mode of formation: Alluvial fan and talus deposits, Fluvio-lacustrine deposits, and recent floodplain deposits (Table 3-3).

Table 3-3: Lithological succession of the soft sediments in Kathmandu Valley (DMG, 1998)

Formation	Thickness (m)	Main Lithology	Age
Alluvial Fan Deposit	Varies	Gravel, sandy gravel, sand, and silt	
Tokha Formation	200	Well-graded sandy gravel, peaty clay and lignite	Pleistocene to
Gokarna Formation	300	Fine laminated poorly graded silty sand, gravel	
Chapagaun Formation	110	Silty sandy gravel with occasionally boulder beds	

Formation	Thickness (m)	Main Lithology	Age
Kalimati Formation	450	Organic clay, fine sand beds and peat	
Kobgaun Formation	50	Fine sand, silty sand and poorly graded gravel	
Lukundol Formation	80	Sandy, clayey silt with gravel and clayey sand	
Basal Boulder Bed	100	Boulder conglomerate with sand and silt	

Source: DMG 1998

The Kathmandu Valley was originated due to geological cause. During the process of Himalayan range formation, a mega geological fold system, called as the Mahabharat Synclinorium, was formed. It is a well-known fold system in the geology of Nepal Himalaya, which is the main generator of the Kathmandu basin. The axis of synclinorium trends WNW–ESE and runs parallel to the ridgeline of the Chandragiri Range, but observed on about 500 m south from the ridgeline. This synclinal fold is also named as Chandragiri Syncline (Stocklin & Bhattarai, 1977). There is a local anticline fold observed between Tinthana and Kirtipur trending WNW–ESE, but its western continuation is covered with valley sediments. Besides the folds, there are local faults occurred in the Kathmandu Valley. A large fault named Kalphu Khola Fault runs almost east-west direction through the northern part of valley. It has produced a faulted topography with horst and graben structure (Sakai, 2001). This Kalphu Khola Fault seems equivalent to the MCT reported by (Rai, 2001). Sakai (2001) has recognized two active local faults in the southwest of the valley, namely the Chandragiri Fault and the Chobhar Fault (Sakai, 2001). Another fault, named as the Chandragiri Fault, passes through the Bosan Khola on the northern foothill of the Chandragiri Range, while the Chobhar Fault passes through the north of the Chobhar and Kirtipur hillocks. In addition, Sakai (2001) presented some more longitudinal faults extending west-east, such as through Pasupatinath, Swayabhu, and Balkhu, and one transform fault near to Danuwargaun (Arita et al., 1973; Saijo et al., 1995; Yagi et al., 2000).

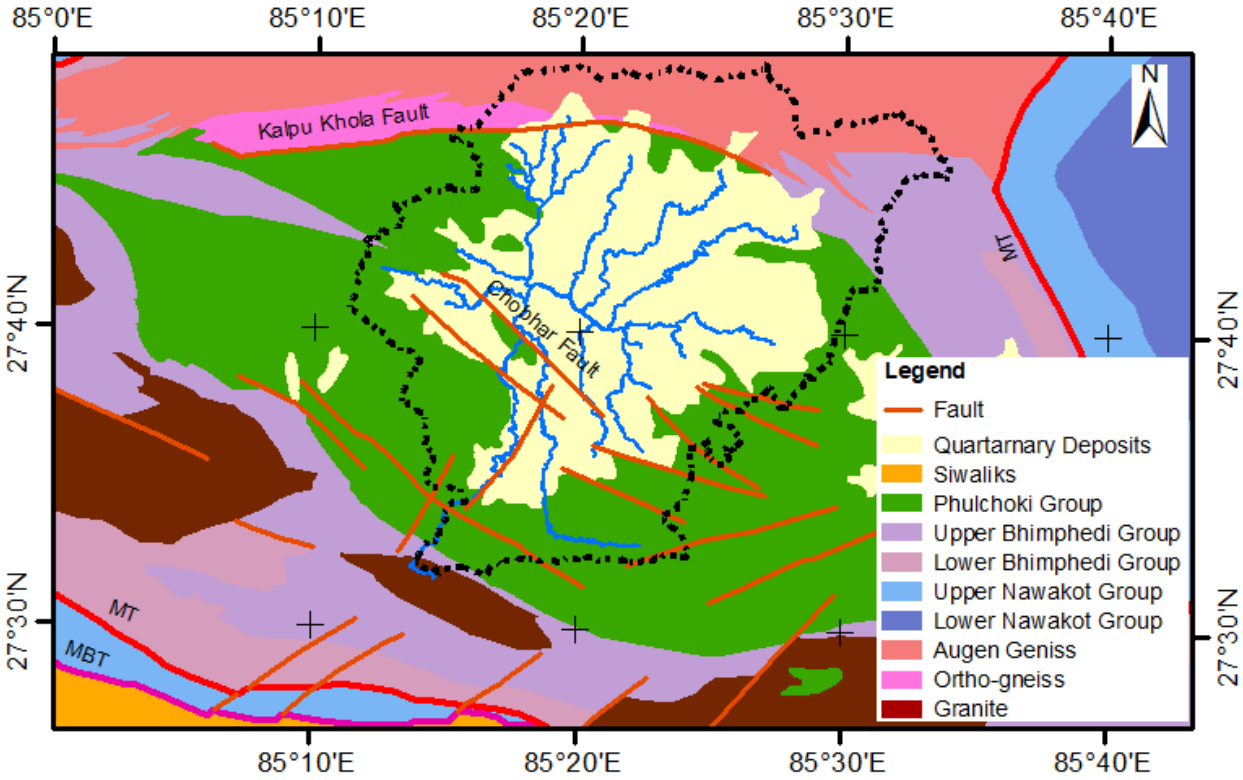


Figure 3-3: Regional faults along with bedrocks in the vicinity of the Kathmandu Valley *(Map compiled by Irwin et al., 2014)*

Figure 3-4: *Weathered augen gneiss bedrock exposed near to Mulkharka*

Figure 3-5: *Huge gneiss boulders in Nagmati Khola to the north of Sundarijal*

Figure 3-6: *Limestone bedrocks exposed near to Lele, Lalitpur*

Figure 3-7: *Highly jointed metasandstone exposed near to Muhanpokhari, Bhaktapur*

The engineering geological map of the Kathmandu Valley published by Department of Mines and Geology in 1998 highlighted the presence of different types of soil in the Kathmandu basin and their general geotechnical characteristics. DMG categorized the soft sediments of Kathmandu Valley into 8 different units. Irwin et al. (2014) slightly modified the previous map by adding some field-based information and presented a geological map in an assignment for Kathmandu Valley Development Authority (KVDA).

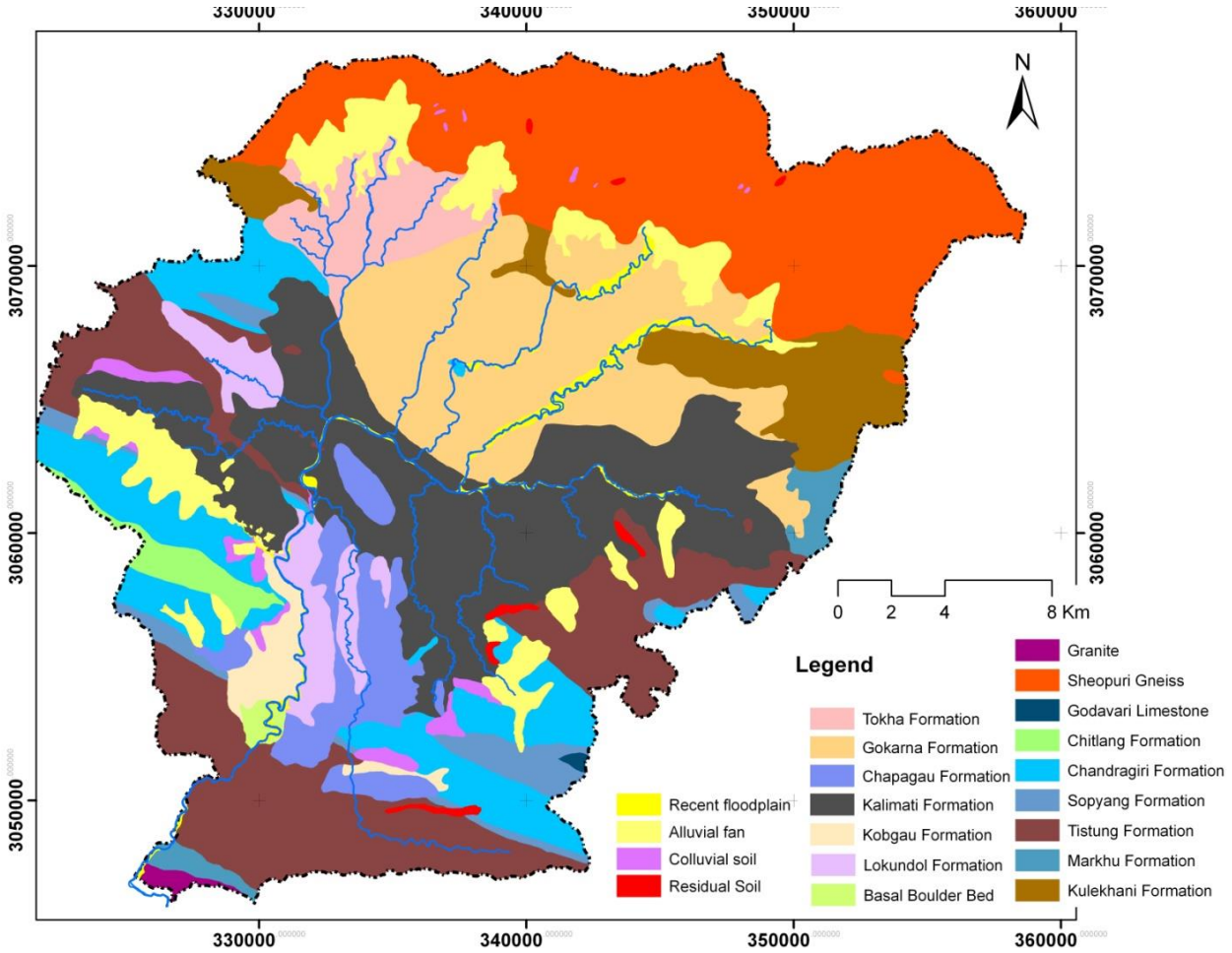


Figure 3-8: Engineering Geological Map of Kathmandu Valley
(modified by Irwin et al. (2014) after (DMG, 1998))

3.2.2. Soil Pattern and Stability Mapping

In the Kathmandu valley, there are four different types of soil based on their mode of formation. Residual soil is found in the top of peripheral hills. Due to highly weathering rate of gneiss, the Shivapuri area comprises thick residual soil cover than other parts. The sloping terrains of these hills are composed of colluvial soil that shows the occurrence of landslides in ancient time. The central part of the valley shows lacustrine soil, which is comparatively impermeable at many places and covered by recent alluvial soil. The peripheral hilly area of the Kathmandu valley shows rugged topography and steep sloping terrain. Due to rapid urbanization, most of the sloping terrains and hillocks are being excavated haphazardly. Thus, there is potentiality of severe gully erosion and landslides in this area. In addition, improperly conducted open stone mining practices have created threat to the slope stability of the valley hills.

The soft soil in the valley has low bearing capacity and shows liquefaction at many places during an earthquake. There were number of cases of liquefaction reported in Kathmandu Valley, such as in Gongabu, Kalimati, Bungmati during the recent Gorkha earthquake 2015.

The liquefaction potentiality differs from place to place due to heterogeneity in soil composition, fluctuation in groundwater table, different compactness and age of sediments at different place and the nature of earthquake shaking at a particular place. The subsurface geological setting has prime role in the calculation of liquefaction potential at a location. The spatial distribution of liquefaction potential values in the soft sedimentary deposits of the Kathmandu Valley shows that the areas in the vicinity of Kalimati, Nakhu, Suryabinayak, Thimi, Lazimpat, and Tokha would experience high to liquefaction. It is also suggested by the cases reported during the 2015 Gorkha Earthquake. In general, most of the valley sediments would be moderately liquefied due to such earthquake.

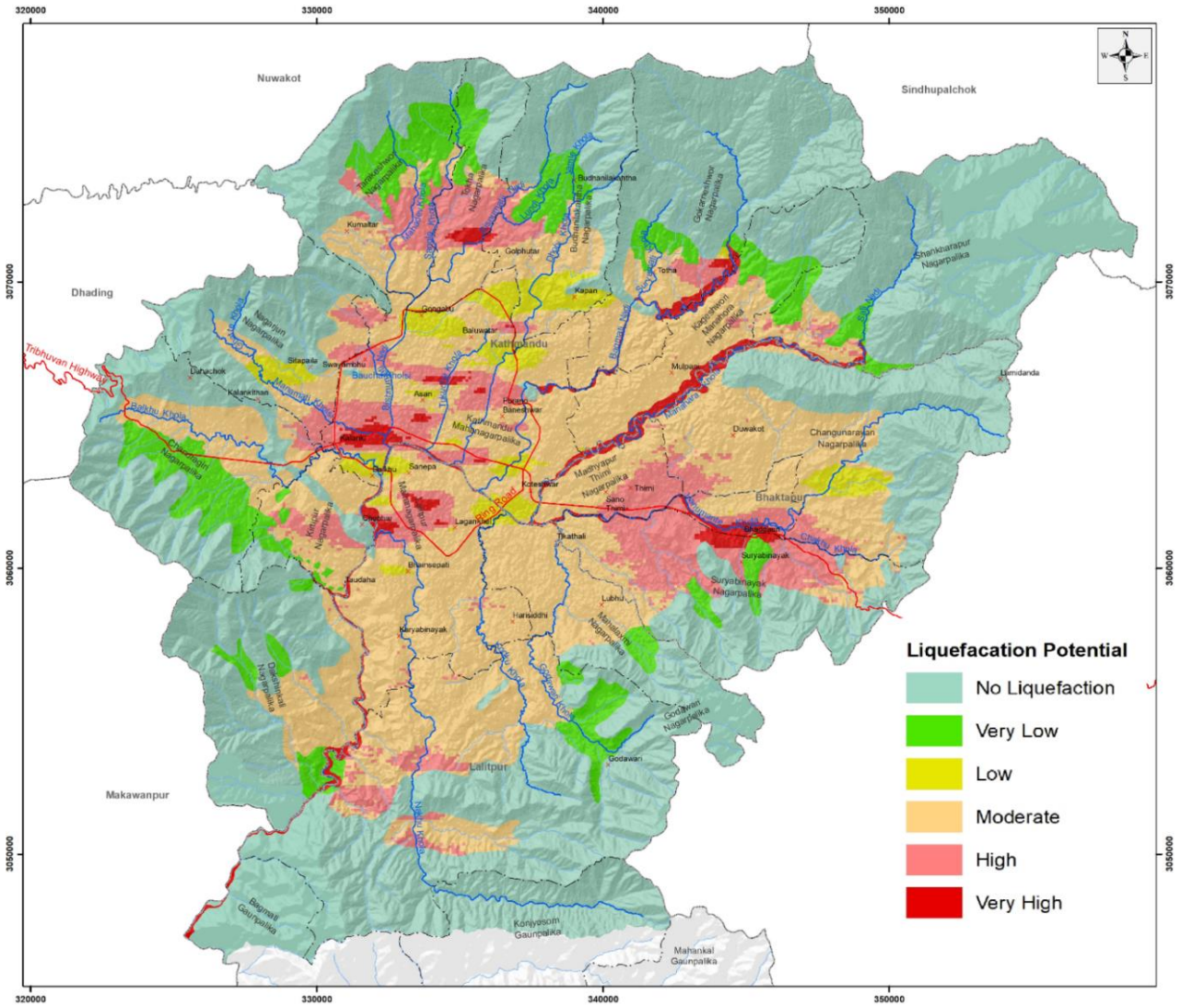


Figure 3-9: Spatial distribution of liquefaction potential in Kathmandu Valley

3.2.3. Climate Change Scenario

The climatic analysis using Representative Concentration Pathways (RCP) 4.5 and 8.5 based on Global Circulation Models (GCMs) from Coupled Model Inter-comparison Project Phase 5 (CMIP5) datasets of the IPCC's Fifth Assessment Report (AR5) suggest that average annual mean temperature is likely to rise (MoFE, 2019). RCP 4.5 projected the increase by 0.81-0.86 °C and 1.1-1.18 °C in medium-term and long term respectively (**Table 3-4** and **Figure 3-10**). The highest rates of mean temperature increase are expected for the post-monsoon season followed by the winter season. Raising temperature further will create the water stress during the dry months through decreasing the agricultural production and thereby increasing food insecurity. Increasing temperature is also likely to contribute for evolution and spread of the crop diseases, pest and weeds (Pandey, 2012; Bhandari et al., 2019).

Table 3-4: Mean annual temperature scenario

District/ Change Scenario	Change (°C)					
	RCP 4.5			RCP 8.5		
	Ref. Period (1981-2010)	Mid Term (2016-2045)	Long Term (2036-2065)	Ref. Period (1981-2010)	Mid Term (2016-2045)	Long Term (2036-2065)
Kathmandu	16.5	0.86	1.18	16.5	1.02	1.73
Bhatapur	16.4	0.84	1.15	16.4	1.01	1.7
Lalitpur	14.9	0.81	1.1	14.9	1.01	1.68

Source: MoFE, 2019

Average annual precipitation is likely to increase in both the medium-term and long-term periods. It is likely to increase by 7.9-8.03% and 10.38-10.58 % in the long period based on RCP 4.5 and RCP 8.5 respectively (**Table 3-5** and **Figure 3-10**). This means precipitation related disaster such as erosion, landslide and flood will be increase in the future. Alternation of precipitation will impact overall agricultural practices and productivity.

Table 3-5: Precipitation change scenario

District/ Change Scenario	mm	Change (%)				
	RCP 4.5			RCP 8.5		
	Ref. Period (1981-2010)	Mid Term (2016-2045)	Long Term (2036-2065)	Ref. Period (1981-2010)	Mid Term (2016-2045)	Long Term (2036-2065)
Kathamndu	2094	2.33	8.03	2094	6.35	10.4
Bhaktapur	2106	2.28	7.97	2106	6.51	10.58
Lalitpur	2056	1.97	7.9	2056	6.1	10.38

Source: MoFE, 2019

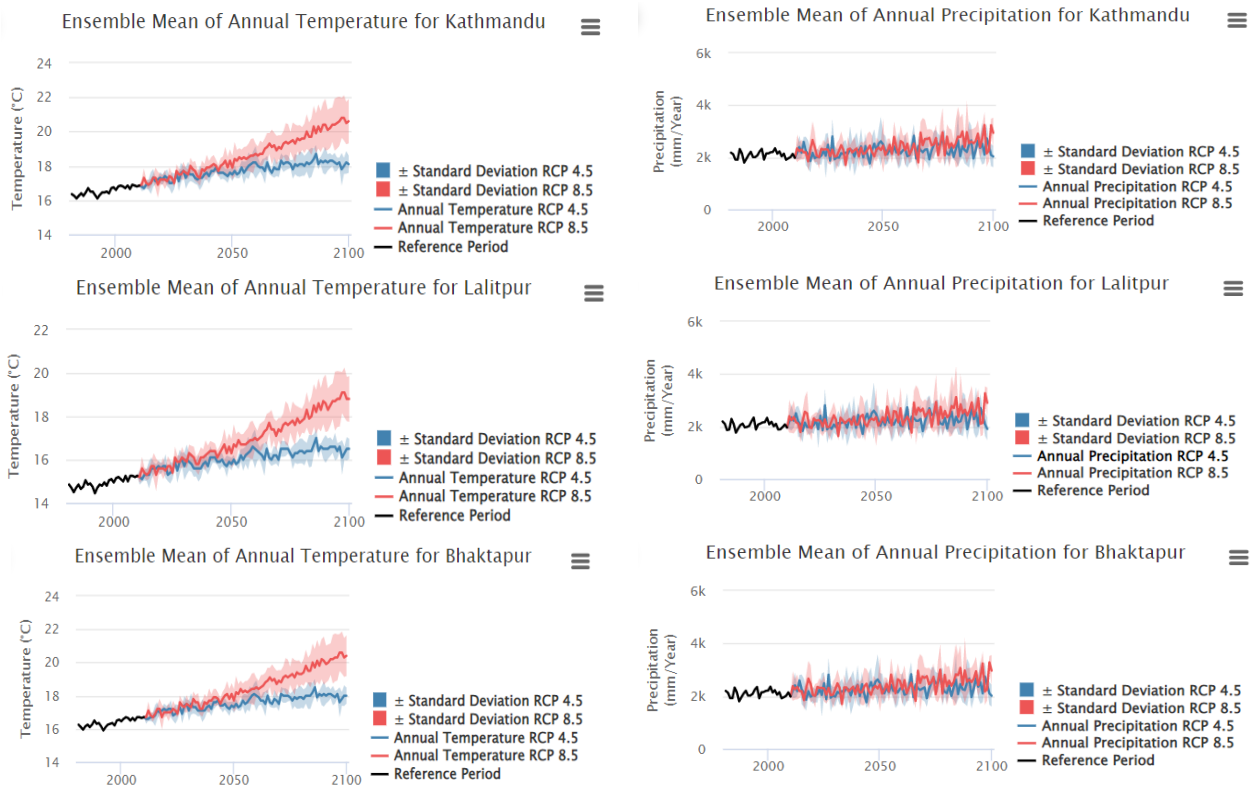


Figure 3-10: Ensemble mean of annual temperature and annual precipitation of project districts (*Source: MoFE, 2019*)

3.2.4. Hydrology

Trend analysis of the hydrological and meteorological data represent the variation of the discharge and precipitation over the time period which are crucial parameters to evaluate the impacts of climate change, urbanization and other factors on the hydrology of Bagmati basin. From overall trend analysis, hydro climatological changes are observed in Bagmati basins which are due to regional, global and local effects.

The trend analysis of average seasonal discharge; the average winter discharge in Bagmati river at Khokana and Sundarijal is decreasing whereas at Gaurighat is increasing. For average pre-monsoon discharge the trend analysis shows increasing trend at Khokana and Gaurighat whereas decreasing at Sundarijal. The trend analysis of monsoon discharge which is mostly responsible for flood events in Kathmandu Valley shows decreasing trend in Khokana and

Sundarijal whereas increasing trend in Gaurighat region. Average post monsoon discharge at Khokana follows decreasing trend whereas at Gaurighat follows increasing trend and at Sundarijal follows uniform non-varying trend. Variation in the trend of river discharge at different stretches is the result of spatial variation of rainfall in different region of Bagmati Khola basin and its catchment at the same time period.

Trend analysis for seasonal precipitation shows uniform values of winter precipitation, increasing trend in pre-monsoon precipitation, decreasing trend in monsoon precipitation and slightly increasing trend in post-monsoon precipitation values. Maximum Daily Precipitation follows the decreasing trend over the years and annual precipitation in Bagmati basin also follows the decreasing trend.

The details are presented in Supplementary Volume II: Hydrological Modeling Report.

3.2.5. Groundwater Recharge and Water Sources

The northern hilly region of Kathmandu Valley, generally known as Shivapuri area, comprises dominance of augen and banded gneiss with frequent mineralized pegmatite veins. The gneiss is highly weathered in many places and plays as a good recharge zone to the groundwater of Kathmandu Valley. The middle and southern peripheral hills including Chobhar area show limestone dipping towards north. These zones are also good aquifer for the groundwater of Kathmandu valley. The surrounding bedrocks with alluvial fan deposits on the foothills are serving as good recharge zone to the groundwater of the valley.

The groundwater of the Kathmandu Valley is recharged mainly by infiltration of rain water in the surrounding. On the basis of geological and physiographical setting, there are four different zones of groundwater recharge have been identified. These are:

i) Northern Recharge Zone-I: It covers the northern foothills composed of coarse sediments, specially made up of alluvial fan deposits. The subsurface materials in this zone have high permeability and porosity, so the surface water quickly infiltrates through this zone.
ii) Northern Recharge Zone-II: This zone comprises the bedrocks found in the northern part of the valley. The Shivapuri area comprises gneiss, which is good recharge zone of the Kathmandu Valley. In addition, the bedrocks in the northern part of the valley are contributing to the groundwater in the northern part.
iii) Southern Recharge Zone-I: The alluvial fan deposits in the southern part of the valley are included in this zone. As in the north, this zone comprises high porosity and permeability.
iv) Southern Recharge Zone-II: All the bedrocks having different lithology found in the southern part of the valley are included in this zone. This zone recharges the groundwater in the southern part of the valley.

There are more than 70 perennial springs identified in the peripheral foothill of valley that also shows the surrounding hills are recharge zone of valley groundwater. These springs are also sources of streams in the valley.

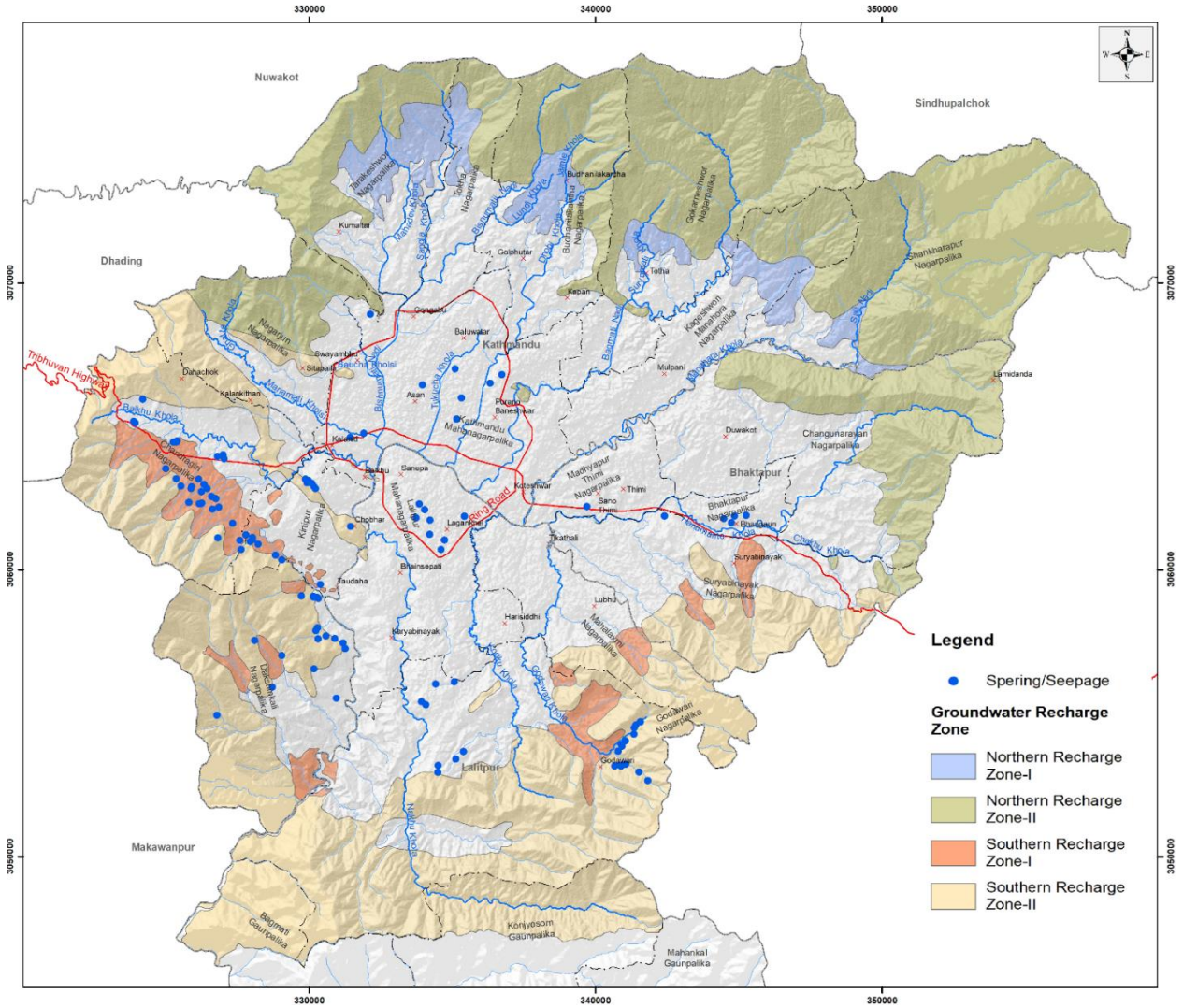


Figure 3-11: Distribution of prime groundwater recharge zones and springs in the Kathmandu Valley

3.2.6. Traditional and local water storage

There are 52 traditional Newar settlements in the Kathmandu valley and each of the settlement has approx. 6-8 water bodies, numerous hitis (dhunge dharas) and often all have raj kulo (water canals) passing through the settlement. When we look into history we see that often the state took leading role in the construction of the water system while community played a key role in the management of such systems under Guthi administration. As many as 27 of about 160 inscriptions known so far during the Lichchhavi rules are exclusively related to water and its usage. (Tiwari, 1998). Besides these historic water infrastructures almost all the traditional settlements have wells within the residential quarters and Jahru (stone water spigot) as sources of drinking water. Major settlement like Bhaktapur has 35 water bodies and 87 hitis within its historic core (Khaniya, 2005). Similarly, Patan has 30 and Kathmandu has 25 water bodies (Adhikari, 2017). Kirtipur, which sits on a hillock, also boasts of six water bodies in its historic core. These water bodies were often associated with numerous functions like washing, cleaning, animal bathing, ritual functions, industrial usage, local climate regulator, water storage for firefighting, and as water collection areas (collecting water from natural sources or raj kulo before feeding the water to local hitis). Besides fulfilling these functional criterions these water bodies also functioned as ground water recharge areas.

Traditionally, water supply of valley were mostly from Raj kulos which were basically water canals used to bring drinking water from far away sources and are mainly the engineering achievement of Lichhavi period which helped bring drinking water inside the residential quarters of traditional settlements which normally lay in highlands. Besides bringing drinking

water to urban areas, these kulos also helped in bringing water for irrigation purposes to agricultural lands which lay in elevated plain from the river basin. The water bodies like Sapta patal pukhu of Lagankhel and Palesva pukhu of Pulchowk are such examples where water coming from raj kulo are fed into these ponds which feeds the aquifers that in turn feed the hitis.

3.3. POPULATION

According to population census 2011, the population of Kathmandu valley was 2,446,146. The Preliminary Census Report 2021 shows the population of the valley to have increased to 2,953,731 (**Table 3-6**).

Table 3-6: Population size, distribution and density in local units within Kathmandu Valley

Local Bodies	Area (ha)	2011		2021	
		Population	Density (ppha)	Population	Density (ppha)
Kathmandu Metropolitan City	4,945	975,453	197	845,767	171
Lalitpur Metropolitan City	3,612	284,922	79	299,843	83
Bhaktapur Municipality	689	81,748	119	78,854	114
Kritipur Municipality	1,476	65,602	44	81,782	55
Madhyapur Thimi Municipality	1,147	83,036	72	119,955	105
Gokarneshwor Municipality	5,850	107,351	18	151,200	26
Budhanilkantha Municipality	3,480	107,918	31	179,688	52
Kageshwari Manohara Municipality	2,738	60,237	22	133,327	49
Trakeshwar Municipality	5,495	81,443	15	151,508	28
Tokha Municipality	1,711	99,032	58	135,741	79
Nagarjun Municipality	2,985	67,420	23	115,507	39
Chandragiri Municipality	4,392	85,198	19	136,928	31
Dakshinkali Municipality	4,268	24,297	6	26,744	6
Shankharapur Municipality	6,021	25,338	4	30,414	5
Changunarayan Municipality	6,298	55,430	9	88,612	14
Suryabinayak Municipality	4,245	78,490	18	137,971	33
Godawari Municipality	9,611	78,301	8	100,942	11
Mahalaxmi Municipality	2,651	62,172	23	118,710	45
Konjyosom Rural Municipality	4,416	9709	2	9042	2
Bagmati Rural Municipality	11,149	13049	1	11196	1
Total	**87,179**	**2,446,146**	28	**2,953,731**	34

Source: CBS 2011 and 2021 (Preliminary Report)

Population Density

The population density of Kathmandu valley was 28 ppha in 2011. Based on the Preliminary Census Report 2021, the population density of Kathmandu valley is 34 ppha. Among the local units, Kathmandu Metropolitan City has the density of 171 ppha while Bhaktapur Municipality has 114 ppha and Madhyapur Thimi Municipality has 105 ppha densities. The rest have the population density below 100 ppha (Figure **3-12:** Population density of Kathmandu valley in 2011**).**

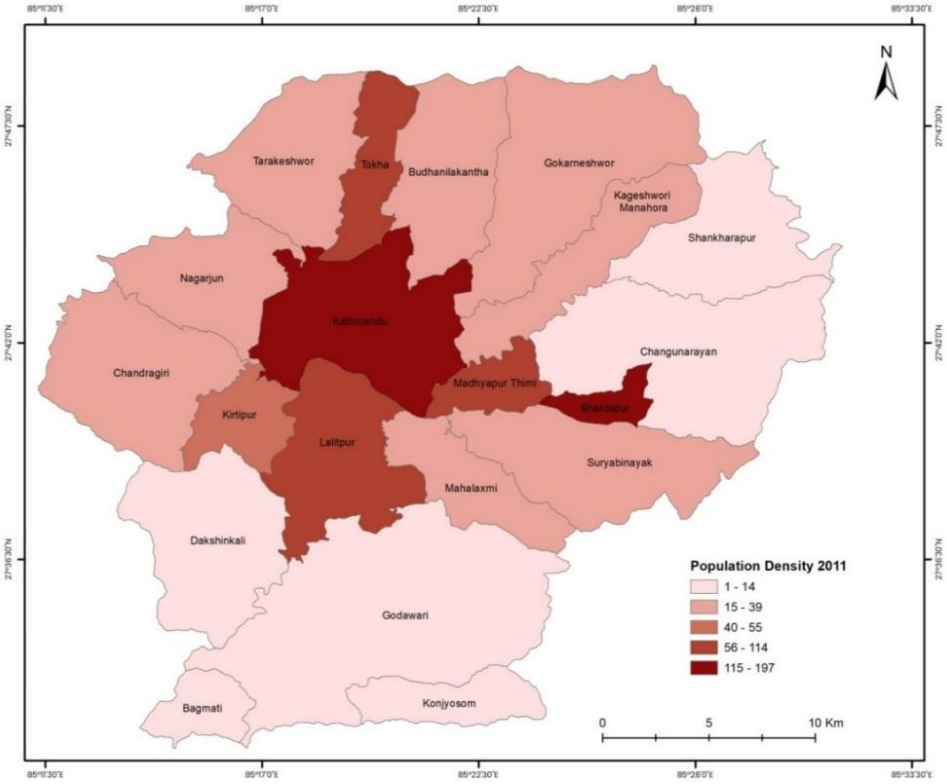


Figure 3-12: Population density of Kathmandu valley in 2011

The comparative analysis shows the increase in population density at peripheral local units of core urban areas of the valley like Budhanilkantha, Kageshwori Manahara, Mahalaxmi and others.

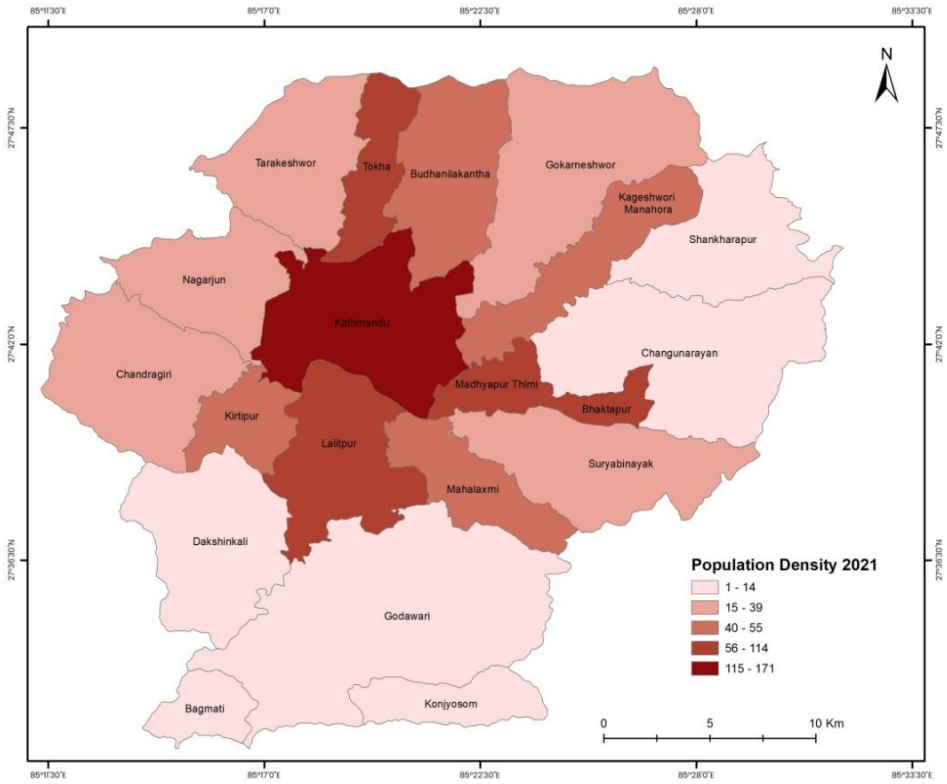


Figure 3-13: Population density of Kathmandu valley in 2021

3.4. SETTLEMENT PATTERN AND LAND COVER

3.4.1. Settlement Pattern and Urban Growth

Settlement in Kathmandu Valley flourished during Malla period. During this period, valley developed as a major trade and administrative center and prospered in its rich social fabric and highly developed cultural pattern. The traditional towns have a definitive urban character of

compact and dense settlements, with urban spaces organized in a very unique and innovate way (Tiwari, 1989). These compact settlements are surrounded with the agricultural field. The traditional settlement of Kathmandu Valley flourished during Malla period are mostly found on the old trade routes except the three major cities of Kathmandu, Lalitpur and Bhaktapur.

The settlement development during these periods has always the strong connections with the river for daily ritual like bathing to other sacraments like *upanayana*: marriage or ancestor worship. Each traditional settlements had designated river edge area for their cultural and ritual activities. So, people built many buildings like patis, dharmashalas, and temples and provided guthi lands for their maintenance. The dead bodies were cremated at the bank of river. (Gutschow, 1995)

Later during Maoist insurgency (1996 – 2005), there has been a huge influx of internally displaced people in recent years in search of security, employment, government aid and shelter. Hence, the urbanizing trend has changed significantly, characterized by haphazard and unplanned development due to lack of effective planning and its implementation. Due to rapid urbanization, scattered traditional settlements are combined and have formed a single compact settlement.

3.4.2. Land Cover

The land cover of Kathmandu valley constitutes of built-up area, cultivation, forest grassland, riverbed, and water bodies. The land cover in the year 2020 shows the majority 40.33% area covered by forest. The cultivation land covers 35.95% area whereas, built-up accounts for 22.61% area. Similarly, water bodies and riverbeds represent only 0.04% area (Table 3-7).

Table 3-7: Land cover change dynamic of Study area

Land cover/ Year	Year 2020	
	Area (Sq. Km)	Percent (%)
Built-up	161.50	22.61
Cultivation	255.61	35.95
Forest	288.01	40.33
Grassland	8.77	1.23
Riverbed	0.07	0.01
Water bodies	0.24	0.03

Source: DoS

3.5. BAGMATI RIVER AND ITS TRIBUTERIES

Bagmati river generates at Shivapuri Hills near Baghdwar and flows southward through Gokarna and Pashupati area and ultimately meets Manohara River, Dhobi Khola (Rudramati), Tukucha Khola (Ichhumati), Bishnumati River and Nakhu Khola before it passes through Chobhar George. The sub-tributaries include Hanumante, Godawari, Kodku, Mahadev, Sangla, Bhaucha, Lundi, Jamle, Manamati, Suryamati, Ghatte and Chakhu Khola. Besides, there are other small streams and numerous *kholsis* within the river system (**Figure 3-14**).

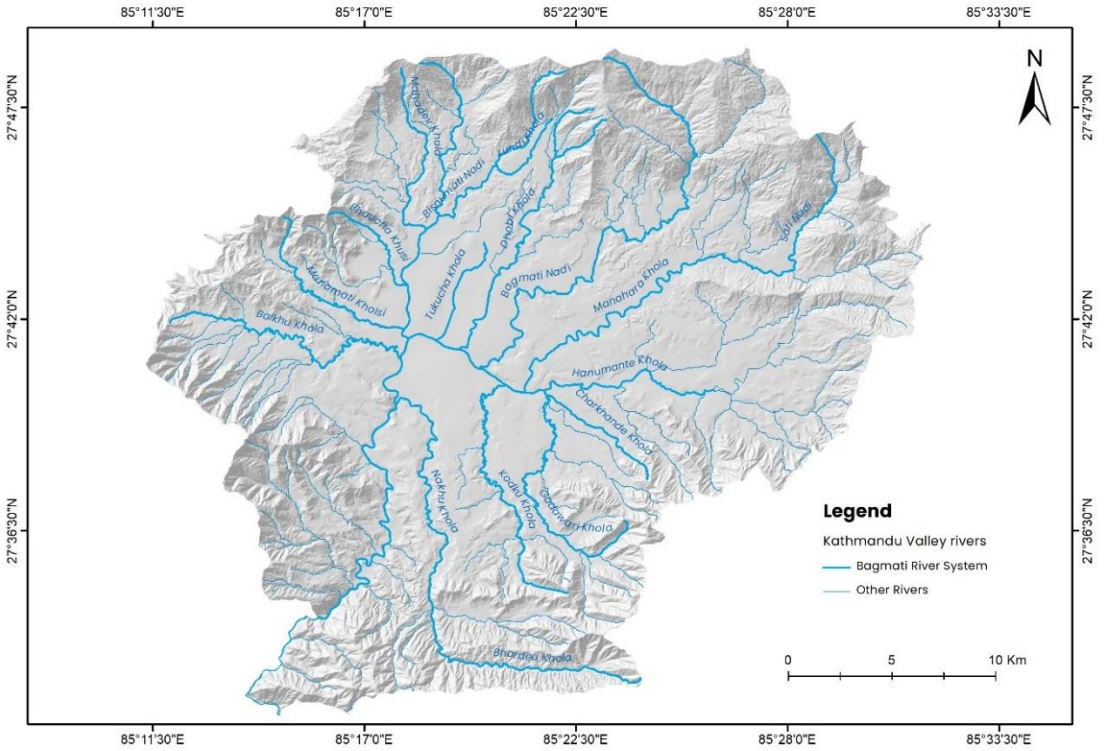


Figure 3-14: River network of Kathmandu valley

The length of Bagmati River is 48.8 km from its origin at Shivapuri hill (2732 m) to Katuwal daha (1140m). In total, about 267.52 km length of Bagmati River and its tributaries have been included in the study for preparation of the Action Plan. The total catchment area of Bagmati River is about 672.34 sq. km.

Table 3-8**:** Rivers studied for preparation of Action Plan

S. N.	Name of River	Stream Order	Length (km)	Location of river (Metro, Sub-metro, Municipality and Rural Municipality)
1	Bagmati River	9	48.8	Bagmati, Dakshinkali, Lalitpur, Kirtipur, Kathmandu, Kageshwori Manahora, Gokarneshwor
2	Bishnumati River	8	18.3	Kathmandu, Tokha, Tarakeswor
3	Manahara Khola	8	29.7	Madhyapur Thimi, Kathmandu, Lalitpur, Changunarayan, Kageshwori Manahora, Shankharapur
4	Hanumante Khola	8	24.38	Madhyapur Thimi, Bhaktapur, Changunarayan, Suryabinayak
5	Balkhu Khola (Indramati)	7	17.05	Nagarjun, Kirtipur, Chandragiri
6	Nakhu Khola	7	26.65	Lalitpur, Godawari, Konjyosom
7	Rudramati (Dhobikhola)	7	15.9	Kathmandu, Budhanilakantha
8	Godawari Khola	7	15	Mahalaxmi, Suryabinayak, Godawari
9	Mahadev Khola	7	8.8	Tarakeshwor
10	Sangla Khola	7	8.3	Tarakeshwor, Tokha
11	Kodku Khola	7	15.75	Lalitpur, Mahalaxmi , Godawari
12	Bhaucha Khola	7	1.8	Kathmandu, Nagarjun
13	Tukucha (Ichhumati)	6	5.5	Kathmandu
14	Lundi Khola	6	3.75	Budhanilakantha
15	Jamle Khola	6	3.2	Budhanilakantha

S. N.	Name of River	Stream Order	Length (km)	Location of river (Metro, Sub-metro, Municipality and Rural Municipality)
16	Manamati Khola	6	10.83	Kathmandu, Nagarjun
17	Suryamati Khola	6	5	Gokarneshwor
18	Ghatte Khola	6	3.3	Nagarjun
19	Chakhu Khola	7	5.46	Bhaktapur, Changunarayan, Suryabinayak

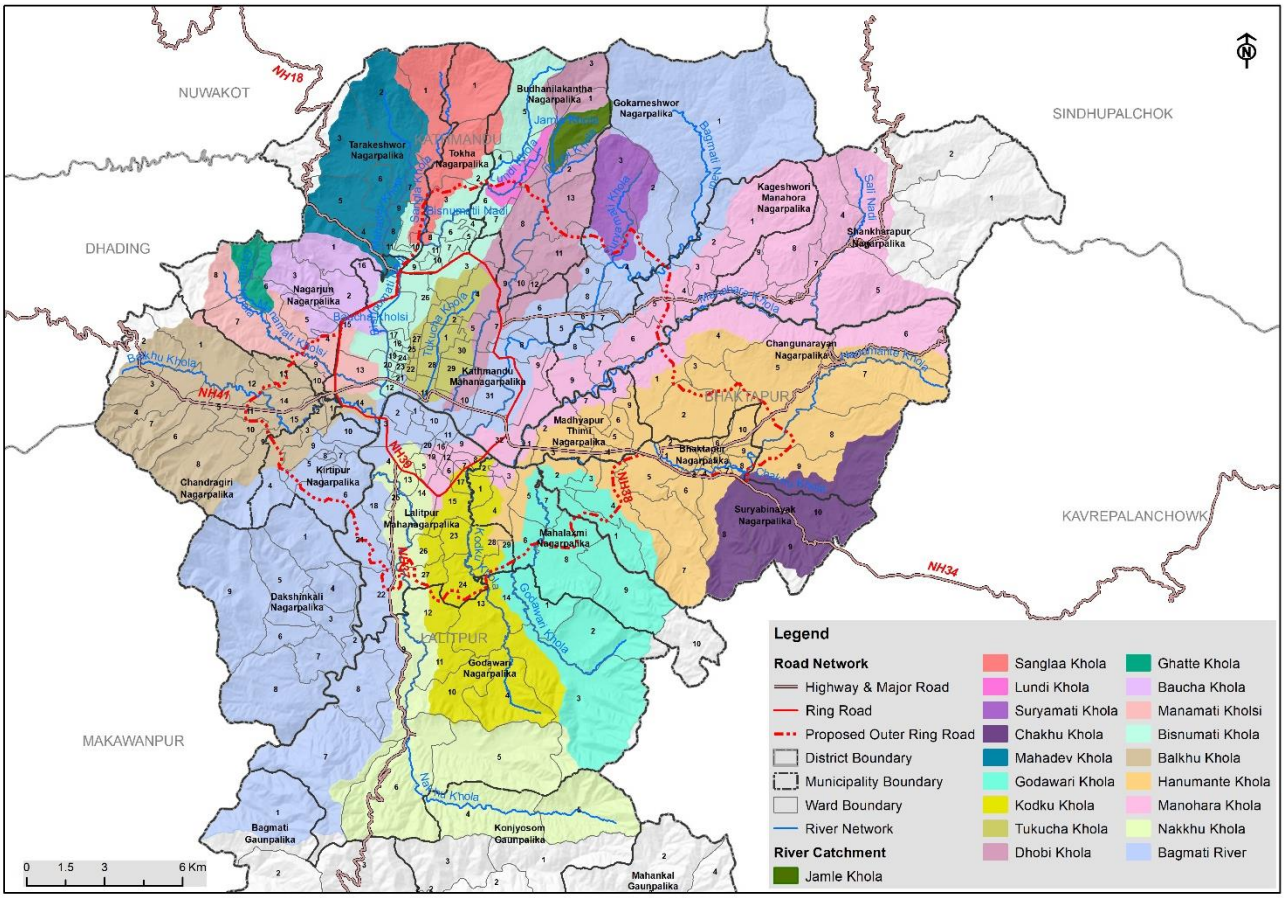


Figure 3-15: Sub Water-shed of River studied

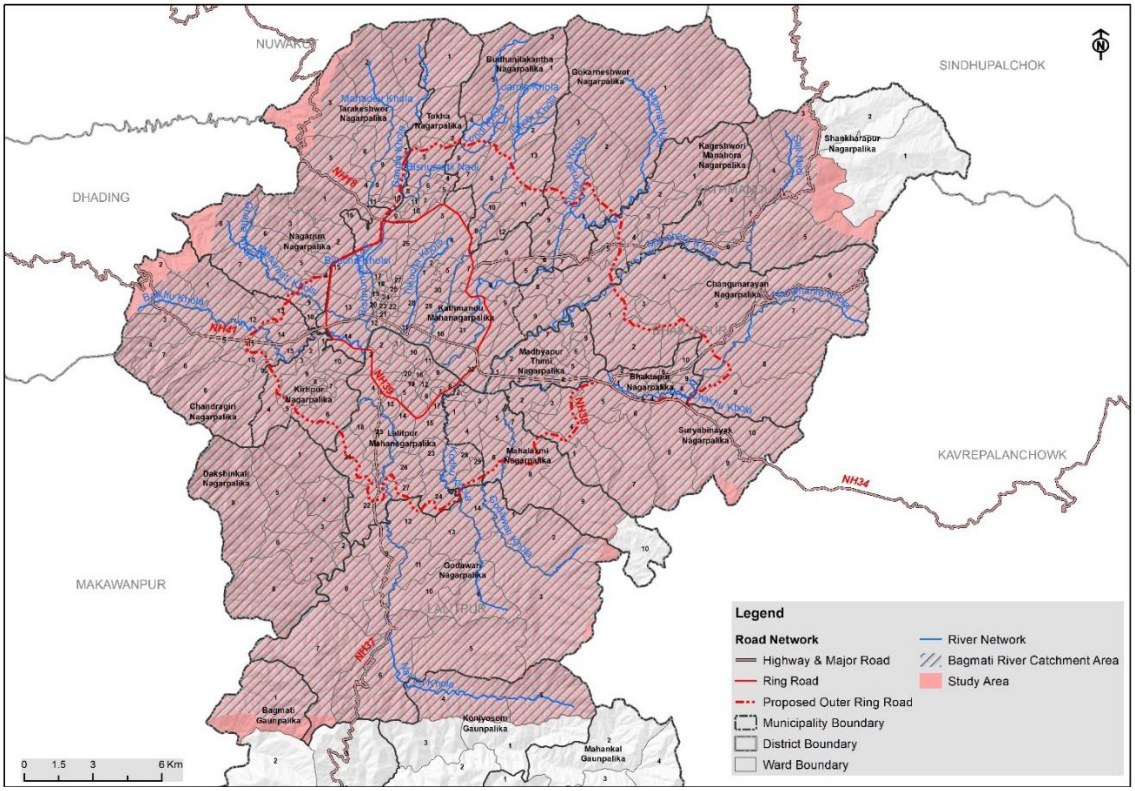


Figure 3-16: Study area overlaid with Bagmati watershed

3.5.1. Infrastructure Assets

Numerous river improvement projects have been implemented which are primarily focused to improve the river health and river bank environment by constructing the number of infrastructures. River corridor roads, river trainings, sewer network system, WWTPs, infrastructures for river beautification, monuments are some of the major infrastructures which are summarized here. The details are provided in Supplementary Volume I for Inventory.

3.5.1.1. Corridor Road

Several government agencies have been collaborating to build various corridor roads on the banks of Kathmandu's rivers, namely Bagmati, Bishnumati, Dhobikhola (Rudramati), Hanumante, Nakkhu, Balkhu, Manohara, Mahadev Khola and others. Underpasses are also being built below the river bridges. Many of them are already in operation while some are under construction. These corridor roads have been helpful in mitigating the issues of nasty jams and traffic holdups and to divert vehicles away from the main lanes.

In some places, the roads only exist on one side of the river, whereas there are roads on both sides of the river in other places. Different types of road exist, such as black topped, graveled and earthen. In some areas the roads are black topped and in good condition. In other places, the roods are either graveled or earthen types and are poorly maintained. Due to water logging during heavy rains, it becomes very difficult to commute along these roads, especially the earthen roads.

Table 3-9: River corridor road and surface types

S. N.	River	Total Length of Corridor Road (m)		Blacktopped Road (m)		Gravel and Earthen Road (m)	
		Left Bank	Right Bank	Left Bank	Right Bank	Left Bank	Right Bank
1	Bagmati	18723.89	16445.35	14066.98	6996.5	4656.91	9448.85
2	Bishnumati	9227.62	10911.94	4879.92	4131.42	4347.7	6780.52
3	Manahara	4948.92	5347.75	1698.08	2647.37	3250.84	2700.38
4	Hanumante	7891.41	9063.33	827.07	1143.47	7064.34	7919.86
5	Balkhu Khola (Indramati)	4705.06	4271.98	1969.87	2444.88	2735.19	1827.1
6	Nakhu	3146.01	13094.88			3146.01	13094.88
7	Rudramati (Dhobikhola)	11796.94	11703.8	11796.94	11703.8		
8	Godawari	2548.45	1147.02			2548.45	1147.02
9	Mahadev	4497.75	4529.93	1379.59	1163.13	3118.16	3366.8
10	Sangla	3293.13	2561.93	3293.13	1904.48		657.45
11	Kodku	2467.97	1954.48	538.1		1929.87	1954.48
12	Bhaucha	1420.95	1163.1	772.12	590.96	648.83	572.14
13	Tukucha (Ichhumati)	274.98				274.98	
14	Lundi		537.92				537.92
15	Jamle						
16	Manamati	1231.87	2334.05		1349.18	1231.87	984.87
17	Suryamati	630.9				630.9	
18	Ghatte						
19	Chakhu		300.6				300.6

Source: Field Survey 2022

Figure 3-17: *Corridor road along Manohara*

3.5.1.2. Crossing Structures

To provide ease in transportation numbers of crossing structures are constructed in the rivers of Kathmandu valley. They are either motorable or for pedestrians only.

Table 3-10: Crossing structures in rivers of Kathmandu valley

S. N.	Name of River	Crossing Structure	
		Type	Number
1	Bagmati River	Motorable Bridge	35
		Pedestrian Bridge	30
2	Balkhu River	Motorable Bridge	39
		Pedestrian Bridge	16
3	Baucha River	Motorable Bridge	14
		Pedestrian Bridge	4
4	Bishnumati River	Motorable Bridge	48
		Pedestrian Bridge	15
5	Chakhu River	Motorable Bridge	7
		Pedestrian Bridge	4
6	Dhobikhola River	Motorable Bridge	26
		Pedestrian Bridge	41
7	Ghatta Khola	Motorable Bridge	13
		Pedestrian Bridge	2
8	Godawari Khola	Motorable Bridge	22
		Pedestrian Bridge	13
9	Hanumante Khola	Motorable Bridge	33
		Pedestrian Bridge	20
10	Jamle Khola	Motorable Bridge	11
		Pedestrian Bridge	4
11	Kodku Khola	Motorable Bridge	27
		Pedestrian Bridge	14
12	Lundi Khola	Motorable Bridge	14
		Pedestrian Bridge	4
13	Mahadev Khola	Motorable Bridge	19
		Pedestrian Bridge	16
14	Manamati Khola	Motorable Bridge	48
		Pedestrian Bridge	26
15	Nakkhu Khola	Motorable Bridge	12
		Pedestrian Bridge	16
16	Sangla Khola	Motorable Bridge	20
		Pedestrian Bridge	9

S. N.	Name of River	Crossing Structure	
		Type	Number
17	Suryamati Khola	Motorable Bridge	6
		Pedestrian Bridge	3
18	Tukucha Khola	Motorable Bridge	7
		Pedestrian Bridge	

Source: Field Survey 2022

3.5.1.3. River Training

Most of the major rivers and their tributaries have been originated from the surrounding hills of the Kathmandu Valley. The major hilly areas are Nagarjung, Sivapuri, Nagarkot and Phulchauki. The rivers in the Kathmandu valley have been the subject to the flood disasters in the past and ongoing. River training works have been done to cope with the flood risk and vulnerability especially bank cutting and providing security to the vulnerable settlements and agricultural lands. River training works can be observed both in the upstream and downstream of the rivers.

Table 3-11: Status of river training works

S. N.	River	Total River Length (km)	Distance to Foothill (km)	River Training Works					
				Total Length (km)		Masonry (km)		Gabion (km)	
				Left	Right	Left	Right	Left	Right
1	Bagmati	48.85	44.4	12.57	10.52	12.33	10.52	0.24	0
2	Suryamati	5	4.5	0.37	0.37	0.19	0.33	0.18	0.05
3	Nakhu	26.65	26	5.78	5.41	4.92	4.86	0.86	0.55
4	Balkhu	17.05	16.75	5.24	5.82	1.87	2.7	3.37	3.12
5	Sangla	8.3	8.1	3.91	2.72	3.7	2.62	0.21	0.1
6	Mahadev	8.8	8.4	3.43	3.35	3.43	3.13	0	0.23
7	Manahara	29.7	29.7	3.61	2.83	0	0	3.61	2.83
8	Hanumante	24.38	19.35	5.76	5.56	5.73	5.42	0.03	0.14
9	Chakhu	5.46	5.46	0.09	0.04	0.09	0.04	0	0
10	Bishnumati	18.3	15	8.79	9.89	8.17	8.74	0.62	1.15
11	Manamati	10.83	10.55	4.58	4.89	4.18	4.68	0.4	0.21
12	Baucha	2.3	2.3	1.2	1.45	1.16	1.45	0.04	0
13	Lundi	3.75	3.75	0.61	0.63	0.53	0.53	0.08	0.1
14	Jamle	3.2	2.75	0	0	0	0	0	0
15	Ghatte	3.3	3.3	0.58	0.42	0.57	0.41	0.01	0.01
16	Dhobi Khola	15.9	15.25	11.59	11.56	11.59	11.56	0	0
17	Tukucha	5.5	5.5	3.28	2.75	3.28	2.75	0	0
18	Kodku	15.75	15.5	3.36	3.97	2.54	3.31	0.83	0.66
19	Godawari	15	14.5	2.31	2.74	1.61	1.15	0.7	1.58

Source: Field Survey 2022

Figure 3-18: *River training works in Manohara*

3.5.1.4. Sewer Network and Treatment Systems

A. Existing Sewer Network Systems

Sewage collection networks have been developed in the core of metropolitan and municipality areas. The pipes constructed to convey sanitary sewage are also used for storm water either direct from roofs or from lanes and roads. The system is very entrenched and thus nearly all drains are considered as combined sewers. The actual condition of existing sewers is not known as even manhole covers are hard to locate in many locations. Existing sewer materials are mostly concrete pipes, with collar jointed pipes and brick manholes. The Kathmandu Valley has three separate systems to collect domestic sewage. They are separate, combined and partially combined/separate system. Branch and Tertiary Systems collect sewage directly from households and transfer to the larger main collector system.

The sewerage system in the Kathmandu valley has mostly turned out to be unmanaged and chaotic. The respective local governments are simply diverting the sewerage through sewer/drainpipes and dislodging in the nearest river. The proportion of houses with septic tanks is very low. Majority houses are connected to municipal sewer pipes that ultimately drain most of the wastewater directly into the river without treatment.

Table 3-12: Status of sewerage outlet in rivers of Kathmandu valley

S. N.	River	Number of Sewerage Outlet		
		Left	Right	Total
1	Bagmati	51	28	79
2	Suryamati	2	3	5
3	Nakhu	38	42	80
4	Balkhu	23	32	55
5	Sangla	32	22	54
6	Mahadev	121	160	281
7	Manahara	43	38	81
8	Hanumante	49	45	94
9	Chankhu	3	1	4
10	Bishnumati	194	275	469
11	Manamati	39	74	113
12	Baucha	20	17	37
13	Lundi	50	25	75
14	Jamle	-	-	-
15	Ghatte	3	2	5
16	Dhobi Khola	703	659	1362
17	Tukucha	Not reachable		NA
18	Kodku	17	20	37

S. N.	River	Number of Sewerage Outlet		
		Left	Right	Total
19	Godawari	10	5	15

Source: Field Survey 2022

The analysis of sewerage outlet density shows higher density in Rudramati Khola, Bishnumati Khola and Mahadev Khola (Figure **3-19**).

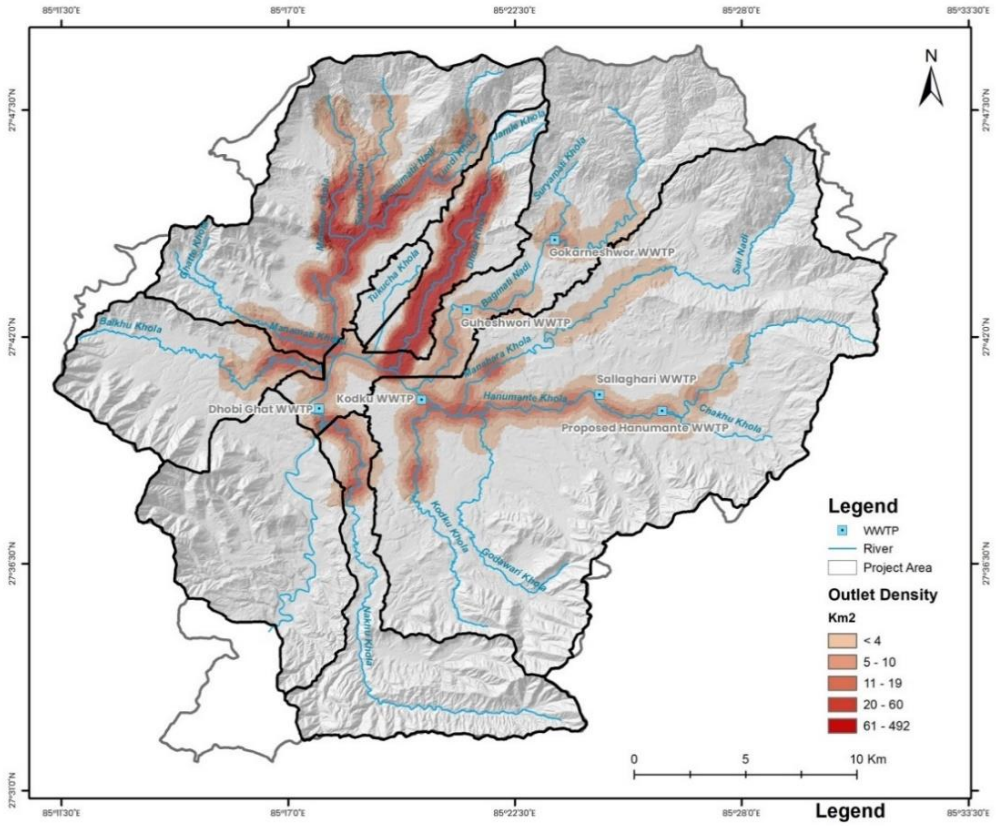


Figure 3-19: Sewerage outlet density in Bagmati River and its tributaries

The storm water in Kathmandu Valley is drained to rivers through road side drains, storm sewers and combined sewers. There has been large number of storm water drains and combined sewers constructed in urban areas of Kathmandu Valley by NWSC/KUKL and the municipalities. Most households are connected to either one or both forms of drainage depending on what type of sewer is closer or most convenient, which means that almost all sewers in Kathmandu Valley are presently operating as combined sewers.

As reported in the Conceptual Wastewater Master Plan for a 15 year planning horizon from 2011 to 2025 and additional information received from the agencies involved in wastewater sector, the details of interceptors along the major rivers and sewer networks are as follows:

Table 3-13: Details of Sewer Networks

Particulars	Length	Status / Remarks
Kathmandu Metropolitan	856 km	Includes only sewer of municipality area
Lalitpur Municipality	232 km	Includes only sewer of municipality area
Bhaktapur Municipality	69 km	Includes only sewer of municipality area
Thimi Municipality	40 km	Includes only sewer of municipality area
Kirtipur Municipality	71 km	Includes only sewer of municipality area
Total Length of Sewer Network	**1,268 km**	

Source: KVWMP, KUKL 2022

B. Interceptors

Interceptor sewers are the main trunk sewers which collect sewer from collector systems and they are usually laid along the river banks leading to the treatment plants or sites.

Table 3-14: Description of existing Interceptors

S. N.	River	Interceptor (km)
1	Bagmati	48.09
2	Dhobikhola	23.26
3	Bishnumati	11.65
4	Nakkhu	12.5
5	Balkhu	4.5
	Total	**100.00**

Source: HPCIDBC

C. Waste Water Treatment Plant (WWTP)

There are altogether 6 WWTP (Dhobighat, Sallaghari, Hanumante, Kodku, Guheshwori and Gokarna) out of which Dhobighat, Sallaghari, and Hanumante are defunct. The problem with the Dhobighat and Sallaghari Treatment plants are the disruption of pumping stations and lack of institutional capability to operate. All the three defunct WWTPs are subject to the combined flow of sanitary and storm water. The WWTP in Kodku, Dhobighat and Sallaghari are equipped with chlorination plants but were not operated.

Table 3-15: Summary of Existing WWTPs in Kathmandu Valley

Year established	Hanumanghat	Sallaghari	Kodku	Dhobighat	Guheshwori
	1975	1983	1982	1982	2001
Original situation					
Design flow(m^3/d)	500	2,000	1,100	15,400	16,400
Process type	Aerated lagoon	Aerated lagoon	Stabilization pond	Stabilization pond	Oxidation ditch
Situation 2012 (Waste Water Quality of influent)					
Connected people to WWTP	600	100	30,000	0	138,000
Average flow(m^3/d)	-	-	2,090	0	17,000
Dry weather flow (m^3/d)	30	5	1,500	0	-
Nominal WW flow (l/inh.D)	50	50	50	-	-
Process type	Stabilization pond	Stabilization pond	Stabilization pond	-	Oxidation ditch
BOD_5(mg/l)	253	233	670	-	380
SS (mg/l)	19	1,384	1,070	-	300
COD_{Cr}(mg/l)	422	410	1,710	-	720
T-N (mg/l)	40	22	-	-	-
NH_4-nitrogen (mg/l)	-	-	127	-	46
T-P (mg/l)	3.3	-	7	-	3
Phosphate P (mg/l)	-	1	-	-	-

Source: KVWMP, KUKL 2022

D. Riverfront Beautification

Several infrastructures such as numbers of aeration weirs along the river reach to improve water quality, long span of aesthetical wall boundaries to demark landscape with riverine area, and several traditional stone cladded Ghats and steps to approach river water for regular and routine religious performances have been constructed at various places. Besides these infrastructures, foot path, cycle track and green Lush Park, both in the river middle terraces and by the side of pedestrian tracks, have been built in order to improve river bank environment for those who commute through roads, cycle and foot tracks.

Figure 3-20: ***Left:*** *Shankha Park constructed on the reclaimed land, also seen are stone steps and bhakaro with few old house along the edge:* ***Right:*** *The width of the river is controlled using vertical walls and seen are the parapet walls along the Sankha Park.*

3.5.1.5. Water Storage/Recharge Structure

The topographical setting of the peripheral hills of the valley has formed numbers of depressions and wetlands. These depressions are generally filled with water in rainy seasons and remain dry in winter. These depressive wetlands are simply called as *dhap*. There is high potentiality to store rainwater in these *dhaps* so that they could contribute the streams in lower region. There are number of *dhaps* identified in the Kathmandu Valley that have potentiality of developing recharge lakes. Some projects are under construction

Chisapani Dhap Dam

There is one recharge pond being completed in Shivapuri National Park near to Chisapani. It is well-known as Dhap in the locality. A concrete faced rock fill dam (CFRD) has been constructed to retain the rain water and aims to recharge the Nagmati Khola, a tributary of Bagmati River. The maximum height of dam is 24m and the length of the dam crest is 175m. It is designed to store more than 861,000 m^3 water in this pond.

Figure 3-21: *Undergoing development of Dhap as a Recharge Lake near to Chisapani in Shivapuri National Park*

Nagmati Dam

Another reservoir dam is under the process of construction in the Nagmati Khola at about 3 km. downstream from the Chisapani Dhap Dam. It is called as Nagmati Dam. The detailed feasibility study of the project has been prepared. Environmental Impact Assessment (EIA) of the project has also been prepared and under the process of approval from the Ministry of Forests and Environment. A concrete faced rockfill dam (CFRD) of about 94.5m height and 554m length is proposed. It aims to generate hydroelectricity as well as to increase volume of water in the Bagmati River.

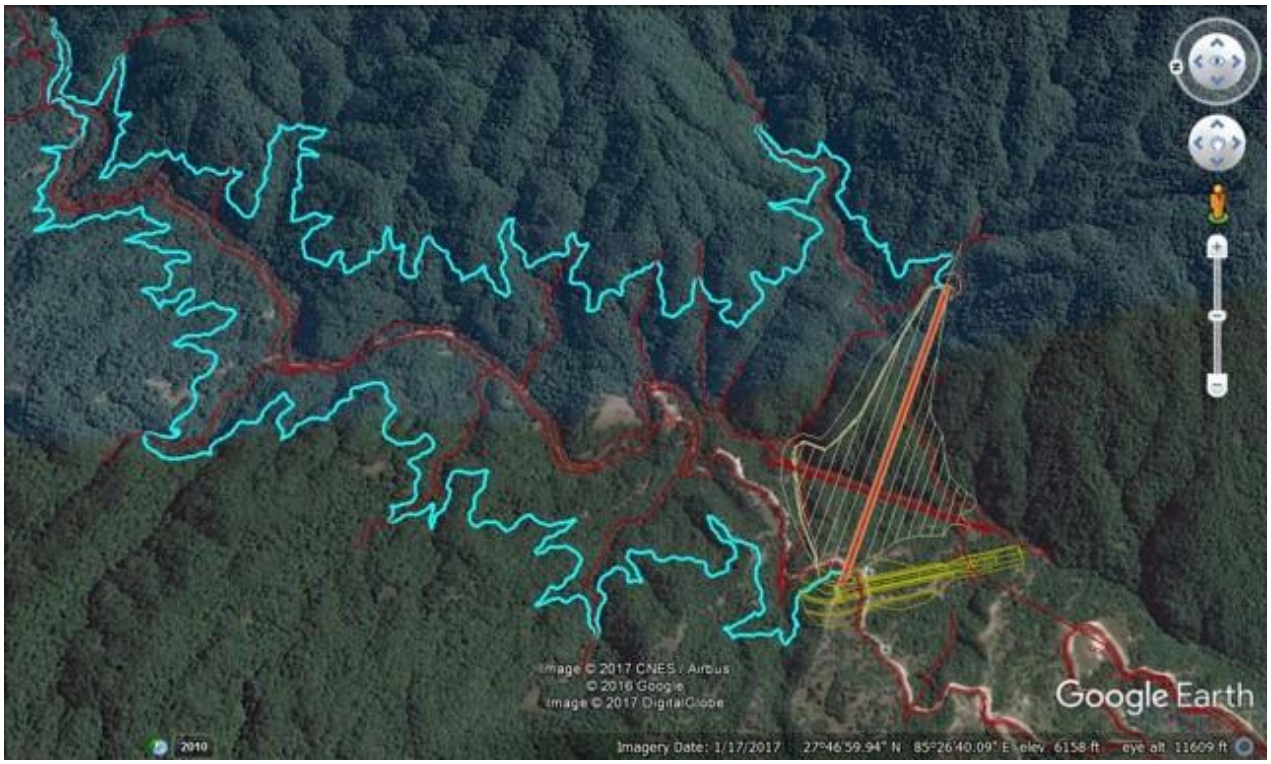


Figure 3-22: *Layout of Nagmati Dam overlayed in Google Earth image (Source: https://dhapdam.gov.np/nagmati-maps/)*

3.5.2. Cultural Heritage and Monuments

The sacred landscape of Kathmandu valley is intertwined with its riverine culture. Water is venerated in Nepal Mandala as divine, life giving, and life maintaining substance. It is regarded as the counterpart on earth of amrita, the immortalizing elixir of the gods. This relation with sacred water is especially visible in innumerable tirthas often located near water - on the banks and confluences, at ponds and pools, at springs and even at seemingly mundane wells. Pilgrimage to these tirthas and bathing in these waters are considered the most compelling religious activities (Slusser, 1998).

Of all the valley rivers Bagmati is considered the most sacred and is studded with holy places and tirthas. The other illustrious rivers with wondorous legends and endowed with numerous holy places are mainly Vishnumati, Manohara and Hanumante. This study has considered 30 holy places and tirthas along these rivers for detailed study to understand the context of their sitting, their relation with the other cultural sites and settlements as well as to understand the intangible attributes associated with these sacred places. The cultural sites situated along the river are often places of cremation where the dying and dead come to be in communion with the sacred water. Besides its association with death rituals, these are the places to seek blessings in the form of offsprings, cure from diseases and for good fortune. This clearly indicate the intricate relation the valley dwellers share with their sacred water.

This study has tried to see the physical context of these heritage sites and find the linkages with the intangible heritages. This attempt has put forth a clearer picture that the heritage sites along these rivers do not sit in isolation or oblivion with the settlements lying in their proximity rather there is complex relationship of these sites with the settlements and the people living there. These relationships often come alive when people move through these spatial arrangements, and during jatras and festivals. The important cultural sites and monuments are listed in **Table 3-16**.

Table 3-16: Cultural heritage and monuments along Bagmati River and its tributaries

Name of Cultural Site	Location	Major Structures/ Monuments	Current Status
Bagmati River			

Name of Cultural Site	Location	Major Structures/ Monuments	Current Status
Bagdwar			
Sundari Mai	Gokarneshwor-1	Main Shrine, Shiva Lingas	The construction of access way and provision of handrails along the trail completed, construction of bridge underway
Gokarneshwor	Gokarneshwor-4	Main Temple, Bhajan Mandapa, Sattal, Cremation Site	The temple is under restoration, its jhingati roof is being changed to gilt copper roof. The ghats on either sides of the river being constructed. There is a plan to create public parks on the eastern banks of the river
Guheshwari	Kathmandu-8	Main Temple, Sattal, Domed Temples, Ghats	The reconstruction of northern and part of western sattal completed, restoration of Tribhuvan-prakesesvara ongoing, restoration of sattal to the north of the mentioned domed temple, the ghat construction on either sides of the river ongoing
Pashupati	Kathmandu-8	Main Temple, Sattals, Patis, Shrines, Ghats, Domed Temples, Tiered Temples, Forest	Restoration of the pinnacle of main temple, reconstruction of Mahasnan ghar, reconstruction of Agnishala, Kotilingesvara,
Shankhamul	Lalitpur-9	Ghat, Cremation Site, Jagat Narayan Temple, Sattlas, Patis	Restoration of Jagat Narayan temple undergoing, Sankha park construction completed and actively used by the public
Kalmochan	Kathmandu-11	Jung Hiranya Hem Narayan Temple Gopal Mandir Bairagi Akhada Udasi Naya Akhada Dash Nami Akhada	Restoration of all the temples and sattals ongoing
Tripureshwor Mahadev Temple	Kathmandu-11	Main Temple, Sattals, Ghat	Restoration of the temple and sattals ongoing with an aim to house the KU school of music in the sattal
Pachali Bhairav	Kathmandu-12	Main Temple, Dya Chen, Sattals	Restoration of Dya Chen completed, restoration of sattals ongoing
Pachali Ghat	Kathmandu-12	Ghat, Rest Houses, Stone Sculpotures and Chaityas, Cremation Sites	Reconstruction of new ghats burying the existing ghat ongoing with an aim to create new green spaces
Teku Dovan (Chitamani Tirtha)	Kathmandu-12	Ghat, Cremation Sites, Temple, Chaityas	Kriyaputri ghar restoration completed
Chobaha	Kirtipur-6	Main Temple Quadrangle And Surrounding	Restoration of the main temple of Adinath completed

Name of Cultural Site	Location	Major Structures/ Monuments	Current Status
		Sattals as well as the Confluence of Bagmati and Nakhu River	
Jala Binayaka	Kirtipur-6	Main Temple, Sattals, Ghats, Creamation Sites	Restoration of main temple and surrounding sattals constructed, access road, new ward office and parking areas developed
Manohara			
Salinadi		Main Temple Area, Park,	Landscaping works under progress, Madhav Narayan temple under construction
Changunaraya n		Main Temple, Kileshwor, Chinnamasta. Krishna Temple, Shiva Temple, Surrounding Sattal	Kilehswor temple reconstruction completed. The reconstruction of surrounding sattal underway.
Bishnumati			
Sapana Tirtha	Tokha-2	Main Temple, Pati, Kunda	The reconstruction of main temple ongoing under municipality budget, a pati to the east of the main Temple is also under construction under municipality budget, the landscaping works are also underway like paving and greenery works
Manamaiju	Tarkeshwor-11	Main Temple, Sattal, Phalcha, Park	Restoration of the north wing of the temple and other phalchas and sattals in the periphery are underway post 2015 earthquake. A park has also been created in a temple land to the west of the temple
Sobha Bhagwati	Kathmandu-15	Main Temple, Bhwye Sattal, Pati, Park	The main temple is standing but the patis are in deteriorated condition.
Bijeshwari	Kathmandu-15	Main Temple, Bahi Quadrangle	The main temple and the sattals were reconstructed post 2015 earthquake
Indrayani	Kathmandu-17	Main Temple, Pati, Cremation Sites	The restoration of main temple is complete, the restoration of the sattals needed; new sattals are under construction to the west of the temple
Kankeshwari	Kathmandu-19	Main Temple, Sattal, Public Library, Cremation Site	The restoration of the main temple completed post 2015 earthquake
Hanumante			
Mahadev Pokhari	Nagarkot	Main Temple, Kunda, Patis	No recent activities recorded

Name of Cultural Site	Location	Major Structures/ Monuments	Current Status
Brahmayani Temple	Bhaktapur	Main Temple, Cremation Site, Sattal	Construction of bridge ongoing and retaining wall construction completed
Ram Mandir	Bhaktapur	Main Temple, Sattals, Ghats	Restoration of sattals completed
Hanuman Ghat	Bhaktapur	Sattals, Small Shrines, Ghats	Restoration of Madhav Narayan sattal, pujari ghar and Krishna Bhajan sattal completed
Dhum Barahi Temple	Bhaktapur	Main Temple, Sattal, Pond, Dhungedhara, Cow Shed	Bridge under construction, water tank to the west of the temple ongoing
Nakhu Khola			
Tika Bhairav	Godavari	Main Temple, Entry Gate, East Phalcha, South Phalcha, Cremation Site on Either Sides of the River, Raj Kulo	The construction of East Phalcha is ongoing, It is new Phalcha. The restoration of the main temple is complete. The river taming works is ongoing.

Source: Field Survey 2022

The details are provided in Supplementary Volume I for Inventory.

3.5.3. Squatters Settlements

Squatter settlements are residential pockets inhabited by lower income groups in urban areas which have emerged and grown upon illegal squatting without formal claims to the land and / or permission from the concerned authorities to build. (Smolka 2002). The key feature of squatter settlement is the absence of ownership of land parcel which they have occupied. These lands are mostly the vacant land either public or private and these lands are mostly located in marginal areas likes risky areas, flood prone areas etc.

In Kathmandu Valley, after Rana Regime, influx of population from different parts of country in-migrated for better services and employment. Rural - urban migration for better jobs, health, education and other facilities; rapid escalation of the cost of land, housing units and rents; government's failure to supply adequate land and affordable housing; escalating poverty; unemployment; and low wages have compelled poor and unskilled migrants to squat and built their shelters on public land and other environmentally sensitive area like riverbanks or flood plains, steep slopes and vacant spaces under high voltage electrical transmission line in Kathmandu Valley. The failure of the rural economy and displacement of people for various reasons, including natural disasters and conflict, are the two major causes for the increase of slums and squatters settlements in the valley. Squatter settlements have grown in number from 17 in 1985 to 46 in 2013, the majority of them located on marginal public land along the riversides (Shrestha, 2020).

Table 3-17: Squatter settlements in Kathmandu Valley

Location	Squatter Settlement
Bagmati River	Kuriyagaun, Sankhamul, Bansighhat, Thapathali, Balkhu, Pragati Tole, Chandani Tole, Sinamangal (Mahabir Galli), Jagriti Nagar, Gairigaun, Shanti Nagar, Dhirghyau Tole, Airport Gairigaun

Location	Squatter Settlement
Bishnumati and Samakhusi River	Buddha Jyoti Marga, Jagriti Tole, Bhimmukteshwor, Dhikure Chauki, Ranibari, Sangam Tole, Narayan Tole, Khandpakha
Manohara River	Maoohara, Palpakot
Dhobikhola	Pathivara, Bishalnagar, Kalopul, Devi Nagar, Shanti Binayak, Anamnagar
Other Location	Radhakrishna Chowk, Mulpani, Hattigauda, Pasikot, Sukedhara, Narayantha, Deuwachowk Mahadev Khola, Mahankal, Kumarigal, Kapan DHungen, Kalimatidole, Maijubahal, Golfutar, Khadga Bhadrakali, Subigaun, Mandikhatar, Ramhiti

Source: DUDBC, 2010

Table 3-18: Growth in Squatter Settlements in Kathmandu

Year	No of Settlement	No of Households	Population	Remarks
1985	17		2,134	
1988	24	348	3,665	
1990	19	859	4,295	
1992	33	1,271	6,355	
1996	47	1,783	8,927	
1998	49	2,021	10,323	
2000	61	2,031	11,862	Source: KMC/WB, 2001
2008	45	2,844	13,243	Source: Tanaka, 2009 Note: At least 4 squatter settlements were evicted for Vishnumati link road project between 1998 and 2008
2010	46	3,227	15,363	Source : DUDBC, Physical Mapping of Squatter
2012	40	2,735	12,726	Source - Lumanti Bulletin, 2069 B.S. Note : On May 2012 squatter in Bagmati was destroyed by GoN, but resettled again after one month
2013	46	NA	24,021	Source: Dangol and Day, 2017

The other stark feature of the urban growth is the emergence and growth of slums and squatter settlements, and also a section of people living in unhygienic and unacceptable condition due to poverty. (KMC/WB, 2001). The trend of growth and locations of squatters also proves the same. Urbanization has bought the squatters alongside, as Shakamul, Kuriyaguan are the oldest squatters area alongside river and with the expansion of urban area squatters also have shifted to new urban areas.

Figure 3-23: *Squatter Settlement in Bagmati*

CHAPTER-IV

4. REVIEW OF ACTION PLAN 2009-14

4.1. ACTION PLAN 2009-14

The Bagmati Action Plan, BAP (2009-2014) has been prepared by High Powered Committee for Integrated Development of Bagmati Civilization (HPCIDBC) in collaboration with National Trust for Nature Conservation (NTNC). BAP has been established as an important guiding conceptual framework document for scientifically and systematically restoring and conserving the Bagmati River and its tributaries within the Kathmandu valley.

Bagmati River is considered as the source of Nepalese civilization and urbanization. It begins at Bagdwar 15km northeast of Kathmandu, exit from Chovar gorge flowing downward through Southern Terai plain and Nepal and merges into mighty Ganges in India. It is holy to both Hindus and Buddhist of Nepal. Besides its religious and cultural values, the river 43434sections has been considered in different sections for different uses through different users such as water source for municipal, industrial and irrigation use, somewhere treated as backyard of the city through deposition of solid waste along bank, somewhere as minerals resources area through extraction of sand, some parts are illegally occupied by squatters etc. These uncontrolled activities along the river have damaged the urban environment of Bagmati and its surrounding.

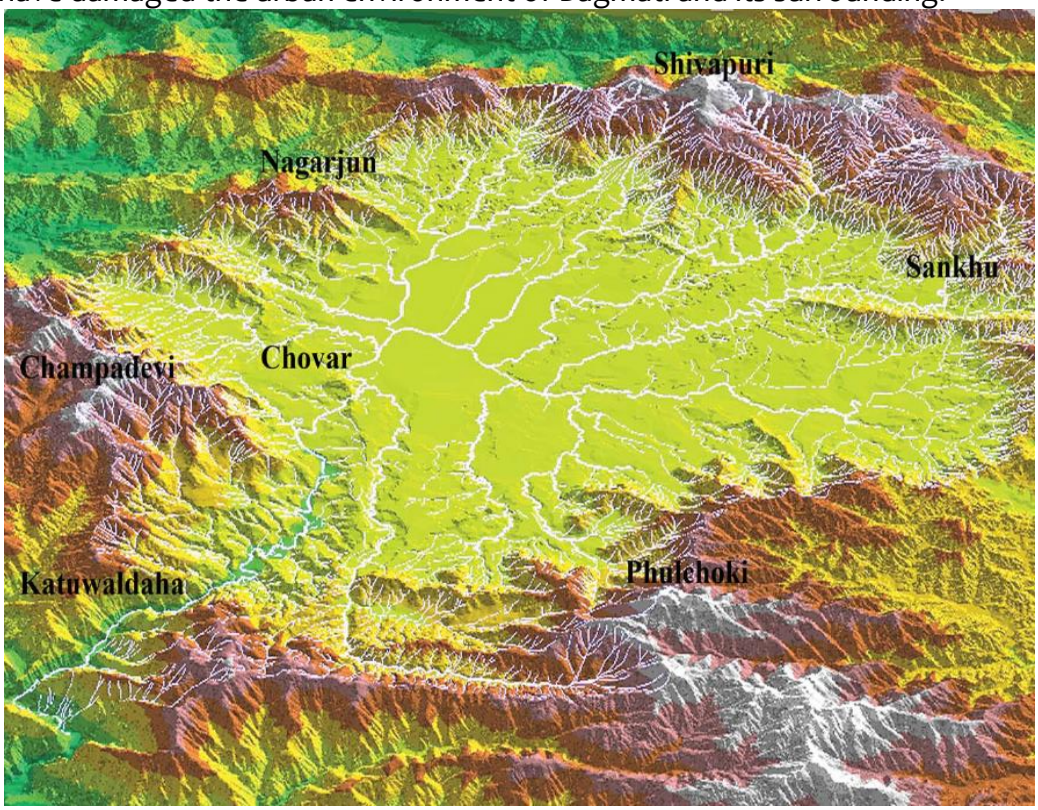


Figure 4-1: *Location Map of Upper Bagmati Basin (Bagmati Action Plan 2009-2014)*

The Bagmati River is one of the important river systems of Nepal with high cultural and aesthetical values. However, in the absence of planned and coordinated restoration and

conservation efforts, environmental degradation and cultural erosion of the Bagmati river system has continued unabated. The Bagmati Action Plan (BAP) has been formulated with the aim to restore and conserve the Bagmati River and its tributaries in an integrated and coordinated approach. BAP covers the Bagmati river system from Shivapuri hill to Katuwal Daha. The Bagmati river system includes seven tributaries - Bagmati, Bishnumati, Dhobikhola (Rudramati), Manohara, Nakkhu, Balkhu and Tukucha (Ichhumati) rivers and the five sub tributaries Godavari, Hanumate, Sangla, Mahadev and Kodku Khola.

The critical issues of Bagmati River and its tributaries are primarily related to river ecosystem, river side land use change, preservation of culture and heritage and institutional related arrangements.

- River Ecosystem and waste water describes briefly on the key issues of decrease in water discharge, degradation of river water quality, degradation of catchment quality, narrowing and deepening of water way and depletion of aquatic biodiversity.
- Riverside land use and socio economic condition describes the issues on changes in riverside landuse and eroding aesthetic value.
- Culture and Heritage describes the issues on deteriorating culture and heritage and eroding cultural values and norms.
- Institutional related arrangement deals mainly the issues of integrating conventional planning with ecosystem management, demand management, payment for services and incentives for conservation and enforcement, coordination and stakeholder participation.

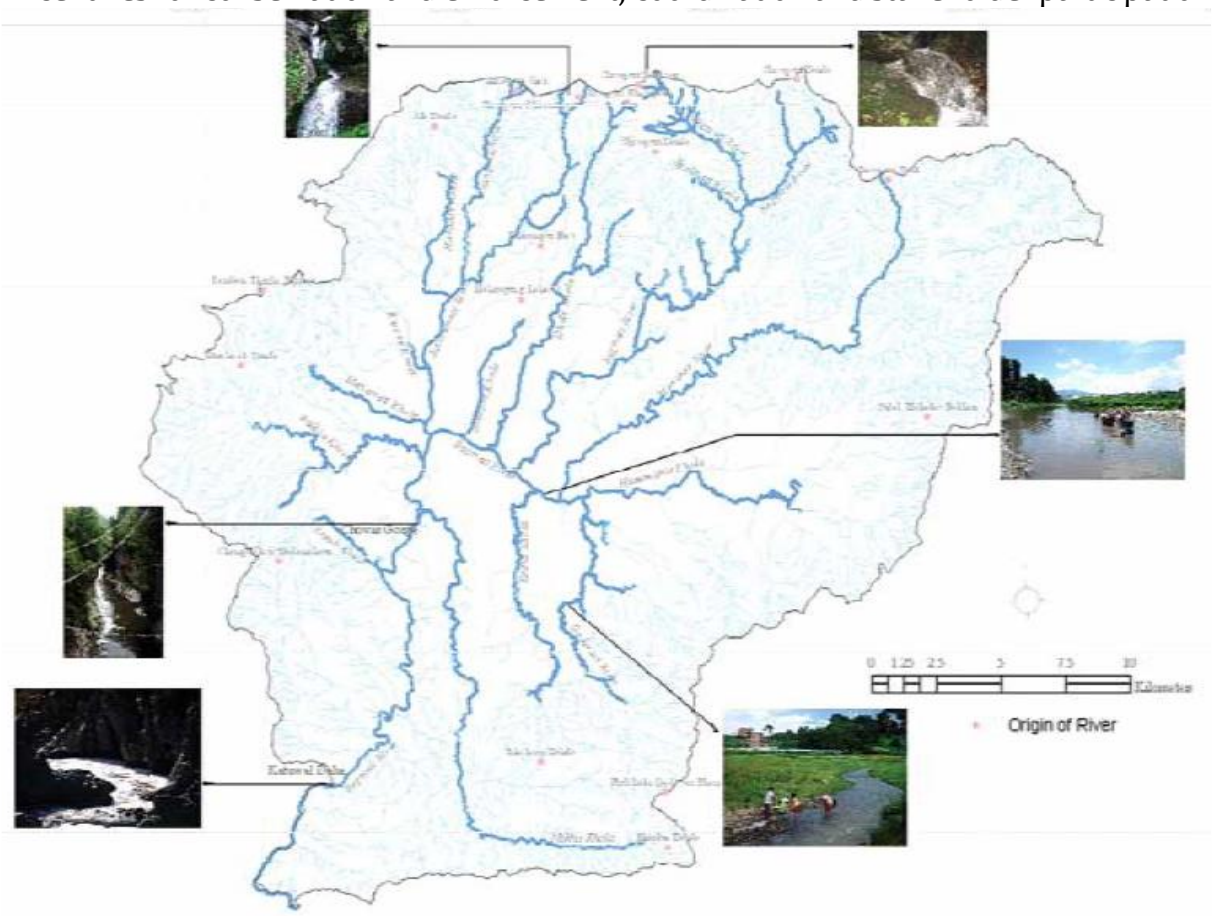


Figure 4-2: *River Network of Kathmandu Valley (Bagmati Action Plan 2009-2014)*

BAP focuses on following activities:

- Key issues of Bagmati River
- Zoning of the Kathmandu Valley River System
- Legislative arrangements
- Action Plan
- Implementation Strategy and Monitoring Plan
- Budget Plan

Joint initiation of citizen and government to make Bagmati a pollution free river resulted in formation of a high-powered Committee for Implementation & Monitoring of Environmental Improvement in Pashupati Area back in 2051 B.S., which is now functioning as High- Powered Committee for Integrated Development of the Bagmati Civilization (HPCIDBC). It builds 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.

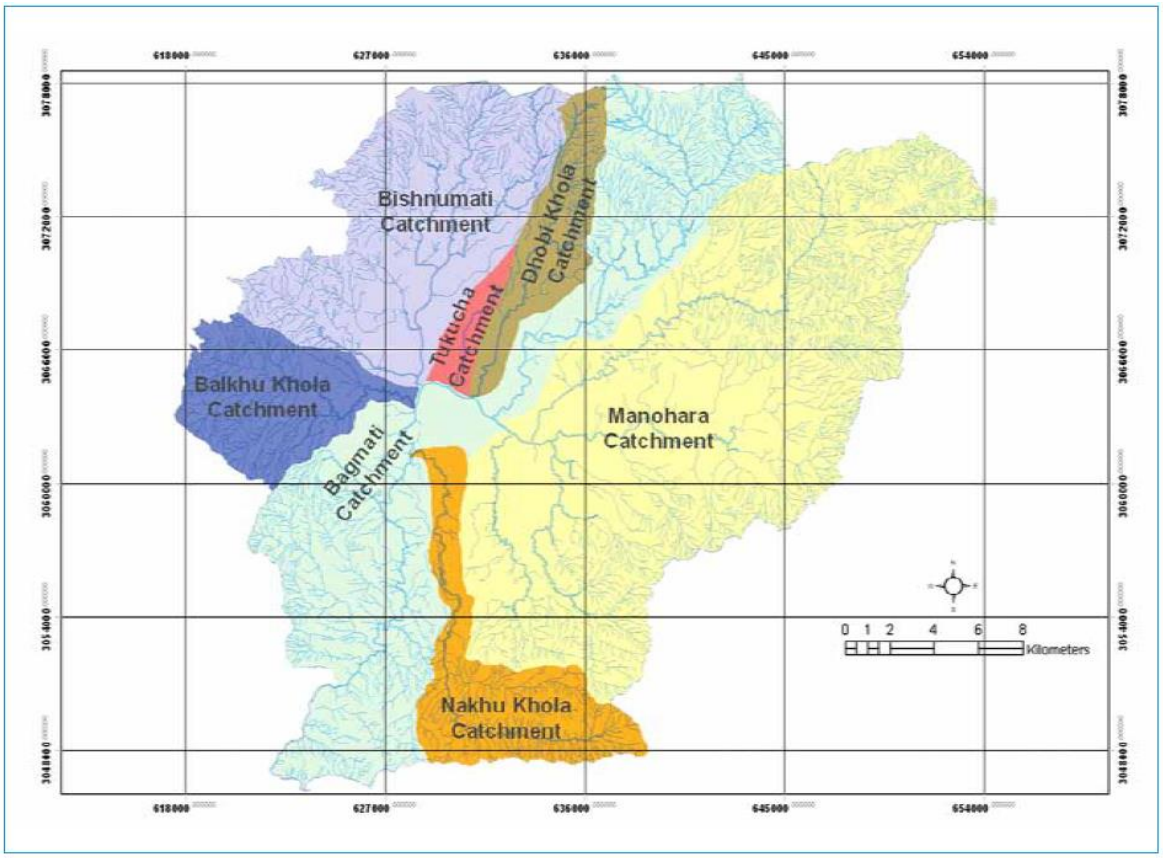


Figure 4-3: *Catchment Map of Major Rivers in Kathmandu Valley (Bagmati Action Plan 2009-2014) (Ref: Bagmati Action Plan 2009-2014)*

The issues of Bagmati River is not same in every segment of river. To effectively address the key issues at micro level, a concept of zonation of the river system within Kathmandu Valley has been introduced in BAP. Zonation of Kathmandu Valley is classified into five different zones on the basis of water quality and population density such as Natural Conservation Core Zone (Zone 1), Rural Zone (Zone 2), Peri Urban Zone (Zone 3), Urban Zone (Zone 4) and Downstream Zone (Zone 5).

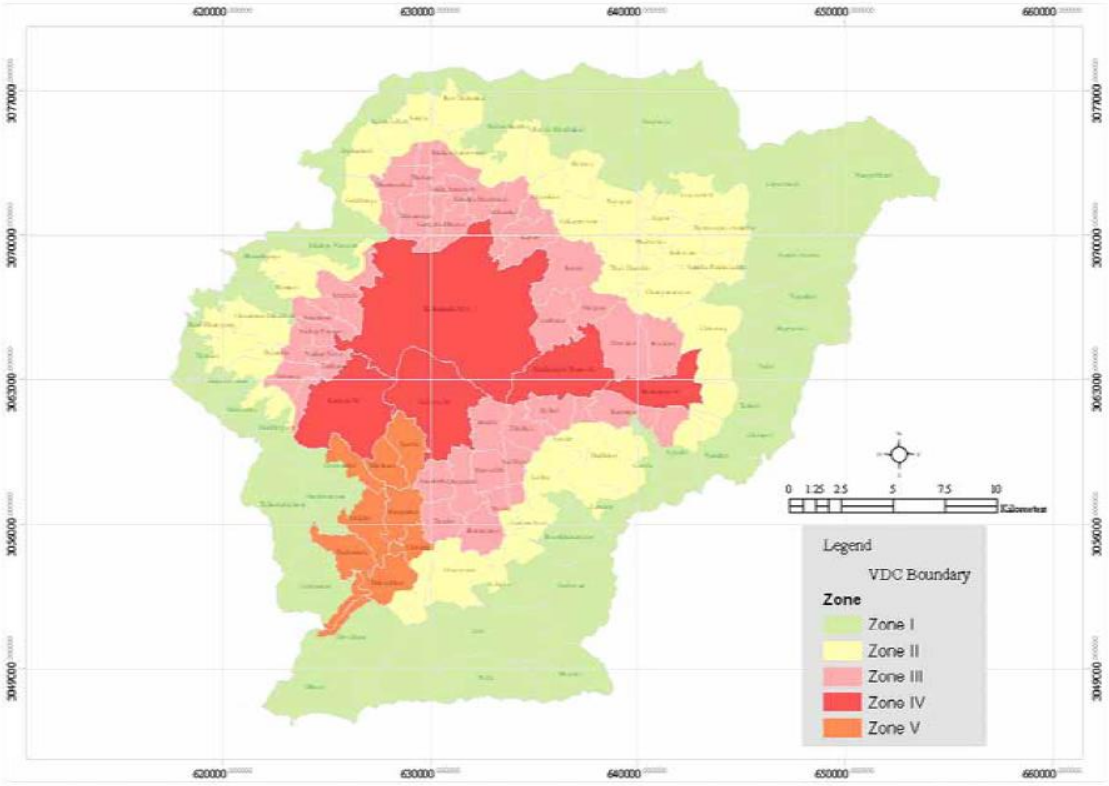


Figure 4-4: *Zonation Map of Kathmandu Valley (Bagmati Action Plan 2009-2014)*

- Zone 1 is natural conservation core zone which is 323 sq.km i.e. 45.1% of targeted area which consist of green hill surrounding the Valley Such as Phulchowki, Shivapuri, Chandragiri and Nagarjuna. The population density is very low and hence the river water quality is in natural condition.
- Zone 2 is Rural Zone which is 150 sq.km i.e. 21% of targeted population. Bagmati River and its tributaries flow through this Zone. This zone is dominated through agriculture use and the population density in this zone is higher than Zone 1.
- Zone 3 is Peri Urban Zone which is 113 sq.km i.e. 15.8% of targeted area which is located between rural and core urban city. Population density is comparatively higher than Zone 2 and lesser than Zone 4 in this area.
- Zone 4 is urban Zone which is highly urbanized zone of Kathmandu Valley and consists of five the then municipalities. The water quality is worst in this zone and the population density is highest among all.
- Zone 5 is Downstream Zone which is southern part of Kathmandu Valley from Sundarighat to Katuwal Daha. This zone is mostly covered with agricultural zone and has comparatively low population than peri urban zone but the water system is extremely polluted in this area.

Bagmati Action Plan sets the overall vision for restoration and conservation of Bagmati River and its tributaries. The vision of the study is –

"Clean, green and healthy river system that is full of life and valued by all".

Apart from vision, the study goals, objectives and activities are sets individual for each zone based on the identified issues. This action plan has given due recognition to the priority activities that have been recommended by previous interventions. One of the major activity and the challenges of each zone is to manage waste (liquid and solid) and to improve the quality of water of river. Certain key activities which are valid in all the zones are included as cross cutting activities. These activities are either common for all zones or their outputs help to build the capacity of HPCIDBC and other agencies working for the restoration and conservation of the Bagmati river and its tributaries.

- For Natural Conservation Core Zone (Zone I), the main goal to maintain and enhance the upstream river ecosystem through the increasing the water discharge in river. The action also emphasize on maintaining the river water quality and promoting the eco-tourism of the area. Moreover it also focus on renovation and conservation of cultural and heritage sites.
- For Rural Zone (Zone II), the main goal is to restore the river ecosystem through sustainable development approach. The action focus on enhancing water flow in river, conservation of biodiversity and riparian landscape, prevention on discharge of waste water and solid waste in river and promotion sustainable agricultural practice. It also focuses on regulation of urban growth and industrial activities and conservation and promotion of culture and heritage.
- For Peri-Urban Zone (Zone III), the main goal is to restore the river ecosystem through effective management of urban growth. The action focus on improvement of river water quality, protection of river side land use, control and relocation of squatter. It also emphasize on conservation and regeneration of culture and heritage.
- For Urban Zone (Zone IV), the main goal is to upgrade river ecosystem, conserve and regenerate tangible and intangible heritage linked with rivers. The action focus on improvement of water quality through management of waste, relocation of squatter and improvement of riparian landscape. It also focus on the renovation and conservation of cultural and heritage site and promotion of tourism
- For Downstream Zone (Zone V), the main goal is to restore healthy river ecosystem with the capacity for self-purification. The action focus on improvement of river water quality, improvement of self-purification process of river and conservation of terrestrial habitat. It also focus on conservation of cultural and heritage site and promotion of eco-tourism.

There are different agencies involved in promotion and development of different zones along Bagmati River. A strong mechanism has to be established for coordination among these institutions for efficient and sustainable management of Bagmati River. BAP has recommended HPCIDBC as key coordinating and leading agency to address the issues and activities highlighted in the plan. All other stakeholders and partners such as CBOs, local government, KVDA, NGOs, DWSS etc must take permission for any activity to be carried out in and around the Bagmati River and it's tributaries aimed at maintaining consistency and avoiding duplication of activities and to bring all the stakeholders under one umbrella. Regular monitoring is required from the concerned authorities.

On the basis of action plan prepared, the total estimate budget for five year is Rs. 15,028 million. Zone 4 requires the maximum budget I.e.46.28% of total budget because this zone covers the urban core area where major activities have been proposed. Similarly, Zone 1 requires least budget ie. 1.47% of total budget. However, 10.98% of total budget has been allocated for cross cutting activities.

4.2. MAJOR PROJECTS IDENTIFIED BY ACTION PLAN 2009-14 AND THEIR CURRENT STATUS

- **Protect and manage wetlands in areas such as Phulchowki and Shivapuri National Park:** *Current Status: Nagmati Dam was identified within Shivapuri National Park and study is on EIA Stage. After the approval of EIA, the construction will be initiated. Wetland studies on other area are not seen in progress.*
- **Construct embankment in dhap (Shivapuri National Park) to increase water recharging capacity:** *Current Status: Dhap Dam is in completion phase and rain water collection will be started from this monsoon in Dhap dam area*
- **Rehabilitation of existing ponds to recharge groundwater through rainwater harvesting :** *Current Status: Some ponds have been rehabilitated and some are under process through local bodies such as Rani Pokhari, Kamal Pokhari, Gahana Pokhari, Ikha Pukhu etc in Kathmandu, Pimbaha Pukhu, Saptapatal Pokhari, Na Pukhu, Balkumari Pukhu etc in Lalitpur, Nhu Pukhu, Rani*

Pokhari, Bhaju Pukhu, Siddha Pokhari etc in Bhaktapur. All these rehabilitation of ponds has not been accomplished from traditional technology, so objective of recharge of groundwater has not been fulfilled as expected. Most of the ponds are rehabilitated for beautification purposes.

- **Prepare and implement land use plan:** *Current Status: There is no progress in this proposed intervention from the aspects of Watershed Conservation.*
- **Construct community managed DEWATS System:** *Current Status: No much progress is observed in this proposed intervention. However some community managed DEWATS System has been constructed.*
- **Construct intercepting sewerage system along both the banks of the rivers:** *Current Status: 71.7km of Interceptor has been laid on Bagmati, Bishnumati, Balkhu, Dhobikhola and Nakkhu. But since WWTP or DEWATS are not in operation phase, sewerage is disposed directly into river.*
- **Rehabilitation of existing WWTP and construction of additional WWTP:** *Current Status: Existing WWTP are under construction for up gradation but additional WWTP has been proposed are going under construction for Tukucha and Dhobikhola.*
- **Verification and relocation of all squatters from the river banks:** *Current Status: Most of the squatters has been identified from different organizations but the numbers and locations are not verified from HPCIDBC. Relocation of squatters has been succeeded in some areas such as Dobikhola Corridor etc from the initiation of the project. Though the relocation seems negligible to the present status.*
- **Control encroachment of the river banks by squatter and others:** *Current Status: Encroachment is minimal but the records have not been updated and verified. No specific program seems proposed.*
- **Construct access roads/foot trails along both the banks of the rivers:** *Current Status: River corridor has been prioritized and developed with footpath along most of river corridors but the foot trails have not been envisioned. Road corridors has been developed along Bagmati, Bishnumati, Rudramati (Dhobikhola) etc. Analysing the present scenario, 161 Km of road corridors have been developed along the river within KV.*
- **Prepare and implement landscape plan of riparian land to maintain green corridor;** *Current Status: Development of river corridor has focused on landscape and green areas which add up the open green park such as UN Park, Sankha Park, Art of Living etc at different areas which are under management of different organizations. However, the riparian concept has not be advocated.*
- **Carry out bank protection works using bioengineering:** *Current Status: No specific projects and programs are proposed for bank protection. However, for the road corridor construction 160.5 km river training wall has been constructed but these protection works do not follow bioengineering concept and fails to recharge the water in river.*
- **Prepare an inventory of existing heritage sites:** *Current Status: No specific projects are designed for inventory of exiting heritage sites*
- **Prepare restoration plans of existing culture and heritage sites and associated cultural activities:** *Current Status: No specific projects are designed for inventory of heritage sites and identification of existing status of existing culture and heritage site. But after Gorkha earthquake 2015, restoration plan for some structures along Bagmati were identified and restored.*

4.3. CRITICAL ANALYSIS OF ACTION PLAN 2009-14

The Action Plan 2009-14 has prepared with the objectives; cleaning Bagmati and its tributaries, increasing water discharge in rivers, preservation of tangible and intangible cultural/historical

heritage within the valley. Plan had identified problems and key issues related with river & heritage and had proposed activities to resolve problem associated. DEWATS, WWTPs, interceptors, conservation & rehabilitation of existing water sources/ponds, restoration of tangible and intangible heritages, biodiversity conservation and restoration were major activities to resolve problems. Plan had given equal emphasis to cleanliness of rivers and restoration of water & forest biodiversity within valley. Though activities proposed are very important and appropriate to resolve problem existed in the valley but implementation of plan could not bring outcome as expected in the plan. Some of issues which hinder proposed project are identified as;

- Activities proposed were more conservation oriented but implementation inclined toward development need of the valley.
- Instable government, irregular/unpredictable source of fund hider timely execution of project proposed like DEWATS, WWTPs, dhap dam, interceptor development etc.
- Priority of right between implementation partners also slow down implementation pace of projects.
- Specified project targets and project location were not detailed which hinder expected results from plan.

Similarly, at one side number of projects proposed remains unimplemented due to obstacle but at the same time there were some externalities too which create obstacle in goal achievement,

- Rate of population growth and settlement expansion in the valley was more than that was expected by plan.
- Development need of the valley create adverse environmental impact on Valley Rivers.
- Water conservation was the priority but water recharge mechanism was not addressed in the report.
- Urban and rural areas are found with different impacts in rivers, uniform strategies provided along rivers minimizes impacts on project objectives.

CHAPTER-V

5. SITUATION ANALYSIS AND KEY ISSUES

5.1. DEMOGRAPHIC ANALYSIS

5.1.1. Population Growth Trend and Projection

According to population census 2011, the population of Kathmandu valley was 2,446,146. The Preliminary Census Report 2021 shows the population of the valley to have increased to 2,953,731 with the annual growth rate of 1.9% per annum which has been decreased from last decade i.e. 4.23% per annum (CBS, 2001 & 2011). On comparison of the population of census 2011 and 2021, it is observed that the population of Kathmandu Metropolitan City has decreased. The population growth rate of Kathmandu Metropolitan City as compared to census 2011 was observed at -1.42% per annum. Similarly, the population of Bhaktapur Municipality, Konjyosom Rural Municipality and Bagmati Rural Municipality has also been decreased at the rate of -0.36%, -0.71% and -1.52% per annum (**Annex II**).

The analysis of population growth trend during 2001-2021 periods shows the reduction in growth rate in 2011-2021 decade, compared to that in 2001-2011 decade (**Table 5-1**).

Table 5-1: Population growth rate in different census period

Year	Population	Growth Rate
2001	1,616,413	-
2011	2,446,146	4.23%
2021	2,953,731	1.90%

Source: CBS 2001, 2011 and 2021 (Preliminary Report)

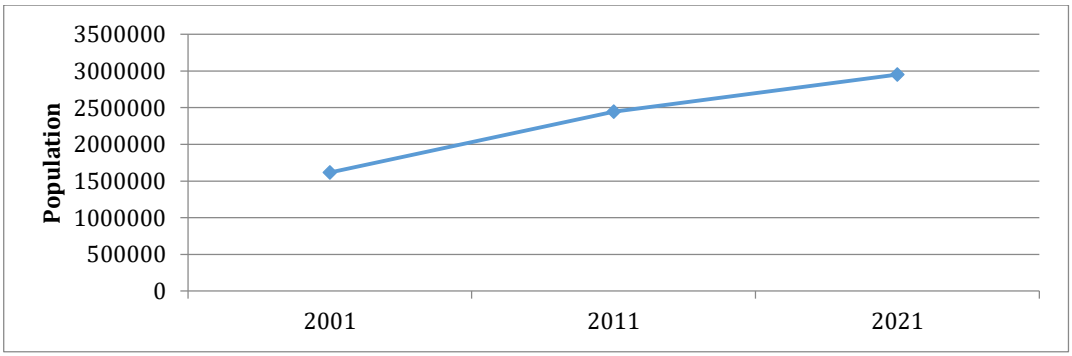


Figure 5-1: Population growth trend of Kathmandu Valley

Looking at the growth rates of the local units within the valley, the growth rate is higher in peripheral local units of core urban areas of the valley. The future growth will also be channeled to these areas where large available built-up area can still be observed. However, not all the area could be developed due to constraint factors like slope, monument zone, historical ponds, forests and other ecological constraints.

The population projection is thus made with the assumptions that the minimum growth rates in the local bodies will be 0.93% per annum which is average annum growth rate of 2011-2021 and

the maximum growth rate of 4.5% per annum. For the remaining municipalities, same growth rate has been adopted till next 20 years period

With the growth rate of 2.58% per annum, the population of Kathmandu valley is projected to reach 5,145,065 by 2042 (**Figure 5-2**).

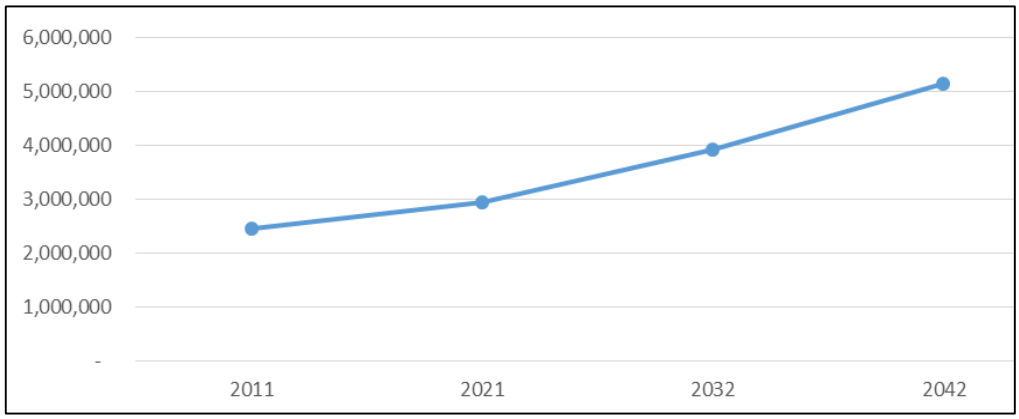


Figure 5-2: Projected population till 2042

Floating population in between of 5 lakh to 10 lakh has been predicted in KV for better urban services in past studies. ADB, 2017 study has considered 750,000 floating population which has been adopted for this study as well for present scenario. Due to decentralization of development of Nepal, people will have lots of options for better services other than KV, so the same population of 750,000 floating population which has been adopted for 2032 and 2042. So, inhabitant of KV in 2032 and 2042 are predicted 4.66 million and 5.89 million.

5.1.2. Population Density

The gross density of Kathmandu valley is expected to reach around 59 ppha in 2042. The computation of projected population densities of the local unit shows the higher density in Madhyapur Thimi municipality (226 ppha), followed by Kathmandu Metropolitan City (208 ppha), Tokha Municipality (154 ppha), Bhaktapur Municipality (139 ppha), Budhanilkantha Municipality (118 ppha), Kageshwori Manohara Municipality (111 ppha), Mahalaxmi Munnicipality (102 ppha) and Lalitpur Metropolitan City (101 ppha). All other local units will have population densities below 100 ppha. The details in presented in Annex II.

5.2. LAND COVER CHANGE

Land use and land cover change is one of the major drivers that alter the ecosystem function in the region. The rapid urbanization can cause serious depletion of the ecosystem services (W. Wang et al., 2020) through depletion in regulating services of climate, air, water and land (Peng, 2018); deteriorate the cultural services (Brosius & Michaels, 2020); hinders in provisional services by reducing the forest and open space (Pokhrel, 2019) and misbalancing the supporting services such as nutrient cycle, water cycling, soil formation and photosynthesis (S. W. Wang et al., 2020; Rijal et al., 2021). The land cover change of Kathmandu valley over the last two decades is evaluated from the land cover database of ICIMOD. The result revealed that valley is facing the rapid urbanization with annual increment in built-up of about 4.56 percentage during last decade which is about four times higher than that of the period from 2000 to 2010 (**Table 5-2**).

Table 5-2: Land cover change dynamic of Kathmandu valley

Land cover/ Year	Year 2000		Year 2010		Year 2020		Area change (Sq. Km)	
	Area (Sq. Km)	Percent (%)	Area (Sq. Km)	Percent (%)	Area (Sq. Km)	Percent (%)	2000-2010	2010-2020
Built-up	87.22	12.25	102.53	14.40	161.50	22.69	15.31	58.98
Cultivation	333.92	46.91	298.90	41.99	255.91	35.95	-35.02	-42.98

Land cover/ Year	Year 2000		Year 2010		Year 2020		Area change (Sq. Km)	
	Area (Sq. Km)	Percent (%)	Area (Sq. Km)	Percent (%)	Area (Sq. Km)	Percent (%)	2000-2010	2010-2020
Forest	277.37	38.96	299.51	42.07	285.34	40.08	22.14	-14.17
Grassland	13.15	1.85	10.71	1.50	8.80	1.24	-2.44	-1.91
Riverbed	0.06	0.01	0.11	0.01	0.07	0.01	0.04	-0.04
Water bodies	0.15	0.02	0.12	0.02	0.24	0.03	-0.03	0.12

Source: ICIMOD 2020

Understanding the spatial pattern and direction of the urban growth is essential for the river system management plan. During the 2000's, urban form inside ring road was dense which readily expanded outer circular over the period of 2000 to 2010. Further outward expansion urban/built-up has evidence in recent decade resulting conversion of prime agricultural land in the valley floor (**Figure 5-3**). Due to ever increasing urbanization pressure, the valley has been facing serious environmental consequences in recent years. And most affected environmental function is on river system.

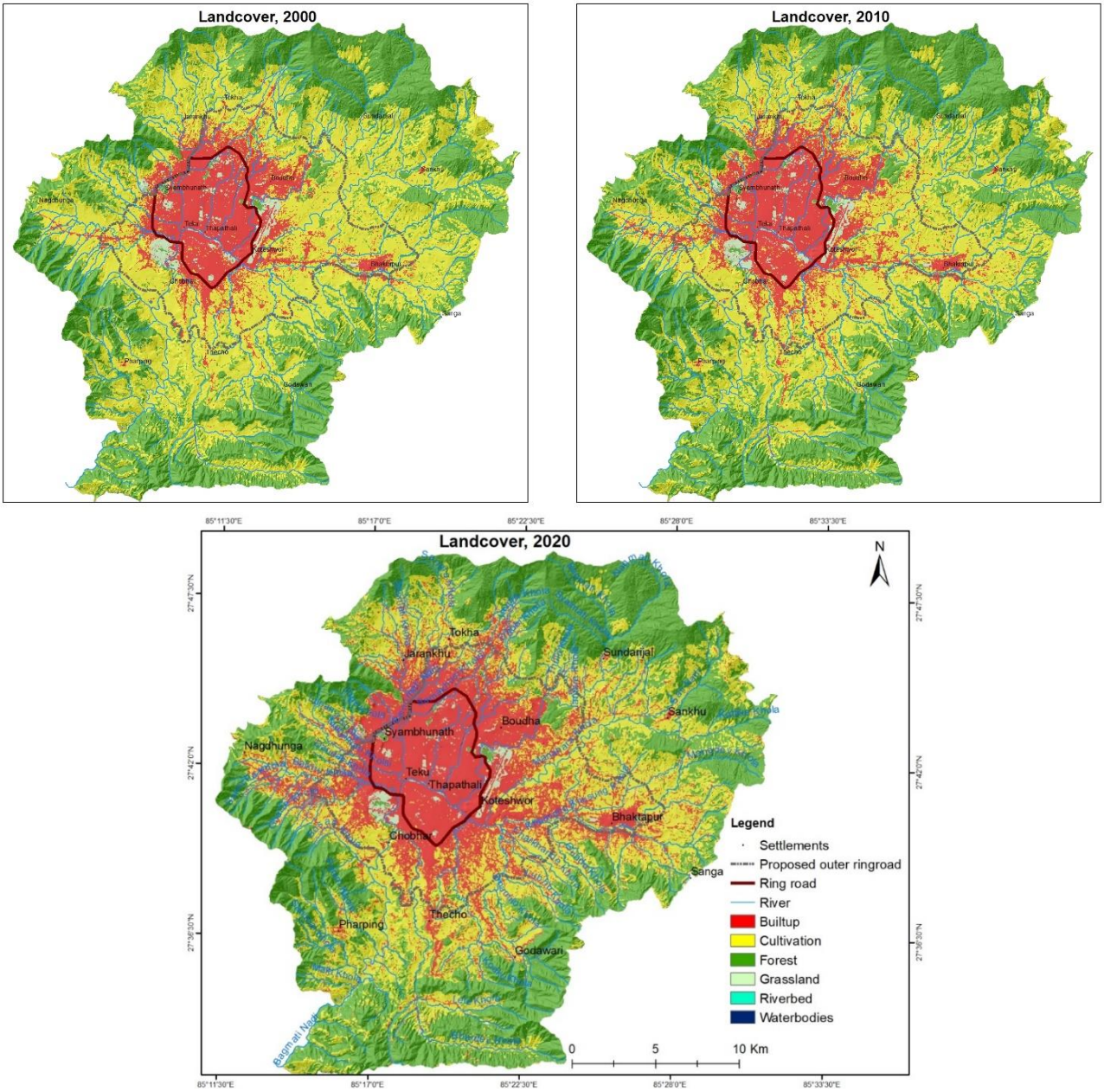


Figure 5-3: Land cover change during last two decades

5.3. URBAN GROWTH TREND

5.3.1. Settlement Development Scenario

Kathmandu Valley is one of the fastest growing metropolitan areas in South Asia and facing the lots of challenges due to rapid urbanization and modernization (WB, 2014). The highest growth rate up-to 6.5% has been recorded within Kathmandu Valley (KVDA, 2016) with dense urban core area within the Ring road area and urban sprawling at the periphery. The rapid population growth in KV was recorded during the period of 1999-2009 with booming period of real estate market largely fueled by influx of migrants from the countryside displaced by political turmoil (Rimal, 2011). After 2009, the growth has been slight slowdown in KV which is illustrated in Figure **5-4**.

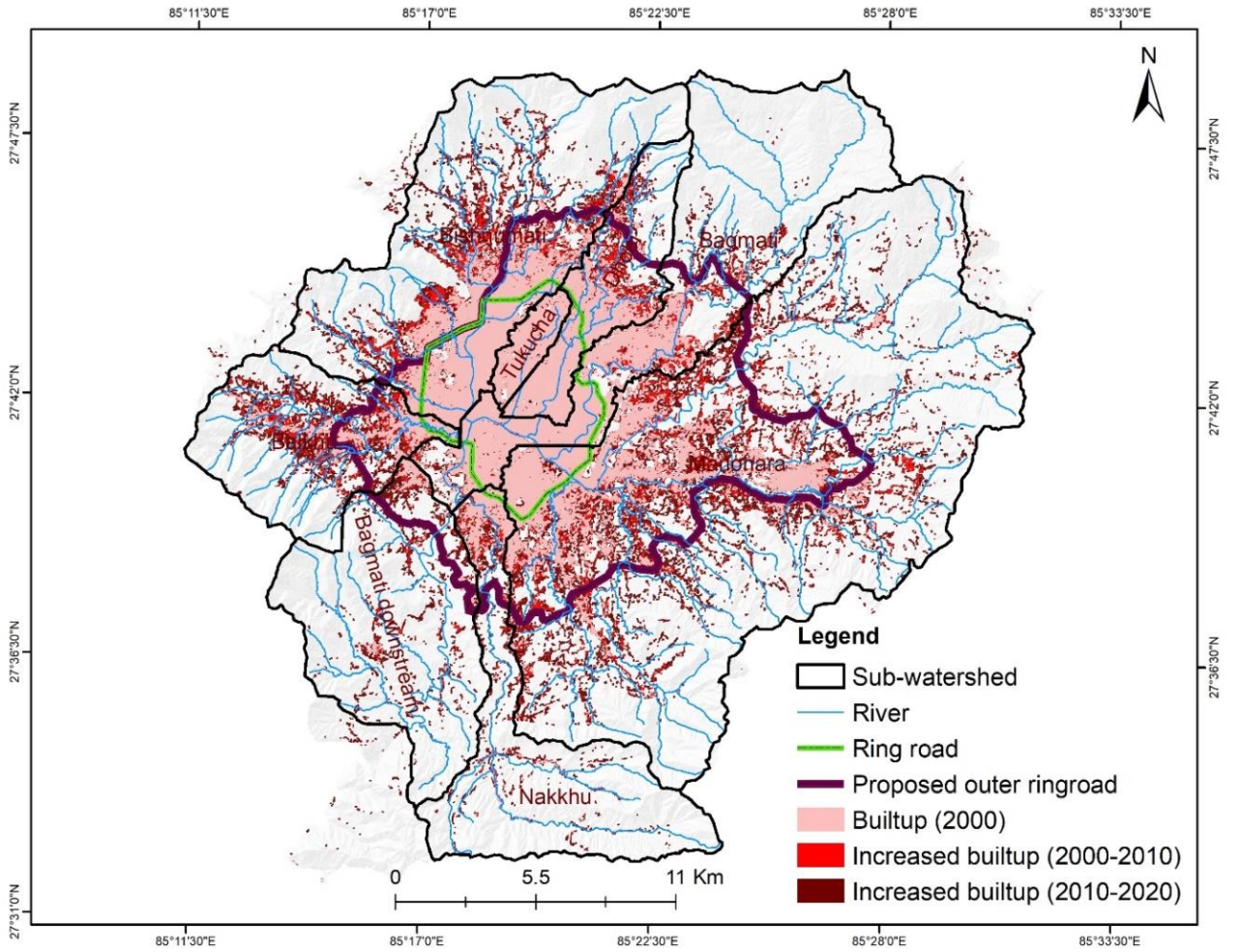


Figure 5-4: Built-up change in Kathmandu Valley 2000– 2020

The population of Kathmandu Valley was recorded 2,446,146 in CBS 2011 which reached to 2,953,731 in CBS 2021 which is increment of 1.90% per year. Population growth rate in new municipalities of Kathmandu Valley is in high pace, the growth rate upto 8.27% has been recorded in Kageshwari Manohara Municipality whereas the major core area of KV i.e. KMC and LMC has population decline. Floating population records remarkably high number in these core areas for economic betterment and better urban services. Floating population in between of 5 lakh to 10 lakh has been predicted in KV for better urban services in past studies. ADB, 2017 study has considered 750,000 floating population which has been adopted for this study as well for present scenario. This hints the inhabitant of about 3.7 million in KV in 2022.

About 45% of total population is considered the floating population (ADB, 2017) in Kathmandu Valley. Inordinate concentration of population is in core area; however sprawl can be marked on the peripheral areas. The growth of urban area on periphery is the result of urban development project or land speculation due to so called development projects.

5.3.2. Current Major Urban Development Projects of Kathmandu Valley

For the development of KV, KVDA is the major organization to prepare and implement an integrated physical development plan for KV which encompasses 2 metropolitan cities, 16 municipalities and 3 rural municipalities. The major development projects which prepare the road map for future development has been summarized below.

- **Outer Ring Road**

KVDA has plan to develop 72 km long ORR to expand the urban areas for homogeneous development of valley. Satellite towns can be developed around the traditional settlement in peripheral areas. This project can be catalyst for development of greater KV. ORR can develop as the delineation boundary of urban-rural resulting in control of urban sprawl.

Contrary to the objective of ORR, the project has boosted the land speculation in the proposed alignment area of the ORR. Remarkable urban growth can be noticed around the alignment area (**Figure 5-5**).

- **Strategic Development Master Plan**

The study has proposed the schematic layout of the proposed land use zones in valley in four different sections as urban central, periphery to urban central, urban extension and suburbs depending upon population density, land use, risk sensitivity, nature of the urban structure and constraints free land use for development.

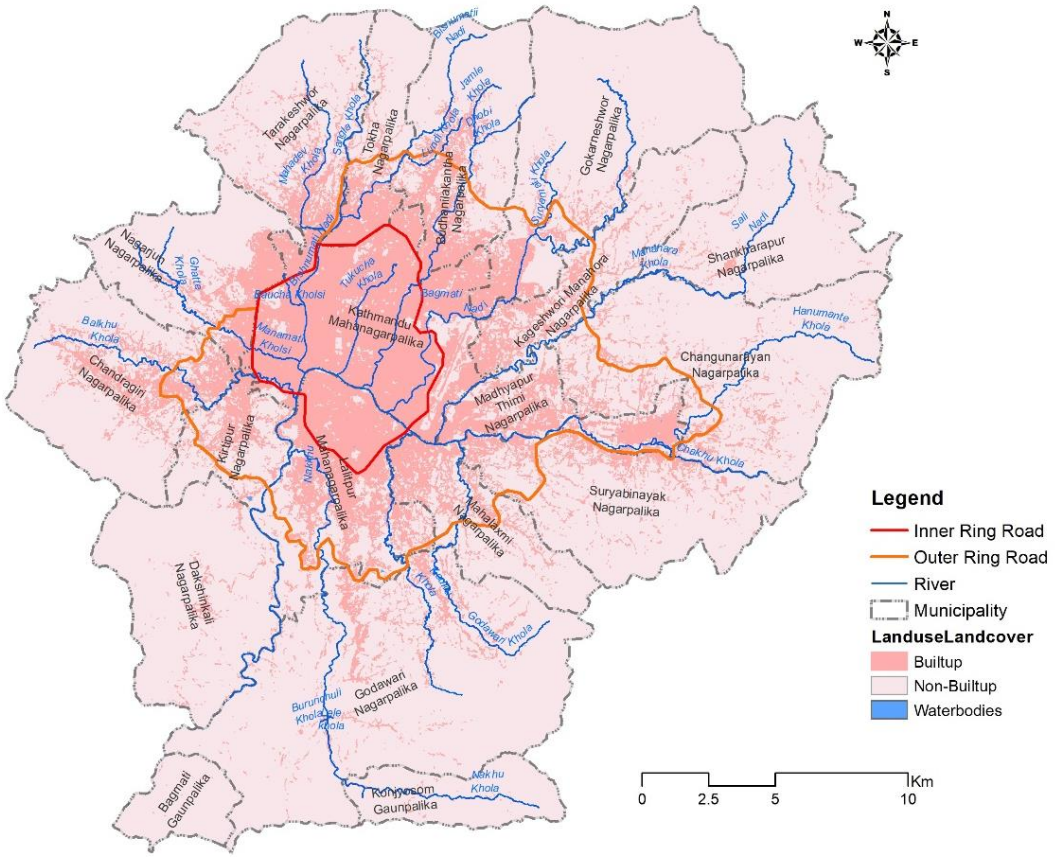


Figure 5-5: Proposed Outer Ring Road Alignment in Kathmandu Valley

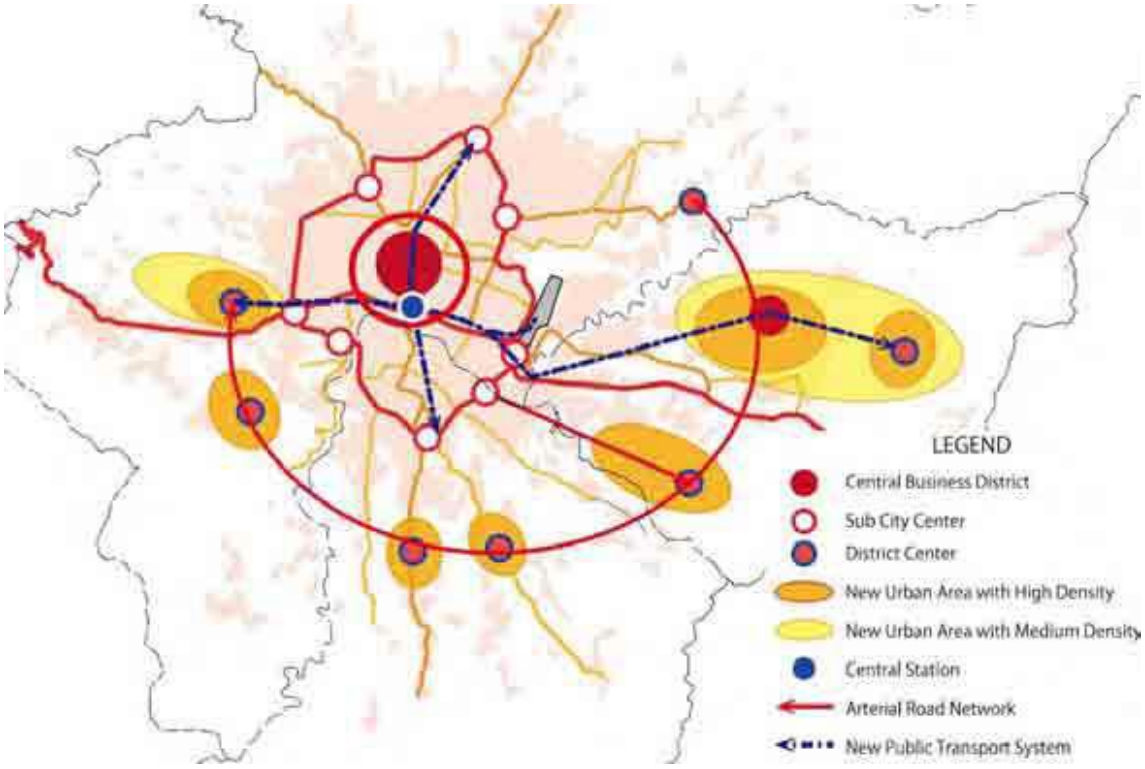


Figure 5-6: Conceptual Urban Development linking with urban mobility

The project has envisaged the urban extension area for next 20 years and the link road has been planned connecting to these proposed development area. The major affect from the plan is not noticed on ground (**Figure 5-6**).

- **New Town Project**

To improve the existing urban space within valley, KVDA has planned new town/satellite town/smart cities in four corners of the valley (**Figure 5-7**).

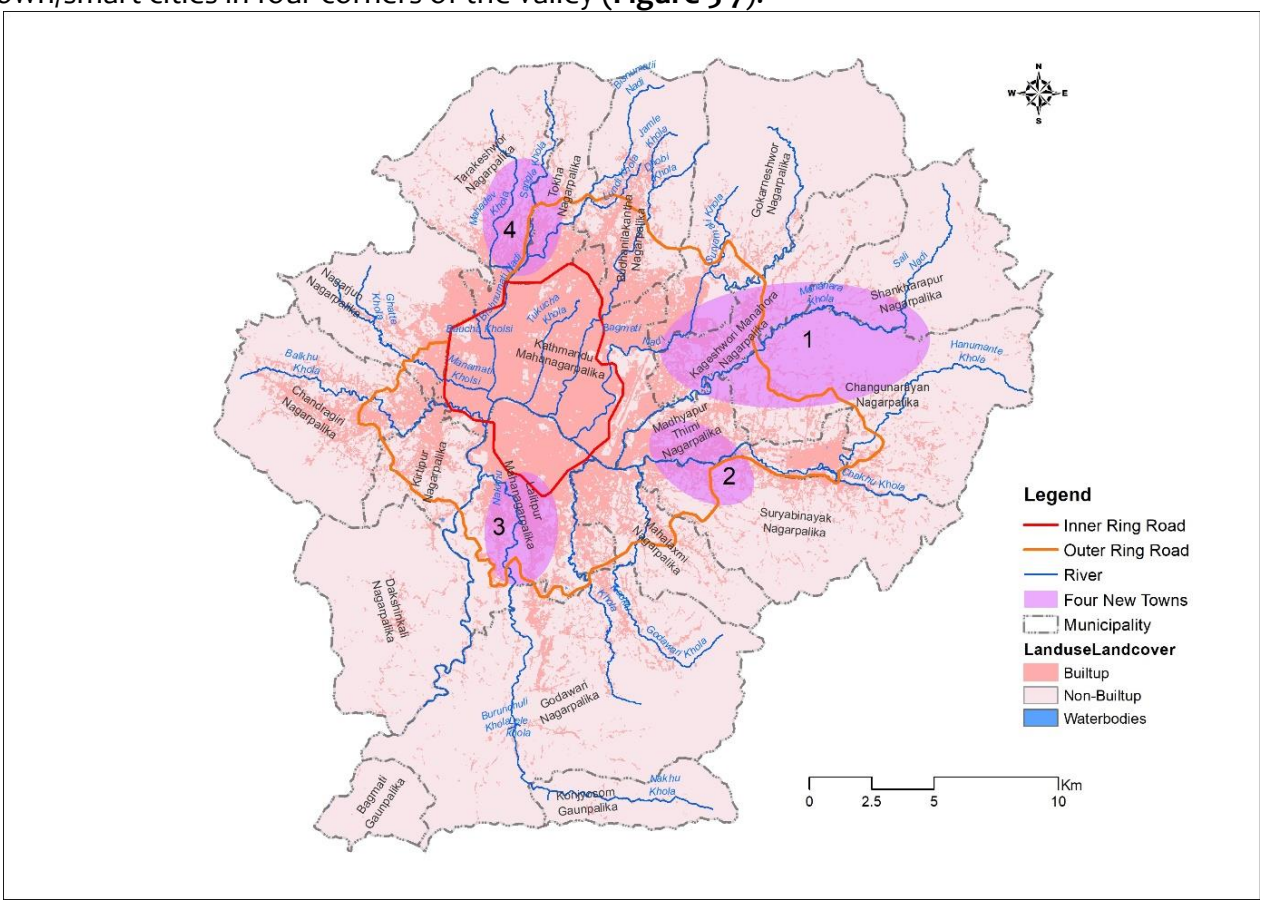


Figure 5-7: Proposed New Town area at Kathmandu Valley

- **(1) Kathmandu Ishaan –** It is proposed on North-East Side of KV with vision to develop planned settlement within 100,000 ropanies of land. This project includes the area of Nagarkot and Telkot area of Bhaktapur, Sankhu, Jorpati, Mulpani and Gothatar of Kathmandu
- **(2) Kathmandu Agneya** – It is proposed on South-East Side of KV with vision to develop planned settlement within 10,000 ropanies of land. This project includes the area of Suryabinayak, Balkot, Biruwa, Thimi and Anantalingeshwor of Bhaktapur
- **(3) Kathmandu Nairitya** – It is proposed on South West Side of KV with vision to develop planned settlement within 10,000 ropanies of land. This project includes the area of Sainbu, Khokana and Bungamati
- **(4) Kathmandu Uttar** – It is proposed on North Side of KV with vision to develop planned settlement within 10,000 ropanies of land. This project includes the area of Samakhusi, Tokha, Bypass, Malung and Kavresthali area

5.4. ENVIRONMENTAL AND DISASTER ISSUE

Much of the current undesirable state in rivers can be attributed to disruptive anthropogenic activities. Because of contemporary socioeconomic development, rivers have been facing growing threats from several quarters-unsustainable withdrawals, pollution, landuse conversion and habitat deterioration, among others.

5.4.1. Degradation of Water Quality

Degradation of water quality is associated with the river use, solid waste dumping, direct discharge of sewer and industrial effluents and use of chemical fertilizers and pesticides in agriculture.

Figure 5-8: Effluent discharge from dying industry in

Rivers in the Kathmandu valley are used for various purposes like washing clothes, domestic animals, vehicles, vegetables, cultural rituals, bathing and disposing remains after rituals, sewerage discharge, solid waste dumping and others. With rapid urbanization informal settlements along the river banks and industries have increased. Number of small industries such as cattle farm, poultry, piggery, concrete, dying, saw mills, paper mills, etc. are established. There is no any systematic sewage treatment system till date. A huge volume of waste water generated from the households and industries is directly discharged into the rivers. Disposing municipal waste in the river banks is still very common. Despite the establishment of door to door waste collection system and landfill site solid waste problems and the discarding of waste along river banks and river itself still continues. It is common problem in almost all the rivers of Kathmandu valley. The problem is worst in the dense urban cores. The waste segregation and transfer points are established at the bank of some rivers like Bagmati, Rudramati, and Bishnumati among others.

5.4.1.1. Water Quality Analysis

Pollution level on different stretch of Bagmati, Dhobi Khola, Bishnumati and Hanuumante were evaluated and found that upstream areas are less polluted. Considering the Bagamati sub-watershed, pollution level is increased along the downstream except at Gaurighat and Aryaghat stretch. Existing waste water treatment facilities at Gaurighat has contributed to lowering the pollution level and it again increase in the downstream. Similar pattern of pollution level is observed further downstream from confluence of Bagmati and Manohara.

Similar pattern is seen in Dhobi Khola sub-watershed and Ratopul stretch found to be most polluted area, which slightly decrease in downstream along the Budhanagar and at the confluence of Dhobi Khola and Bagmati. Moreover, pollution in Mahadevkhola is at higher level

in Busnupati, accompanies with moderate level pollution in Tokha stretch whereas, Hanumante sub-watershed is relatively less polluted.

Considering the monthly pollution status, pollution has increase in driest month in all studied stretch, which indicates the discharge in river has significant role in determining the pollution status. Moreover, the total suspended solid play an important role for increasing turbidity in the month of Asadh,

During the study period, Dhobi Khola downstream from Ratopul stretch is found as most polluted river, followed by Mahadev Khola and Bishnumati downstream from Khusibu stretch. Coherently, these areas also receive higher number of sewage discharge, reflecting the main cause of pollution of the Bagmati river system.

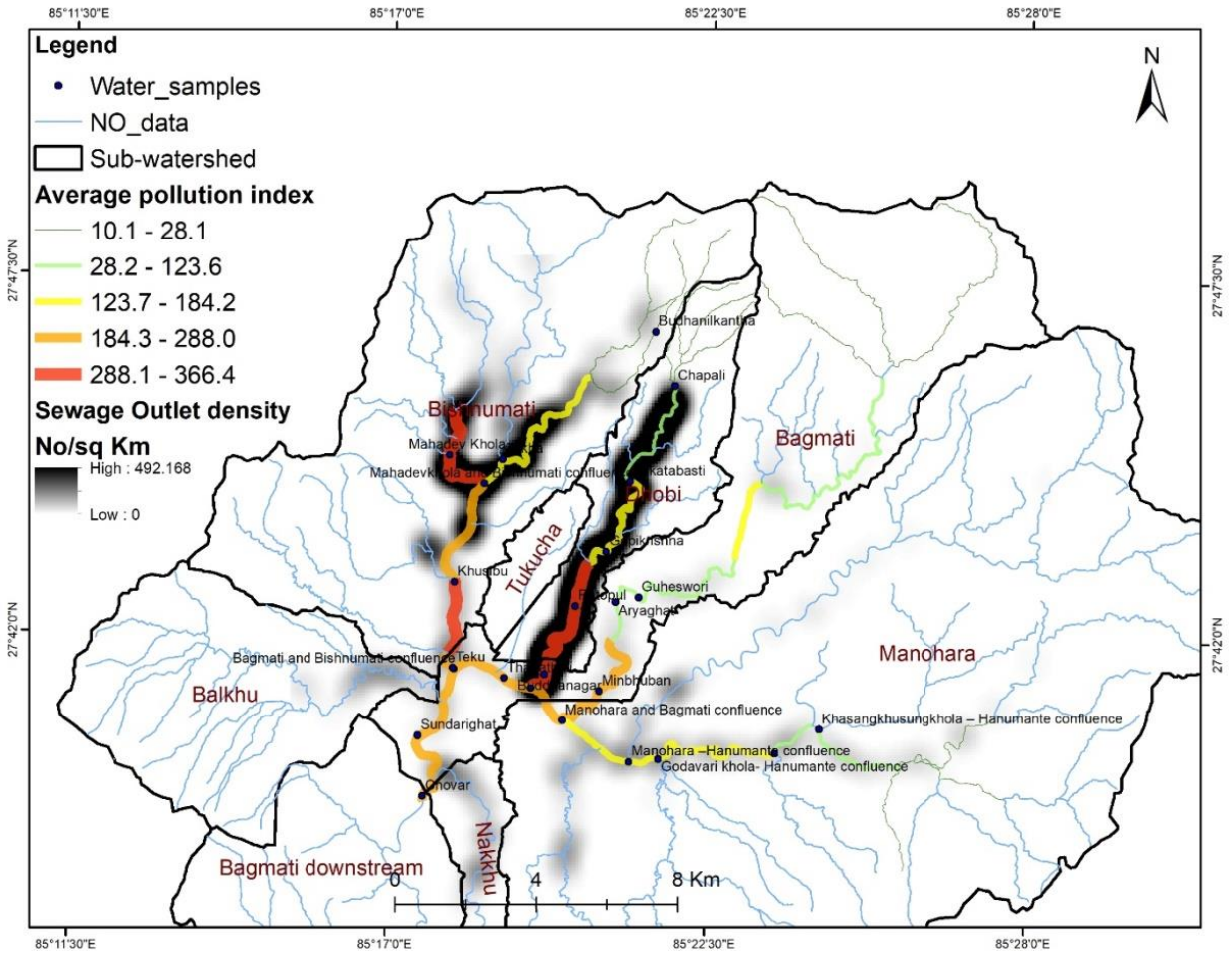


Figure 5-9: Average water pollution index

(*Data Source:* *https://bagmati.gov.np/np/download-types/bagmati-river-water-quality-test-report/*)

5.4.2. Degradation of Catchment Quality

Degradation of catchment quality is mostly associated with the landuse conversion through settlement expansion, extensive land plotting and unregulated quarries. The upstream areas have significant forest cover and are conserved but still there exists settlement areas and are expanding for housing and agriculture. The land cover change analysis of last decade also shows the decrease in forest cover (**Table 5-2**). Rapid and unplanned urbanization has led to concretization of the valley floor and is expanding towards the peripheral hillslopes. There are

more than 550 such land plotting and half of them has average slope more than 15 degree. Similarly, more than 20% of such plotting are situated on marginal land having slope more than 20 degree (**Figure 5-13**). Besides there are some quarry sites in the upstream areas. These activities have reduced the water recharge areas and degraded the catchments of Bagmati River and tributaries.

5.4.3. Decrease in Water Discharge

One of the major causes for decrease in water discharge is the water use. The water use is mostly related with tapping of water from the river/streams for drinking, irrigation and industrial uses. Water is tapped every day from rivers such as Bagmati, Bishnumati and other small streams originating from the Shivapuri hills. Sundarijal, upstream Bagmati, Bishnudwar of Bishnumati, Sangla river, Chapagaun of Nallu river, Godavari river, Mahadev Khola are major locations where huge volume of water has been diverted daily for drinking and irrigation purposes. Water from rivers such as Manahara, Nakkhu and Balkhu has been intensively utilized for agriculture, industries, and other activities. Moreover, a large volume of water is transported to city centers by tankers. The tapping of water from main sources of rivers is a root cause of decreasing water discharge.

The other associated causes are associated with climate change impacts like drying up of water sources. Decrease in water discharge is also linked with the ground water extraction. The excessive ground water extraction to meet the growing urban water demand results in the lowering of ground water table. The likelihood of lowering ground water table is high because of increasing trend of extracting underground water, channelization of rivers and urban expansion in the hillslope. With lowering the ground water table, rivers may turn into losing streams, resulting the decrease in surface discharge in future. Moreover, alluvial soils of the flood plain have higher infiltration rate which were largely invaded in Kathmandu valley through the channelization of river and expansion of settlements. Additionally, expansion of land development (plotting) in colluvial hillslope, surrounding the valley is directing towards destruction of recharge zone.

As expected, the forested land in upper and mid hillslope of Bagmati river system will contain the surface runoff and contribute to infiltration rates but surely this will not sufficient to sustain the river quantity and quality in the downstream.

Decrease in water discharge exerts enormous impact in overall river ecosystem by reducing the self-cleaning mechanism, enhancing pollution concentration, damaging the habitat of aquatic biodiversity, exposing the river banks and channeling of flow.

5.4.4. Narrowing and Deepening of Waterways

Narrowing and deepening of the waterways are the results of river encroachment, unplanned construction of embankments, roads and other infrastructures and excessive mining of sands. Though regulated sand mining still exists in upstream areas of Majority Rivers. Sand mining is also done in downstream areas of Bagmati River. The river training works have resulted both in the protection and risk to flood events. These works have confined a definite channel course providing bank protection as well as from human encroachment but at the same time the narrowing of the river channel have resulted in inundating because of narrow passage of river channel. This suggests for proper planning to river training works while maintaining certain river widths in reducing flood risks.

Balkhu Khola

5.4.5. Depletion of Aquatic Biodiversity

The diversity of fish fauna in the rivers of Kathmandu valley was once quite rich. A survey by Tribhuvan University in 1979 reported 54 fish species in the river system. With the degradation of the water quality the number of fish species decreased. The survey conducted by the Melamchi Water Supply Project in 2000 reported only 12 fish species. Freshwater species are seen only in the upstream section of the Bagmati River and its tributaries. Since most of the river's water is diverted for water supply, irrigation and industrial use there is little fresh water flowing in the river channel during dry season. As the river flows downstream, it receives considerable amount of domestic and industrial wastewater highly depleting its DO level. Only pollution-tolerant fish such as catfish are present in the slightly too moderately polluted sections. Freshwater fish are completely absent in the extremely polluted sections.

5.4.6. Natural Hazard

Kathmandu Valley is prone to different types of natural hazards: earthquake, landslide, flood and urban fire and its built environment is very vulnerable.

A. Flood Hazard

The major causes of the flood in the valley are the river bank encroachment, high sinuosity of river, narrow outlet, increase in riverside settlements etc. With the rapid urban expansion in the Kathmandu Valley, the settlements have expanded even along the banks of rivers and streams. This has also affected the natural path of river by altering the river channels and diverting the flow. Though there seems to be nonexistent of the flooding problem during the low flow period in pre-monsoon season, the flooding situation in the monsoon period has threatened the lives and properties. River bank cutting, channel shifting and inundation are the major flood related problems.

According to the study conducted in 2009, high flood vulnerable area was situated near Jorpati, Gaurighat, Tilganga, Subidhanagar, Thapathali, Teku confluence and Balkhu confluence of Bagmati River. Likewise, the high vulnerable area was found near the confluence of Manohara and Hanumante rivers, Katubahal and Anamnagar of Rudramati, around the confluence of Mahadev Khola and Bishnumati, Mhaipi and Khusibu of Bishnumati River, Kalanki-Bulkhu area of Balkhu Khola.

Low vulnerable areas were noted at upstream from Gothatar of Manohara River, upstream from Jorpati of Bagmati River, upstream from Katubahal of Rudramati, upstream of Mahadev and Bishnumati rivers, upstream from Kalanki of Balkhu Khola, and the river corridors of Nakhu and Godawari.

Wide coverage of moderate vulnerable areas was noted in Guheswori-Gokarna segment and area around Sankhamul of Bagmati River, river sector between Magargaon to Chhapro of Manohara River, around Maitidevi in the Rudramati sector, around Balaju, Banasthali and downstream from Dhalko of Bishnumati and Thimi to Lohakinthali of Hanumante Khola.

The high risk area were situated at Thapathali, around Bishnumati and Balkhu confluences along the river corridor of Bagmati River, small strip at downstream from confluence of Manohara and Hanumante, downstream from confluence of Karakhusi and Bisnhumati, while the moderately risk areas occured at Gaurighat, Tilganga, Shankhmul, Thapathali along the sector of Bagmati River, around and downstream from confluence of Manohara and Hanumante, around Anamnagar of Dhobi Khola, downstream of Mhaipi and around Khusibu of Bishnumati, around Balkhu of Balkhu Khola and Thimi to the confluence of Godavari Khola along the Hanumante (DWIDP, 2009).

The present scenario of flood vulnerability is more or less the same, with only the river training works improved along the rivers preventing the bank cutting. In turn the river training works along with the bank encroachment have resulted in narrowing and deepening of the river channel. Field evidence and historical data illustrate that flooding of these rivers is also inundating considerable distance from the river course because of narrow passage of river

channel, strong river encroachment by private building etc. and highly meandered river morphology with low bank height.

Figure 5-10: *River bank cutting by Manohara River*

B. Soil Erosion

Many factors are responsible soil erosion of Kathmandu valley, among which topography, geology, soil composition and land use play leading roles. Tillage farming in the marginal slope also causing the surface soil erosion, however, intensity of such loss has been decreased in recent year. The larger volume of soil loss is contributed by the ever-expanding land plotting in the hill-slope. There are more than 550 such land plotting and half of them has average slope more than 15 degree. Similarly, more than 20% of such plotting are situated on marginal land having slope more than 20 degree (**Figure 5-13**).

This enormously increasing land conversion in the hill-slope also possesses threat to tremendous decrease in ground water infiltration from the region, which ultimately decreases long term water availability of Kathmandu valley.

The erosion process has also accelerated from road construction and hill-slope excavation for sand, stone and gravel.

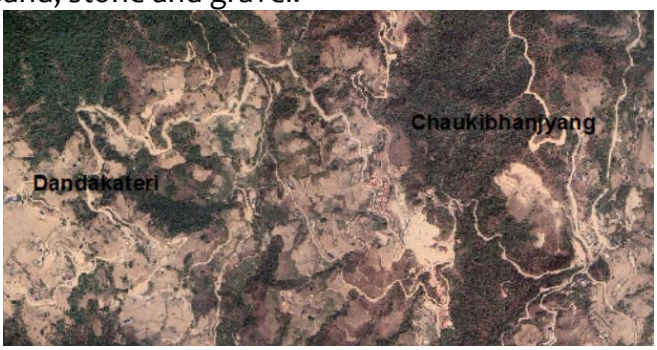


Figure 5-11: *Road network in Manohara upstream*

Figure 5-12: *Hillslope excavation in Nakhu upstream*

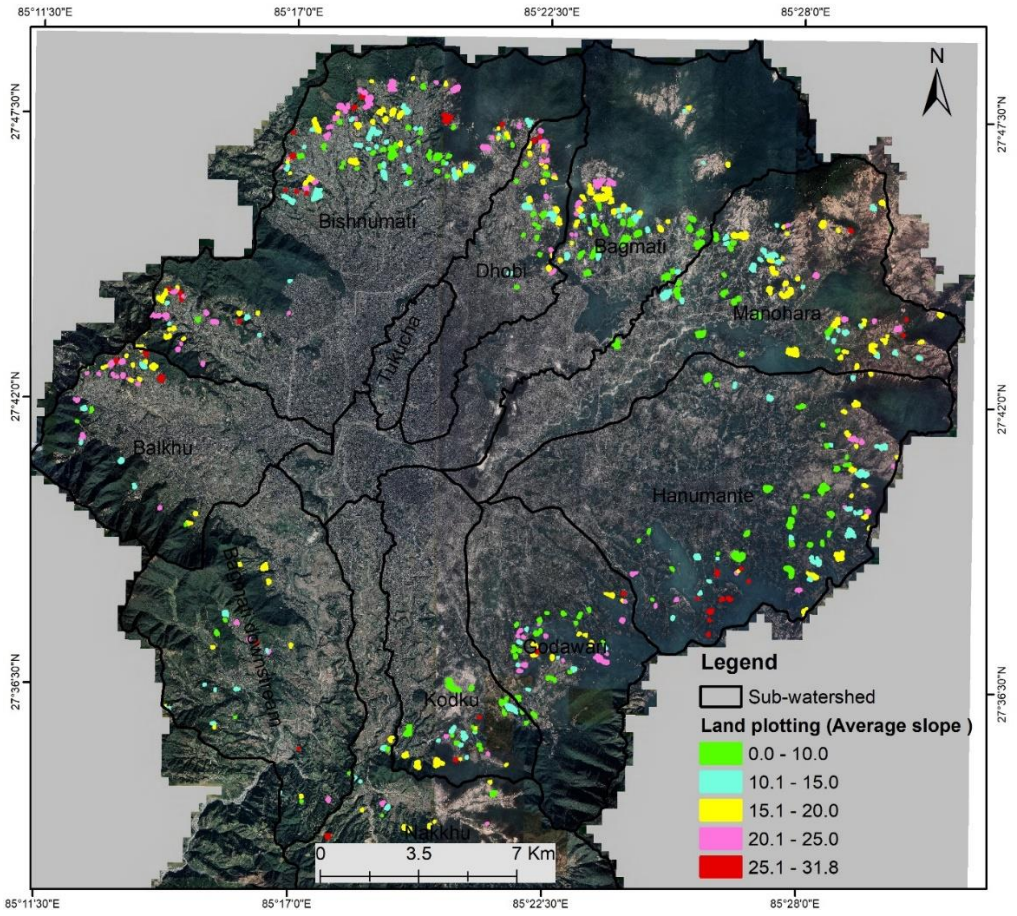


Figure 5-13: Land plotting area vs average slope in degree

Revised Universal Soil Loss Equation (RUSLE) has used for predicting of the long-term average annual rate of soil erosion by combining several factors having a bearing on the erosion rate, namely; rainfall erosivity(Figure 5-14), soil erodibility (Figure **5-15**), steepness and length of the slope (topography)(Figure 5-16) vegetation cover and conservation support practices.

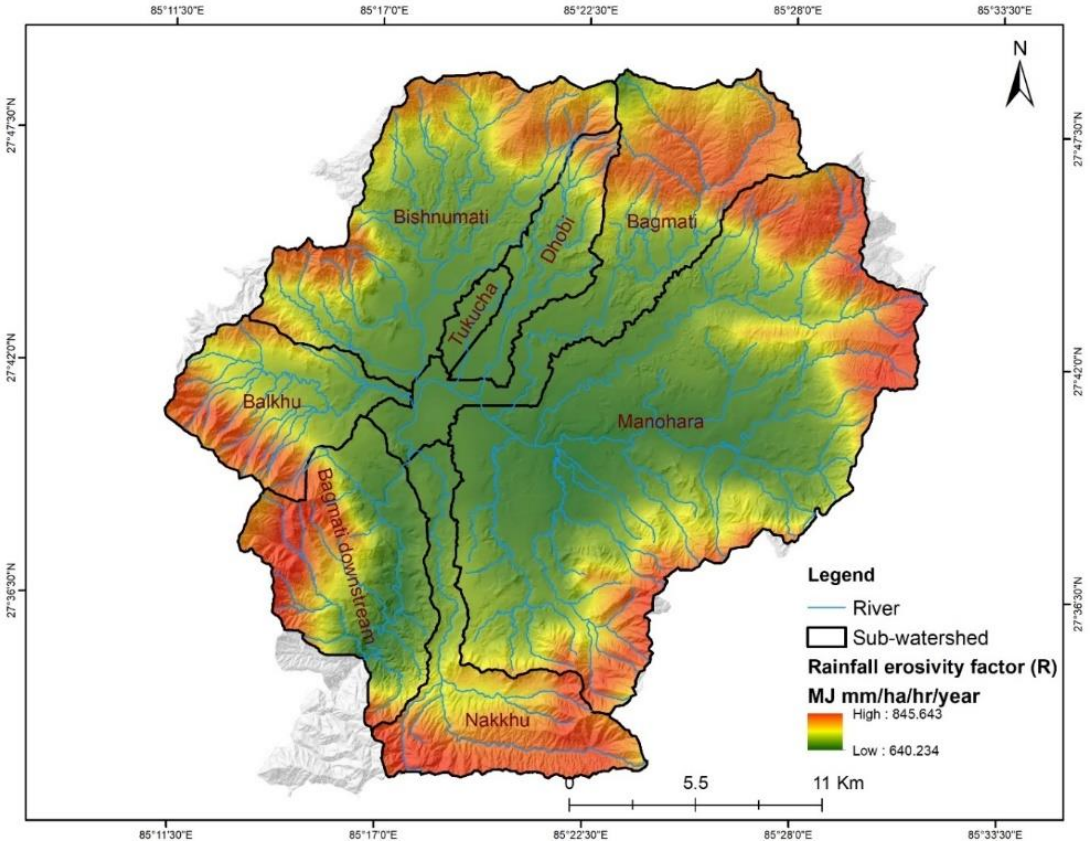


Figure 5-14: Rainfall erosivity factors of the Bagmati river system in Kathmandu valley

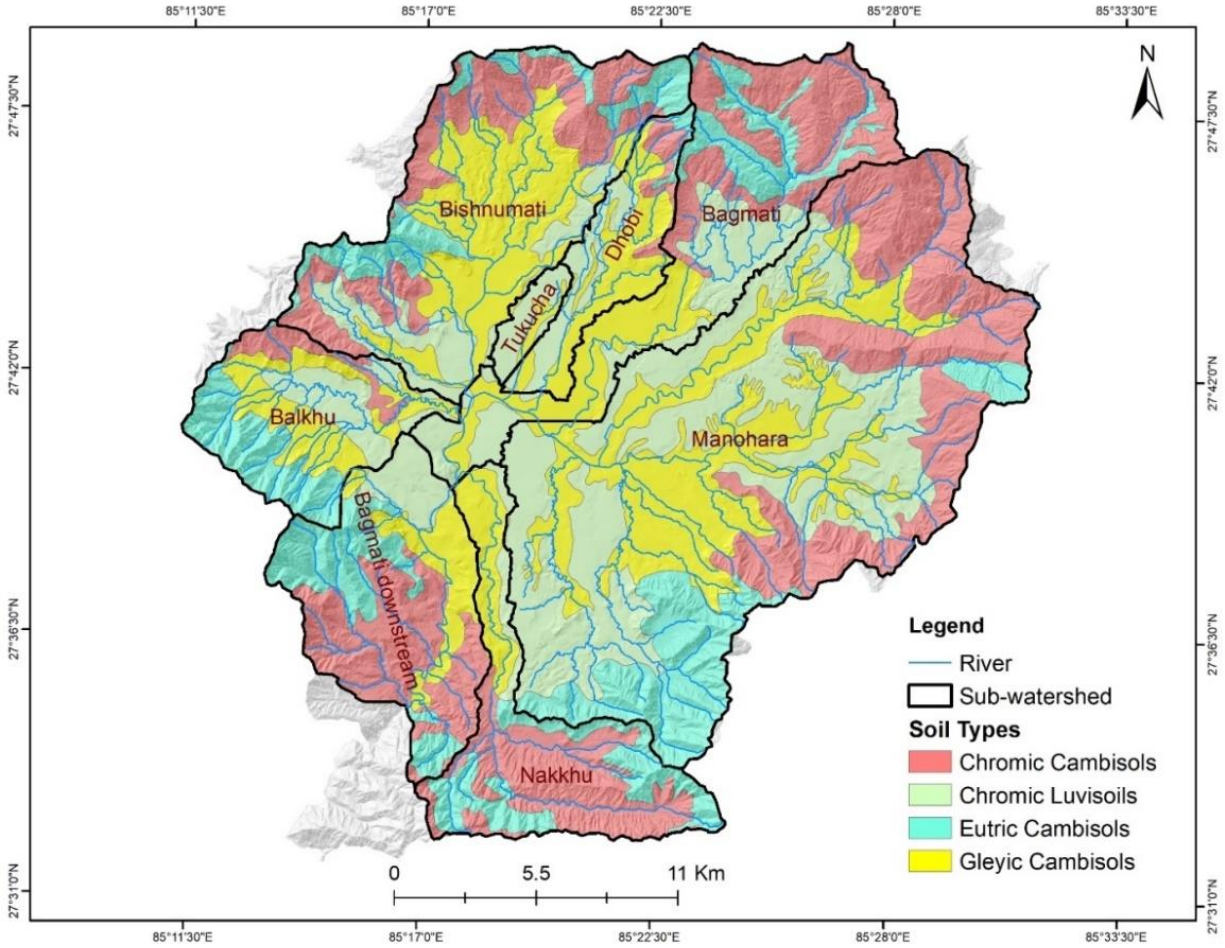


Figure 5-15: Soil types in study area

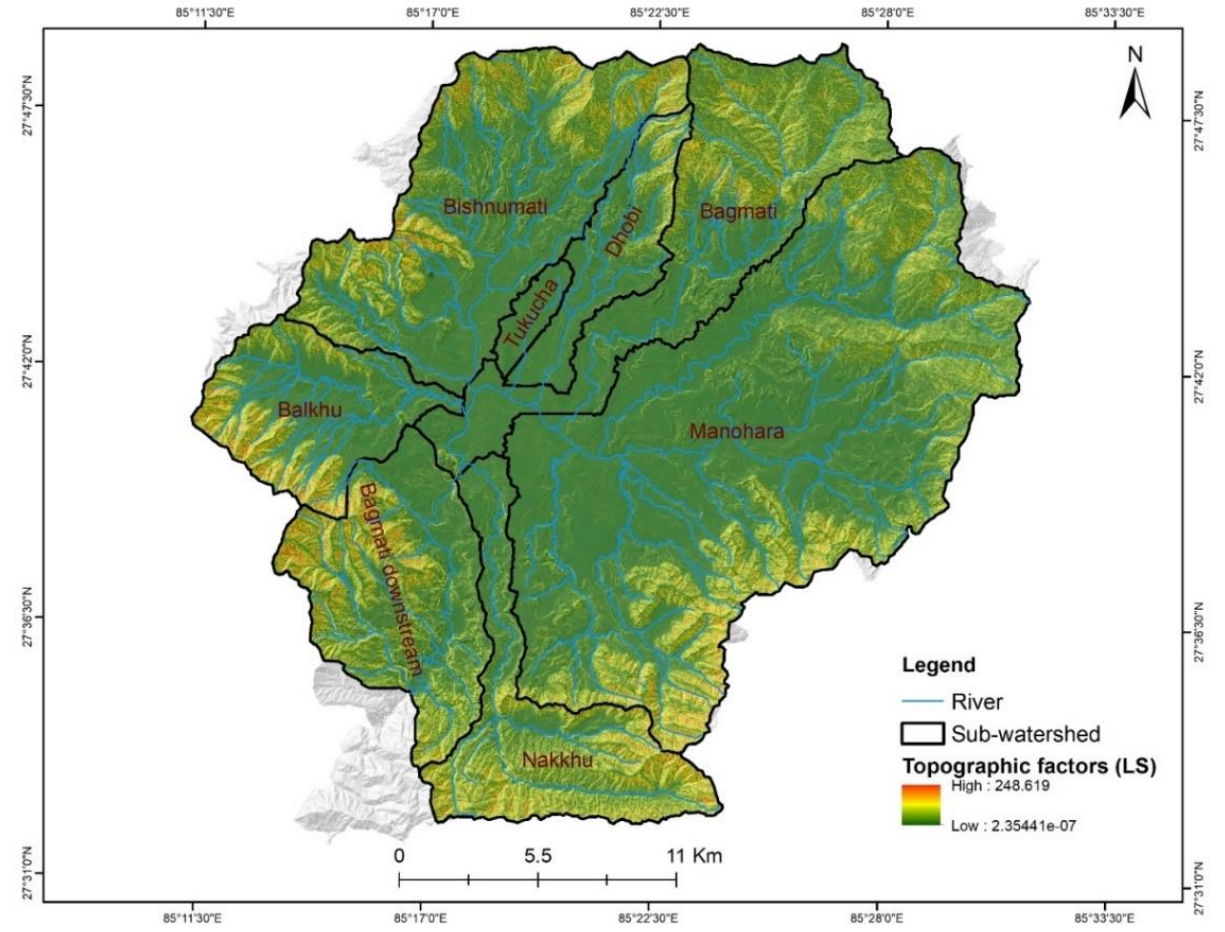


Figure 5-16: Distribution of topographic factor (LS)

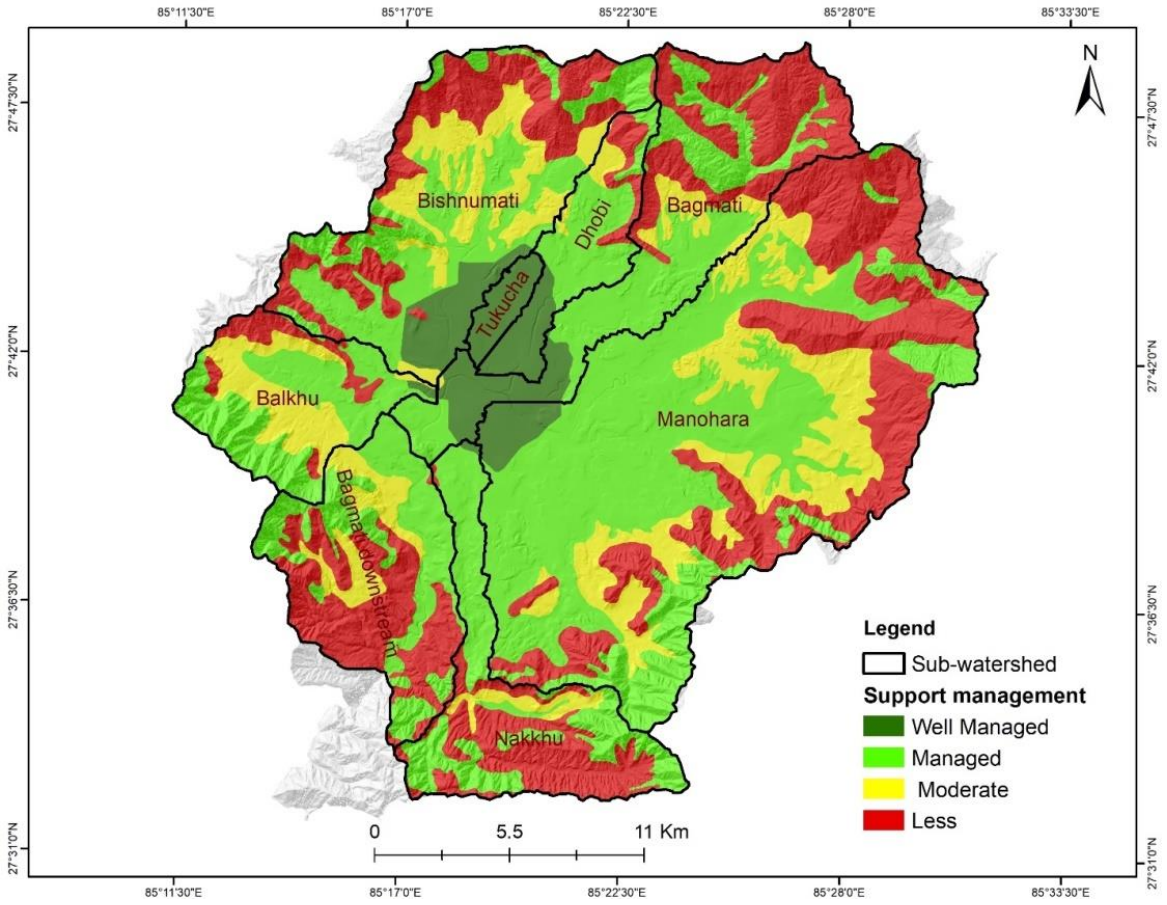


Figure 5-17: Level of supportive management

The RUSLE model, estimated annual soil loss of the area ranges between 0.001 -148.3 tons/ha/yr. with an average of 6.6+-26.5 tons/ha/yr (**Figure 5-18**).

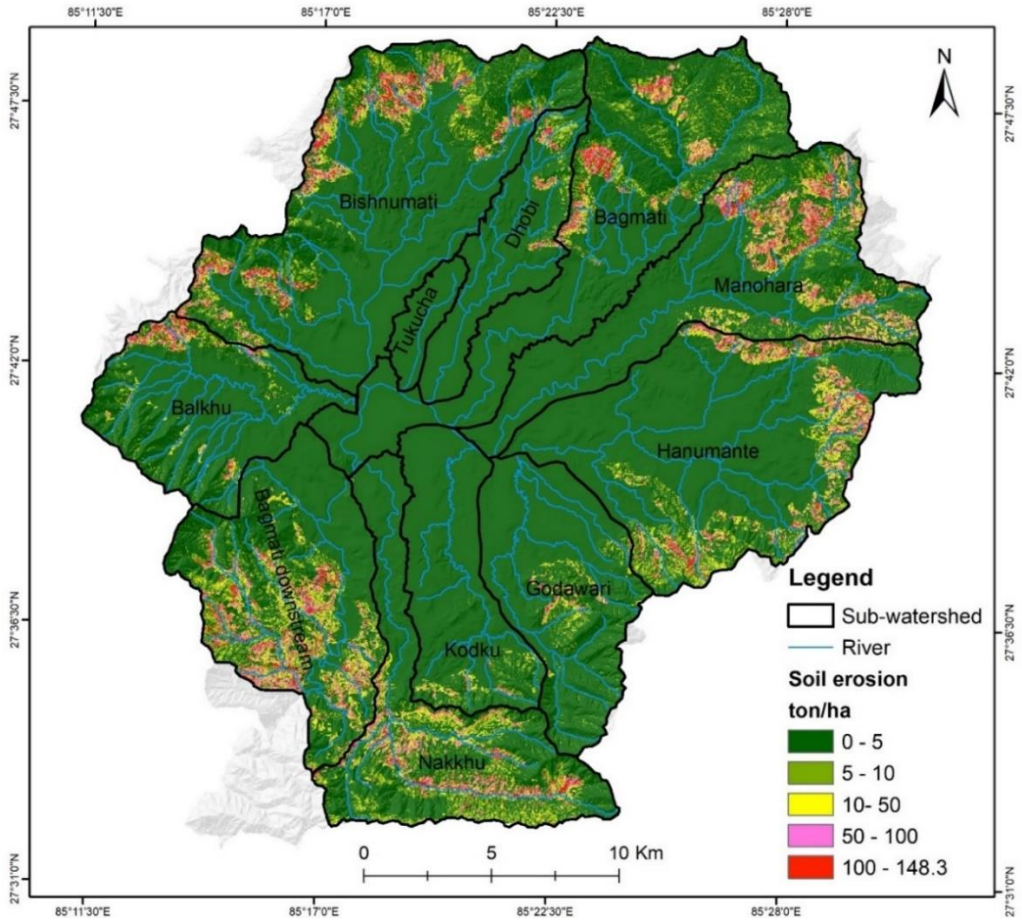


Figure 5-18: Slope erosion susceptibility

Total soil loss of the Bagmati basin is estimated as 5.7 million tons/yr., among which Bagmati downstream, Bishnumati, Manohara, Hanumante and Nakhu contributes larger volume (**Table 5-3**).

Table 5-3: Estimated Soil loss in Bagmati basin and sub-watersheds

Sub watershed	Rate of Soil erosion (ton/ha)	Total Soil loss (million tons/yr.)
Bagmati	5.7	0.48
Dhobi	3.1	0.09
Bishnumati	8.9	0.94
Balkhu	5.7	0.26
Tukucha	0.0	0.00
Nakkhu	11.7	0.66
Kodku	1.4	0.05
Godawari	2.4	0.11
Hanumante	7.6	0.74
Manohara	11.9	0.88
Bagmati downstream	14.5	0.95
Total		**5.17**

C. Gully Erosion Susceptibility

Gully erosion occurs when water is concentrated in narrow runoff paths and washes away the soil along the drainage lines. The first and second order streams generated from ALOS DEM (5m) along with landcover, slope of terrain and soil depth were used to evaluate potential gully advancement in hillslope of Kathmandu valley.

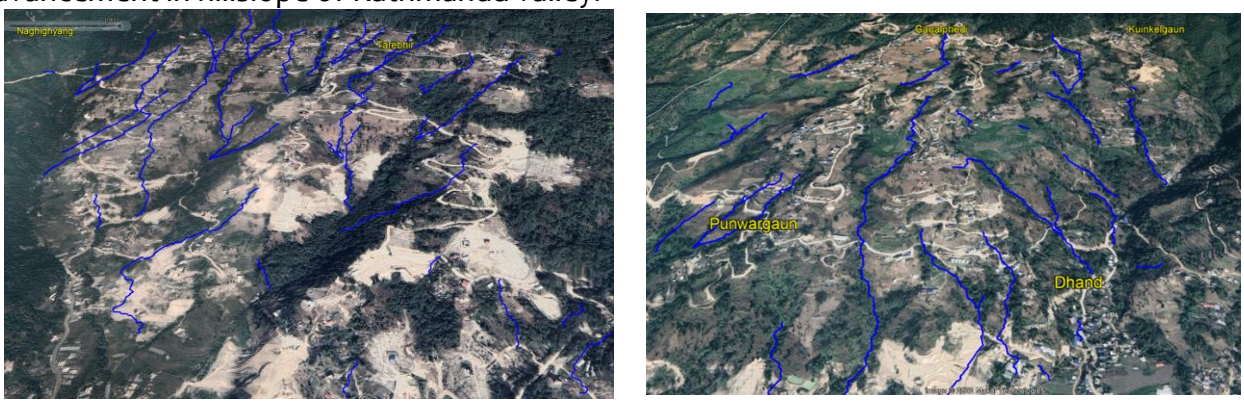


Figure 5-19: *Observed Gully erosion in hillslope*

In many places, land plotting has altered the slope of the terrain and thereby accelerated the gully erosion process (**Figure 5-20**).

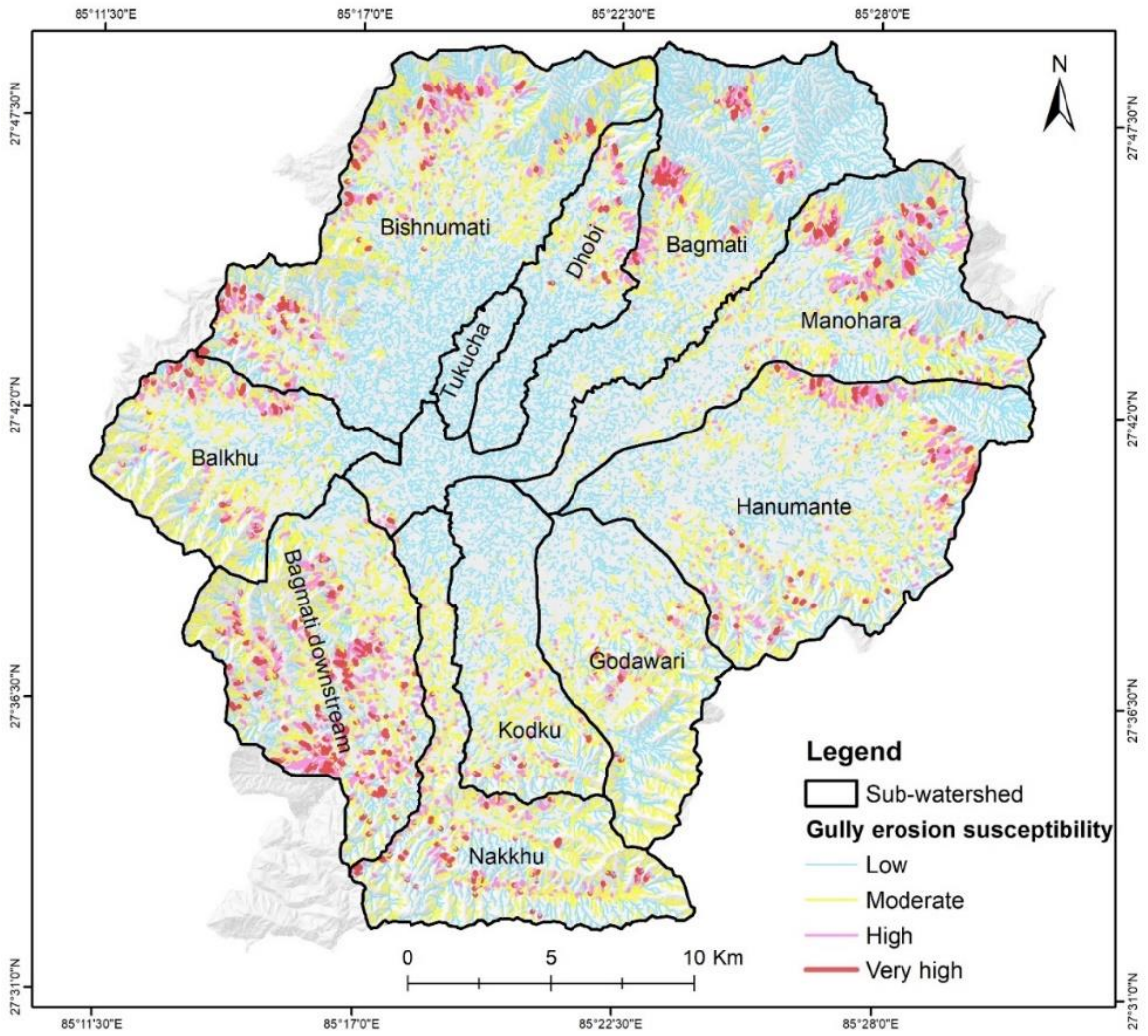


Figure 5-20: Gully erosion susceptibility

The high and very high erosion susceptible area should be prioritized to stabilize the gullies and their numbers as well as length are estimated as in **Table 5-4**.

Table 5-4: Gullies erosion in sub-watershed of Bagmati basin

S. N.	Name	Number	Length (Km)
1	Bagmati	191	35.1
2	Dhobi	75	12.3
3	Bishnumati	449	66.4
4	Balkhu	206	30.1
6	Nakkhu	277	33.1
7	Kodku	96	10.5
8	Godawari	101	10.9
9	Hanumante	382	53.9
10	Manohara	326	54.9
11	Bagmati downstream	685	92.4

D. Landslide Susceptibility

The occurrence of landslides in the valley is mostly near the foot hills of the valley and most of them were debris flow. The major landslide events occurred in 1993, 2002, 2007 and 2012; however, occurrence of small-scale landslide is frequent and spreading throughout the hillslope of Kathmandu valley. Expansion of road network is causing numerous acute landslides in several places and likelihood of causing chronic landslide is also high. Moreover, expansion of land development (plotting) in the hillslope also invaded the previously slope failure area. Detail study should be performed for risk evaluation.

Figure 5-21: ***Up****: Landslide and fragile terrain in and around Baluwa, 2003;* ***Down:*** *Land development evidence, 2020*

In positive notes, several landslides occurred places during 1993 and 2002 have been revegetated in natural process and few were controlled using structures measures.

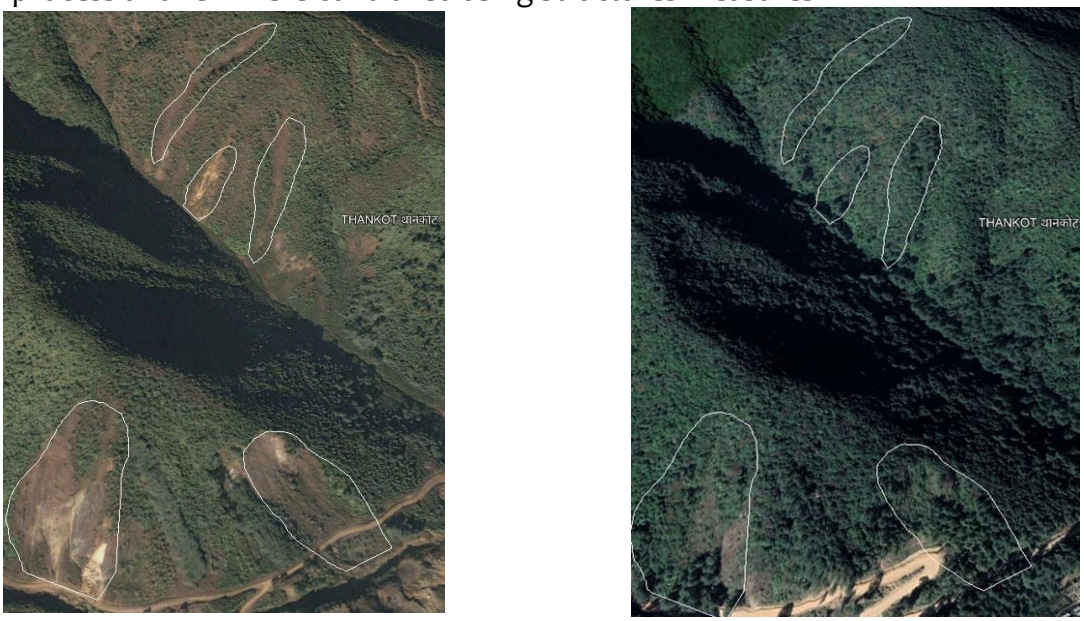


Figure 5-22: *Revegetated landslide area 2003 (****left****) and 2020 (****right****)*

Landslide hazard is represented by susceptibility, which is the likelihood of a potential damaging landslide and erosion occurring within the Bagmati basin in Kathmandu valley and assessed

through weight of evidence (WoE) method. According to the analysis; 8.09%, 11.25%, 11.87%, 19.94% and 48.85% of total areas lie on very high, high, moderate, low and very low zone respectively (**Table 5-5** and **Figure 5-23**).

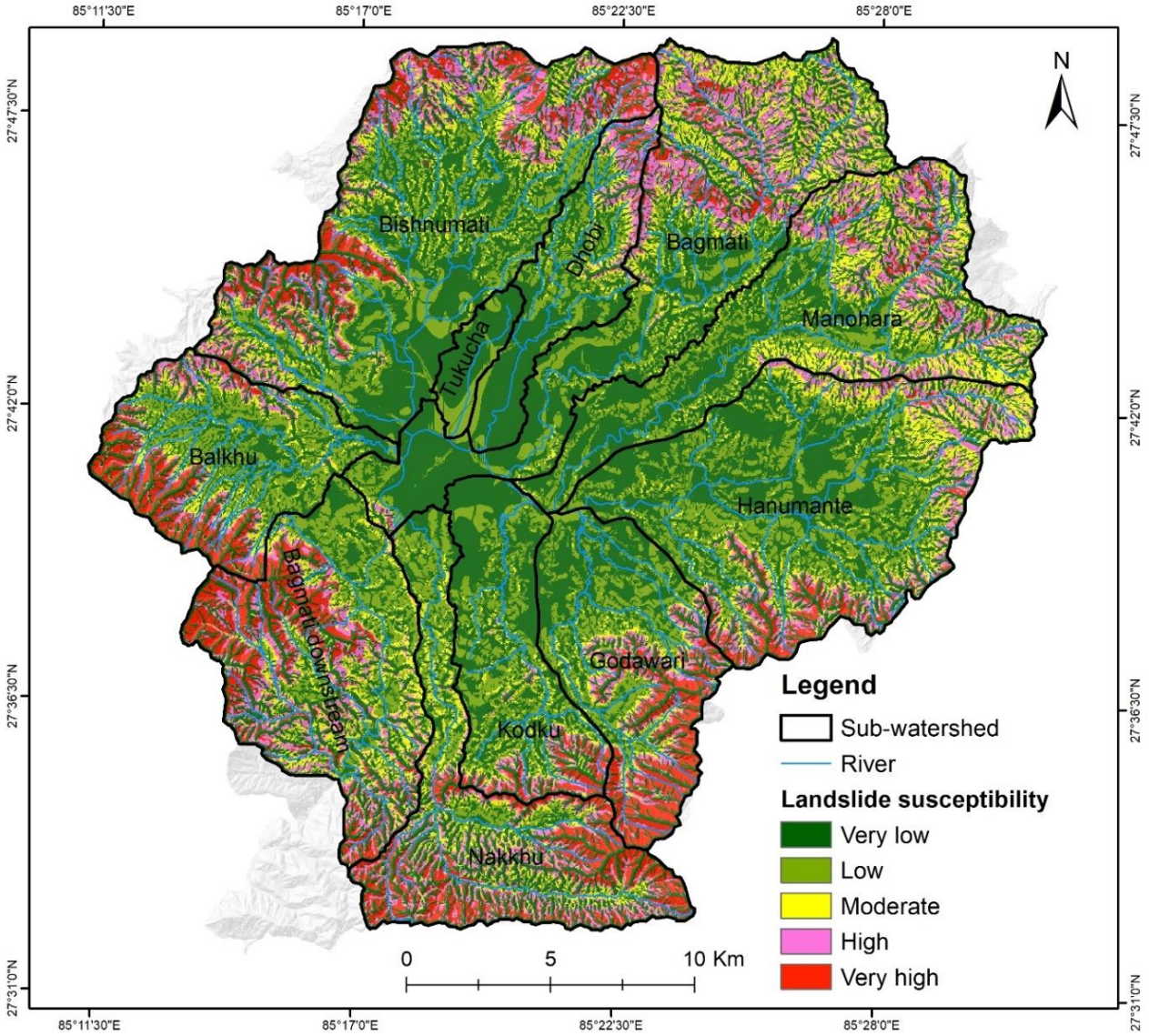


Figure 5-23: Landslide susceptible area

Table 5-5: Distribution of landslide susceptible area in sub-watershed of Bagmati basin

Sub-watershed/ Landslide susceptibility	Very low	Low	Moderate	High	Very high
	Area (Sq Km)				
Bagmati	44.07	13.15	12.87	11.83	2.50
Dhobi	16.44	6.45	2.11	2.24	0.78
Bishnumati	50.87	20.86	11.06	12.91	9.72
Balkhu	18.84	11.75	4.57	3.84	6.74
Tukucha	5.43	1.99	0.00	0.00	0.00
Nakkhu	24.62	8.08	6.40	8.22	9.17
Kodku	22.16	10.45	2.83	1.92	1.80
Godawari	22.48	10.69	3.29	4.46	7.41
Hanumante	50.18	23.52	11.52	8.20	3.44
Manohara	37.21	12.89	13.25	9.53	1.35
Bagmati downstream	25.98	10.10	9.45	10.19	9.84
Total Katmandu valley	**318.30**	**129.93**	**77.34**	**73.34**	**52.74**
Landslide susceptibility (%)	**48.85**	**19.94**	**11.87**	**11.25**	**8.09**

5.5. SOCIO-ECONOMIC ISSUES

5.5.1. Social Issues

Construction of corridor road, river trainings, revitalizing cultural heritages and monuments has impacted local society significantly. Road development increases settlements along corridors and hence growth in population growth, change in social composition etc. Cultural and historical monuments along river corridor are protected and reconstructed which helps to preserve valley civilization. Corridor roads at one side help to minimize flood impacts and control encroachment along river banks but at the same time it also restrict free access to rivers. Though recent construction started stair incorporation but previously completed corridor development have narrowed river flow area significantly and are left with limited space for development. Study discussed about the social issue and problems related with project development as follow;

a. Encroachment of Religious, Cultural and Historical Heritage

With increase in population and commercial activities, historical, religious and cultural locations within valley are increasingly facing encroachment incidents. Numbers of location have been using for businesses, housing, community institutions by the individual, institution and community. Limited land availability, increase in land prices, hidden financial interests, etc. are some possible reasons behind encroachment of public spaces within valley along rivers. This study discussed and identified encroachment of the historical, religious, cultural locations and other public lands along the river corridor area.

b. River Culture and current status within neighborhood society

Cultural connection of the local people with rivers for *dev karma, pitri karma*, religious bathing, and cultural celebration are major attributes of valley civilization. In recent years degradation of River quality has significantly impacted in believe systems of society related with Rivers. This study found, increases in migrant population, expansion of commercial activities are major reasons for change in people connection. Similarly corridor development has controlled access of the people to rivers for multiple cultural and festival. River training construction directly restricted the access of people to rivers and whereas change of river water quality indirectly make people avoidance of the river.

c. Migration & Changes in Social Composition

High migration after 1990s, population within valley increased significantly. Initially settlement expansion takes place within ring road area but later it expanded along outer areas with road facilities. Developments of corridor roads are evident helping settlement expansion in area adjacent and along river corridor. This expansion of settlements consequently changes the social composition in historically settlements and river corridor. Native communities in Kathmandu valley are directly linked with rivers of valley for multiple cultural and religious activities. But change in social composition highly influences the relation with river and heritages along rivers. Historically Dalit community from Newar Ethnicity used to resides along the river especially along the Bagmati and Bishnumati but majority of households from the community are displaced with development activities along river corridors. Increase in facility also attract squatter settlement along the river bank and abandoned flood plain and emerges as big problem for valley.

d. Health Consequences

Increase in population and commercial activities within valley deteriorated rivers health and health of the surrounding people of Kathmandu valley. Decrease in aquatic lives and river biodiversity, increase in health expenditure, increase in number of hospital and clinics provide evidences for change in river water quality and its impacts on public health. Though, the impact of river quality on public health is serious issue but segregation of causes of illness particularly from river is not possible this time.

e. Food habit/lifestyle changes in new social composition:

New urban lifestyle also impacted local culture of the valley significantly. Change in the lifestyle of the people change food habit, waste generation, number of restaurant, and so dumping of waste into rivers, and direct draining of liquid waste into rivers are major issues related with river quality. With the expansion of settlements along rivers, hotel, restaurants also have been increasing and the waste generated by them increasing waste in rivers.

5.5.2. Economic Issues

Development of corridor road has been facilitating bypass to vehicles to avoid traffic congestion in major valley location. Storage houses, vegetable market, distribution centers, go-downs etc. are popular commercial structures expanding along river corridor area. With increase in transportation access, industries, hotels, restaurants, hospitals, also are expanding services in these areas. Previously lowland area along rivers in the valley, which was declared less suitable for habitat now, can be seen used for residential construction with conditional improvement in bylaws. There has been cyclical effect between population increase and commercial activities in most of the river corridor after the development of river corridors.

a. Road and Transportation

Development of corridor road has improved the transportation access of the distant settlement in the valley, along the river, which were previously not well connected with road transportation. Increase in road access has promoted transportation businesses and employment along corridors, educational and health access of the people. Increase in economic activities has increased the volume of intra commercial transaction but at the same time is also promoting waste generation, pollution, congestion, encroachment of public lands, etc.

b. Increase in land price/Value

With increase in transportation, sewerage line, and other facilities land value also increased in farther settlement of the valley. At one side it help to land owners & real estate businesses and at the same time it helps to land fragmentation and land plotting in the area which ultimately promote land use change in the valley from agriculture to the rest of the sectors.

c. Residential Expansion

Opening of corridor roads shorten the travel distance between valley central area and distance settlement within valley that finally help to expand residential development along corridors. Such development has been helping to minimize population pressure; demand of urban services (water, sewerage, and other) within ring road of the valley.

d. Commercial Expansion

With the increased access of transportation and increase in population, commercial activities along corridor are increasing. Groceries stores, restaurants, hotels, hospital, school & colleges, faming, retail & wholesale businesses are major activities have been expanding outside ring road area along river corridors. Such increase in commercial activities has promoted investment in the expanding area of the valley.

e. Income and Employment Opportunities

Increases in commercial activities along corridors outside ring road, more people have been facilitated with employment and income opportunities. Bagmati action plan has expanded land spaces to production houses, industries, school & colleges, restaurant, hotels, restaurants etc. in the valley. Now more people from valley and even outside valley are involved in commercial activities within valley. Segregation of BAP impact in socio-economic development of valley is almost impossible but looking at increase in economic activities along especially corridors, it can be said that BAP has significant impact in development along different river corridors of the valley.

f. Tourism Infrastructure

Mainly religious centers are tourism destinations within the valley. Pashupati nath, Guheswari, Gokarneswar, Teku, Budhanilkantha, Bhadrakali, Hanuman Ghat, Sankhmul, Aadinath Chobhar, etc. are major destination along Bagamati and its tributaries within valley. Pashupatinath, Guheswari, Budhanilkanth and Gokarneswar are major famous destination among pilgrims from outside the valley. Majority of people visit these destinations during their journey in the valley.

g. Future Possibility

Primary objective of the plan was to improve river and cultural ecosystem of the valley associated with Bagmati River and its tributaries. National priority of the government, legal complexity, budget deficiencies, authority right dispute between development partners etc. have slowdown speed of attaining plan objectives. Increase in population, political changes, new constitutional arrangement, under-specified bylaws, unplanned/unexpected/ uncontrolled/profit motivated residential expansion also hindered the goal achievement. Number of projects and programs along rivers are under construction to improve river ecosystem and to promote and preserve Bagmati civilization. Completions of these projects are expected to improve quality and quantity of rivers, and preserve Bagmati civilization in the future. Similarly these activities will also support economic development of 19 local governments within valley.

5.6. ISSUES OF CULTURAL HERITAGE AND MONUMENTS

The issues are listed in detail in all the studied cultural heritage and monuments in **Table 5-6**.

Table 5-6: Issues of cultural heritage and monuments

Name of cultural site	Issues
Bagmati	
Sundari Mai	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The construction of concrete steps by removing stone steps and using metal handrails painted bright blue is hampering the spiritual environment, the construction of steel bridge nearby makes the experience of taking a long trail to reach the temple diminish
Gokarneshwara	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The ongoing restoration works is being carried without expert advices and without following standard protocols leading to loss of authenticity. For example, the plinth stones are replaced with new ones, and the original struts are being replaced with new ones. Similarly, the tiled roofing is replaced with gilt copper roofing. Waste flowing in the river polluting the ambience, hard core surfaces being added and extended. Jatra route from Gokarneshwor village to the temple needs upgradation.
Guheshwari	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. There is possibility of land erosion along the northern edge where the sattals are standing and are supported by retaining walls mainly during monsoon, the khat jatra needs to cross the river at the location of Gaurighat and not use the existing bridge and there is no provision of proper access to reach the river
Pashupati	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The retaining walls along the Gaurighat eastern bank that retains the area of Kirateshwara needs to be maintained to prevent land erosion of blocking of the river, the retaining walls along the eastern bank of Arya ghat has visible cracks and the area of Pandhra shivalaya sees major settlement

Name of cultural site	Issues
	issues, similarly the steps of ghats leading to the river in the western bank also has settlement issues, The 2022 A.D. Shivaratri saw collapse of the wall of one of the bridges across the river which shows the need of periodic inspection and maintenance.
Shankhamul	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Large construction in proximity of the ghat area is bringing visual disturbance in lack of any guiding or monitoring principle. During summer foul smell makes it impossible to stay in the park for a long time. There are many intangible cultural activities that extends the cultural landscape to as far as Krishna temple in darbar square but there is lack of master plans to preserve the historic ensembles and city plan
kalmochan	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Currently restoration works of the templea and sattals are ongoing but there are still many small monuments in the periphery that needs to be restored in the second phase. The water pollution and foul smell is deteriorating the environment.
Tripureshwor Mahadev temple	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Currently restoration works of the templea and sattals are ongoing but there are still many small monuments in the periphery that needs to be restored in the second phase. The water pollution and foul smell is deteriorating the environment.
Pachali Bhairav	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Currently restoration works of the templea and sattals are ongoing but there are still many small monuments in the periphery that needs to be restored in the second phase. The water pollution and foul smell is deteriorating the environment. The approach road to the temple needs to be upgraded and blacktopped. There are issues regarding cleanliness and management of the temple periphery.
Pachali ghat	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The water pollution and foul smell is deteriorating the environment. Recent creation of new ghats is narrowing the river and there are patis that needs to be restored.
Teku dovan (Chitamani tirtha)	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The water pollution and foul smell is deteriorating the environment. Construction of toilets along the river on an encroached land to the east of Krihna temple, cleanliness and management issues. Approach road to the tirtha needs to be upgraded.
Chobaha	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Currently restoration works of the temple is complete and that of sattals needs to be restored in the second phase. The confluence area is highly polluted and the access road is not properly developed. There are patis and sattals in the confluence area are in deteriorated condition.
Jala binayaka	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The establishment of dry

Name of cultural site	Issues
	port in the vicinity is a threat to the serenity of the temple premises. There is an old pedestrian suspension bridge at teh gorge point which holds historic value and needs to be preserved.
Manohara	
Salinadi	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The ongoing beautification works like painting retaining walls is actually degrading the natural beauty of the area, similarly the construction of Madhav Narayan temple as RC structure in one of the holiest Hindu sites defies the issues of authenticity, cutting of the hillock to create an access road is harming the natural terrain. Besides the nearby hills along the way to Bajrayogini are being extensively used for sand mining and as a result forest area is also decreasing.
Changunarayan	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The restoration of monuments are ongoing but has issues of quality control mechanism. The intangible heritage are slowly disconnecting due to lack of funds allocation, for example there used to be 6-7 types of musical instruments played during nitya puja of the main deity on a daily basis but due to lack of funds only one type of music is played. The khat jatra of Chinnamasta and Bhiarav crosses the Manohara river to visit the adjoining villages but the jatra route needs upgradation. The main temple is located in hillock and has issues of proper drainage management mainly with solid wastes.
Bishnumati	
Sapana tirtha	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Some 7 to 8 years ago cremation sites were added to the southern periphery of this site under the pressure of the local residents but the temple committee and local of tokha are not satisfied. The wastewater flowing through the rivulets is polluting the temple ambience. The approach road to the site is unpaved and gets muddy during monsoon
Manamaiju	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The main temple needs restoration and maintenance works to be carried out. There is a park to the west of the temple whose periodic maintenance needs to be carried out, a dhungedhara is existing which needs to be restored, similarly a phalcha next t the entry gate to the historic settlement needs to be restored
Sobha Bhagwati	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The main temple, surrounding patis and a bhwoye chen to the west needs to be restored. The temple periphery is not clean and the sattals are also not well managed, the parks in the front is not accessible to public.
Bijeshwari	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. Every 12 years the goddesses are carried to the Vishnumati river for ritual bathing, the route leading to the temple which includes steps, the road (vehicular) and the place near the river needs to be maintained. There are important and historic sculptures lying along the vehicular road to the

Name of cultural site	Issues
	east of temple which needs to be documented and protected from vehicular damages
Indrayani	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. A sattal to the north of the temple needs to be restored. The area ios not clean while the park needs maintenance. There are cremation sites which also need maintenance and proper management. Recently new sattals are built along the west of the temple which was not originally there such sctivities tend to encroach the temple premises and needs to be carefully studied before implementing.
Kankeshwari	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The vehicular road causes disturbance to the temple ambience and river pollution makes it uncomfortable to stay in the temple premises for a long period especially in summer season, vehicle parking is currently being done along the road causing traffic jam. The khat which used to be originally carried into the river water during the jatra and purified with pure water has been stopped, similalrly the jatra route extending from the temple premises to Yatkha baha needs to be upgraded and protected from encroachment.
Hanumante	
Mahadev pokhari	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The residential structures of gurujis needs to be restored. The area sees large numbers of devotees during major festivals like Janai purnima and during such times there is lack of rest houses and toilets.
Brahmayani temple	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The site has open spaces around it which needs protection from encroachment. There is a phalcha and hiti to the other side of the river which has been encroached by the vehicular road and needs to be restored and protected from probable damage. The Nava Durga gods visit the temple during dashain festival and the approach road needs upgradation.
Ram mandir	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The approach road to the temple complex is via a busy vehicular road which needs upgradation. The phalcha at the entry is in deteriorated condition and needs restoration. There is an access from the southern sattal to the river via series of brick steps and pose risk of flooding requiring interventions through construction of ghats.
Hanuman ghat	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The polluted water makes it difficult for devotees to do rituals mainly during Madhav Narayan brata. There are small shrines with vegetative growth and cracks. The stones of ghat steps become loose and scattered.
Dhum barahi temple	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The open space to the west of the temple is being used to construct underground water tank. There is a sattal and hiti to the north of the temple which are in

Name of cultural site	Issues
	deteriorated condition, this is also used as a cow shed. There are numerous stone scuptures along the street from this temple leading to the river which are of high aesthetic and historic value but are deteriorated by pollution and human use.
Nakhu	
Tika Bhairav	There is no complete detail documentation of tangible and intangible heritage associated with this cultural site. The khat jatra crosses the river and the khat is allowed to rest on the other side of the river for a whole day, but the access to river is difficult as there are no steps to access the river and there are no physical platforms to easily place the khats. The cremation sites located on either sides of the river are in dilapidated condition and are vulnerable to damage due to flooding and ongoing current river taming works. The temple square has hard core PCC finish, there is a south phalcha with RC slab and do not lend historic character to the area. The river taming work is disturbing the temple ambience and the location of cremation sites. The heavy duty vehicle parking area and the river corridor road is also disturbing the area. Area is the starting point of the raj kulo which brings water to the hitis of Patan but is in dilapidated condition. The local infrastructures like "Pani ghatta" do not exist.

5.7. SWOT ANALYSIS

SWOT analysis is done to portray the strength, weakness, opportunities and threats in various sectors like physical amenities, socio-cultural, environment & disaster, water quality & conservation, settlement pattern & urban scenario and others relating to the Bagmati River system (**Table 5-7**).

Table 5-7: SWOT analysis for Bagmati River System

Sector	Sub-sector	Strength	Weakness	Opportunity	Threats
Physical Amenities	Corridor Road Development	– River corridors with urban sub-arterial roads in the urban road network – 162.17 Kilometer road network – Has conserved river land from encroachment. – Has supported the traffic management	– Discontinuity in river corridor roads due to encroachment – Lack of coordination among local units and other stakeholders – No regural and periodic maintainance – Turning of road is minimum without extra widening, which may create safety issue – Footpath of corridor road has not followed standard so it create pedestrian move from roadway instead of footpath (Low level of Pedestrian mobility footpath) – Non-standard footpath has green belt, which create no space for Pedestrian mobility	– Expansion of urban settlements & private investment along river corridor – Management interventions like BAP	– In migration, waste generation, river pollution in upstream area also. – Encroachment of public and cultural land area. – Congestion along river corridors due to high transport demand – Footpath encroached by NEA and other services agencies, which create no space for pedestrian mobility
	Interceptor development	– Interceptors are developed in some locations and are under construction and plan in other locations	– Inadequate coverage of interceptor in the valley.	– International sources of fund	– Disturbance of river corridor land
	Wastewater treatment plant	– 6 WWTP (Dhobighat, Sallaghari, Hanumante, Kodku, Guheshwori and Gokarna) – Upgradation works ongoing	– Weak operation and maintenance of WWTP	–	–

Sector	Sub-sector	Strength	Weakness	Opportunity	Threats
	River training	– 151.98 km river training along both sides of the Valley Rivers.	– Structure are made haphazardly by different stakeholders – River narrowed by road, training and other along the river	–	– Encroachment of river corridor land – Over flooding and inundation in low land area due to narrow space of rivers.
Socio-cultural Amenities	Tangible and Intangible assets	– Pashupatinath, Guheswari, Gokarneswar, Budhanilkantha, Shankhmool, Teku, Hanumanghat like internationally recognize, included in world heritage, monuments are along river corridor areas. – Jatra routes, celebration connected with rivers, mela location, religious journeys are along majority of rivers. – Diversity of religious beliefs	– Insufficient documentation of large number of historical, cultural and religious monuments along river in valley. – Condition of large number of structure along river is under threat after 2072 earthquake – No proper conservation plan for existing monuments. – Poor upkeep of the site and encroachment – Lack of master plan	– Religious tourism, – Meditation, and Baidik knowledge sharing	– Encroachment of rivers, monuments and intangible assets along corridors. – Monetary valuation (assets used for generating financial resource and jobs) of historical assets – Decreasing social belief system of people in the valley – Degradation of serenity of the site caused by corridor roads and heavy traffic throughout the day
	Demographic composition	– Increasing economically sound population in valley. – Increase in number of stakeholder of historical assets in valley.	– Migrated people neglected cultural Heritage, monuments and assets. – Local communities are continuously displacing by migrant people and impacting civilization assets.	–	– Organization and institutions concerning festivals and rituals of river has been decreasing.. – No knowledge, skill, ritual transfer from generation to generation in mixed communities.

Sector	Sub-sector	Strength	Weakness	Opportunity	Threats
					– Decrease in social value of even local children in mixed society.
Economy	Tourism	– World class pilgrim places; Pashupatinath, Budhanilkantha, Hanumanghat etc. – Forest cover, trekking trails, hiking in river catchments.	– Weak waste management, polluted water, encroachment, along major religious and historical destination.	– Large Hindu community around the world. – Attraction of global people toward culture, architect and are of the valley.	– Cultural invasion. – Monetization
Environment and Disaster	Forest and Environment	– Around 40%, 285.34 sq. km land covered by forest area within valley – Flora and faunal diversity – Availability of water resources; rivers, streams, springs along with groundwater resource – Established municipal waste collection system within valley – Availability of dumping site – Mandatory bylaws of septic tank for toilet in houses	– Lack of sanitary landfill site – Inadequate management of drainage and sewerage lines – 2846 sewerage outlets draining waste water into rivers. – Not all the households have facility of septic tank toilets in their house – Insufficient Public toilets – Solid waste dumping into rivers. – Lack of public awareness regarding solid and waste water management.	– Energy generation form solid and waste water – Eco-tourism in surrounding forest.	– Forest and river encroachment
	Water and conservation	– 19 major rivers and their tributary supplying water to Bagmati from different catchments.	– Decreasing water discharge as a result of Water tapping by KUKL and others from Bagmati, Bishnumati, Rudramati, Sangla, Nallu,	– Private investment in multipurpose recharge dam construction.	– Over extraction ground water within valley. – Deepening level of ground water

Sector	Sub-sector	Strength	Weakness	Opportunity	Threats
		– Multipurpose recharge dam constructed at Dhap area. – Under construction Melamchi project for water supply – Number of Pokhari/ recharge pond within valley – 285.34 sq. km forest cover in surrounding hill slopes.	Godavari, Mahadev Khola and others for drinking, irrigation, industrial and other uses – Budget limitation for constructing more recharge dam in hill slopes and foothills. – Concretization of ponds and land use change of water supply system (Rajkulo) and recharge system in valley.	– Water and adventure tourism investment for water conservation and tourism promotion.	– Increasing haphazard plotting and deforestation surrounding hills of Kathmandu Valley.
	Flood risk and Soil erosion	– Institutionalization of DRM – Availability of physical infrastructure; road, river training, open space, health centers. – Rich forest cover in hill slopes of valley.	– Encroachment and narrowing of river areas. – Land plotting, sand and soil extraction from sloppy land around foothills. – Lack of common multi-sectoral vision for disaster management & related framework	–	– Flooding, inundation, and rise of river bed.
Settlement Pattern and Urban Scenario		– Upcoming commercial activities along the river bank. – Public land being planned and utilized for urban park such as UN Park, Sankha park etc.	– Encroachment of public land by squatters along the bank of river at core area – Encroachment of waterway for development of private property. – Narrow channeling of river way causing flooding and inundation during rainy season	–	– Increasing numbers of squatters over a period of time

Sector	Sub-sector	Strength	Weakness	Opportunity	Threats
			– Masonry wall along the river making river inaccessible during accidents and for cultural activities.		
Institutional arrangement		– Federal government, province government and 20 local governments and government stakeholder for supporting conservation and development activities. – One dedicated institution HPCIDBC with KVDA, KUKL, and different line agencies and international development partners.	– Limited role of local governments. – Less coordination between development partners. – Budget deficiency for program implementation. – Less transparent structure even within development partners. – Lack of documentation multiple baseline information and other.	– Technological, financial and human assistance form international partners. – Voluntary participation of local partners (individuals and institutions)	– Contradictory polices of three Governmental units, and implementation agencies. – Influences of donor agencies

- HPCIDBC has focused on development of physical amenities along river way of Bagmati such river training and river corridor for conservation of river land from encroachment and support of traffic, interceptors for waste water management supporting with wastewater treatment plant but these structure needs to be planned properly in integrated way. Waste water of KV have to be treated before disseminating to river, so it has to be planned to cover the whole valley and it WWTP needs to be operated and maintained properly.
- KV is rich in its historical socio-cultural developments and some of these tangible and intangible cultural assets are along the river banks and are internationally recognized as well. These assets need to be documented and developed with proper master plans. These assets also have touristic values, so need to be developed in integrated way for proper upkeep of the site with local communities' involvement.
- River resilience need to be considered while development along Bagmati River Basin. The informal settlements along the river way need to be managed and for the new developments also proper policies and bylaws have to be prepared.
- River beautification refers to urban environment and touristic economic value, so the cleaning camping of Bagmati and public awareness need to be continued for better urban environment and for development of eco-tourism.

CHAPTER-VI

6. VISION AND LAND ZONING

6.1. VISION

The Bagmati Action Plan 2009-2014 has set the overall vision for restoration and conservation of the Bagmati River and its tributaries with defined goals, objectives and activities for each of zones proposed. This Action Plan is the update to BAP 2009-2014 and the final expected outcome is similar i.e. restoration and conservation of the river system. Thus, it is preferred to continue with the same vision for this BAP as well. The vision statement is:

"Clean, green and healthy river system that is full of life and valued by all"

6.2. LAND ZONING

Bagmati Action Plan 2009-2014 had zoned the KV in five zones based on existing status of the water quality in river segments and the population density of the area. The zonation of river system had the concept of developing and implementing the action plan more effectively in zone level.

The urban growth scenario of KV and new federal system has drastically changed the urban context. In addition, the major urban development projects such as ORR, new town concepts have triggered the development outside the core city to periphery. In addition after the promulgation of new constitution, structure of VDCs and municipalities has been dissolved and the new structure of metropolitan, sub-metropolitan, municipalities and rural municipalities are implemented. In KV also, there is 2 metropolitan cities, 16 municipalities and 3 rural municipalities reflecting more urban characters within the Valley. So, for Bagmati Action Plan 2022 – 42, the new zonation concept has been developed on the basis of KV watershed ecology and urban growth scenario of KV.

Kathmandu Valley is the watershed of Bagmati River and the catchment of river is surrounded around hilly slopes. This hilly forest area surrounding the KV is the main source of water of Bagmati River which needs to be conserved. The flat lands are the agricultural land which has now converting to urban area is rapid pace. So, analyzing the current scenario, for the BAP 2022-42, KV has been planned in 3 Zones as;

i) Conservation Zone,
ii) Peri-Urban Zone, and
iii) Urban Zone.

6.2.1. Conservation Zone

The Conservation Zone is the forest area surrounding the hill-shade of KV. This area includes the forest such as Shivapuri, Phulchowki, Chandragiri and Nagarjun. The Shivapuri Nagarjun National Park lies in this zone. This zone mostly includes forest area which recharges the river system of Valley. This zone also constitutes of important wetlands as *dhap* with high recharging potentiality. This zone needs to be conserved for the recharge of water source.

The major issues in this zone are:

- Expansion of settlement.
- Unregulated land development/ploting and thereby excessive erosion.
- Associated impacts from forest land conversion to agricultural lands, new constructions (road, monasteries, buildings and other infrastructures), commercial & tourism activities and forest resource use (fuelwood and others).
- Decrease in water discharge due to water diversion.
- Increasing pollution due to poor sanitation, use of chemical fertilizers and river use as washing, bathing and others.

6.2.2. Peri-urban Zone

The area between Conservation Zone and Urban Zone is categorized as Peri-Urban Zone which has the pressure of urban development but the conservation measures have to be maintained in this zone for sustaining water quality and water recharge. So, these areas have high responsibility to maintain the river system.

The major issues in this zone are:

- Urban expansion
- Degrading water quality due to untreated sewage disposal, industrial effluents, solid waste disposal and river use.
- Loss of vegetation resulting in loss of biodiversity and aesthetic values of the river.
- Sand extraction and associated impacts.
- Haphazard disposal of contruction material along the river corridor
- Narrowing and deepening of waterway due to river training works, road construction, land plotting and other development works.
- Decreasing water discharge due to excessive water tapping for irrigation, industrial use and others.
- Excessive extraction of ground water for industrial use
- Degradation of catchment quality due to landuse conversion and land development.

6.2.3. Urban Zone

The central core of the KV has been categorized in Urban Zone area which has the highest population density and high urban growth rate. This area has been delineated within the boundary of proposed ORR alignment. This area is planned for dense urban development with developed urban infrastructure to make Bagmati River clean, green and healthy.

The major issues in this zone are:

- Degrading water quality due to direct discharge of huge volume of untreated sewage disposal, industrial effluents, solid waste disposal, and waste disposed from slaughter house and other wastes.
- Narrowing and deepening of waterway due to river training works, road construction, land plotting and other development works.
- River encroachment and squatter settlements.
- Deterioration of traditional and local water storage systems like Pokhari, Dhunge Dhara, Rajkulo and others.
- Degradation of catchment quality due to landuse conversion and land development.
- Deteriorating cultural and heritage assets due to lack of conservation, management and encroachment.
- Haphazard disposal of contruction material along the river corridor

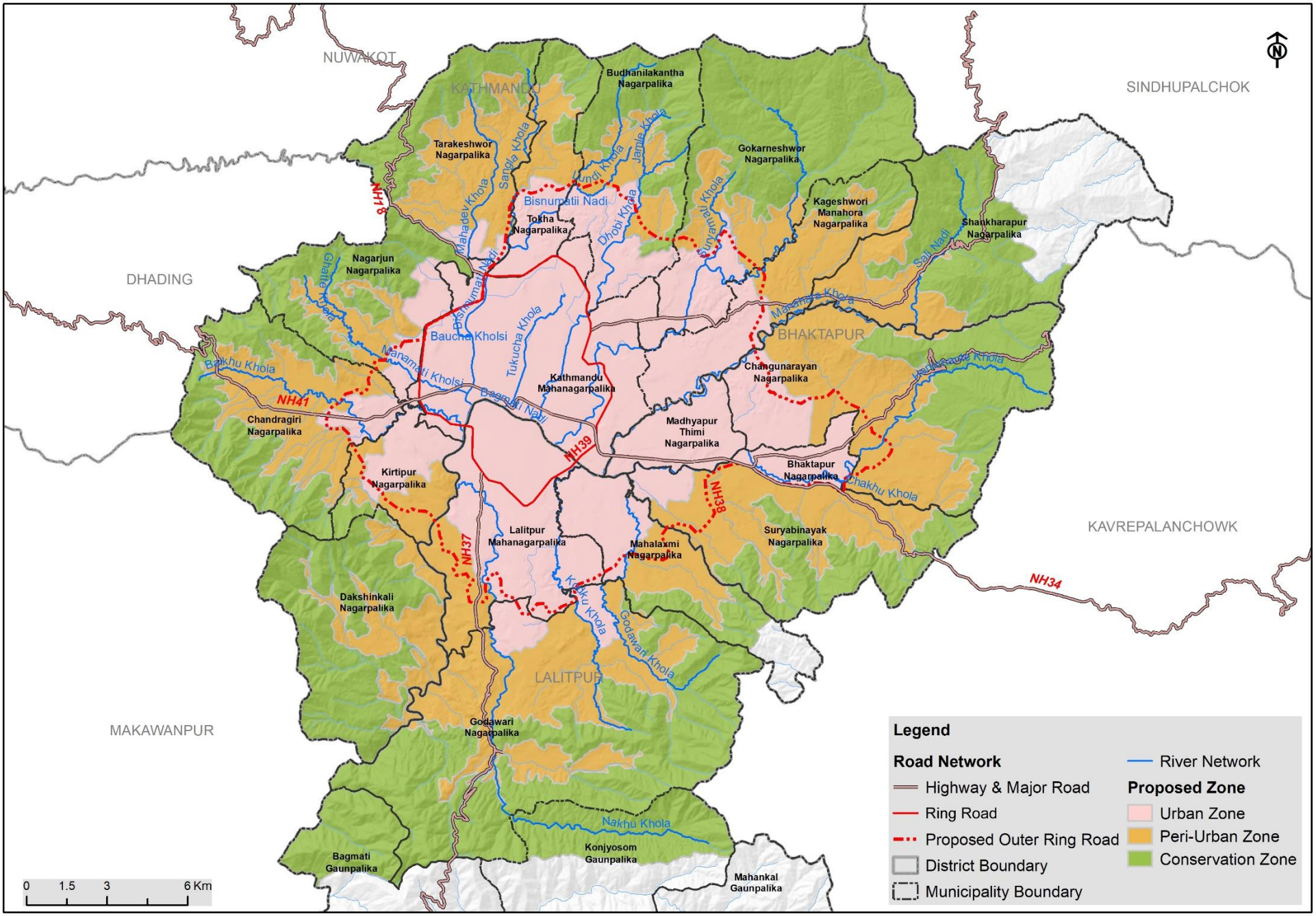


Figure 6-1: Proposed Land use Zonation of Kathmandu Valley

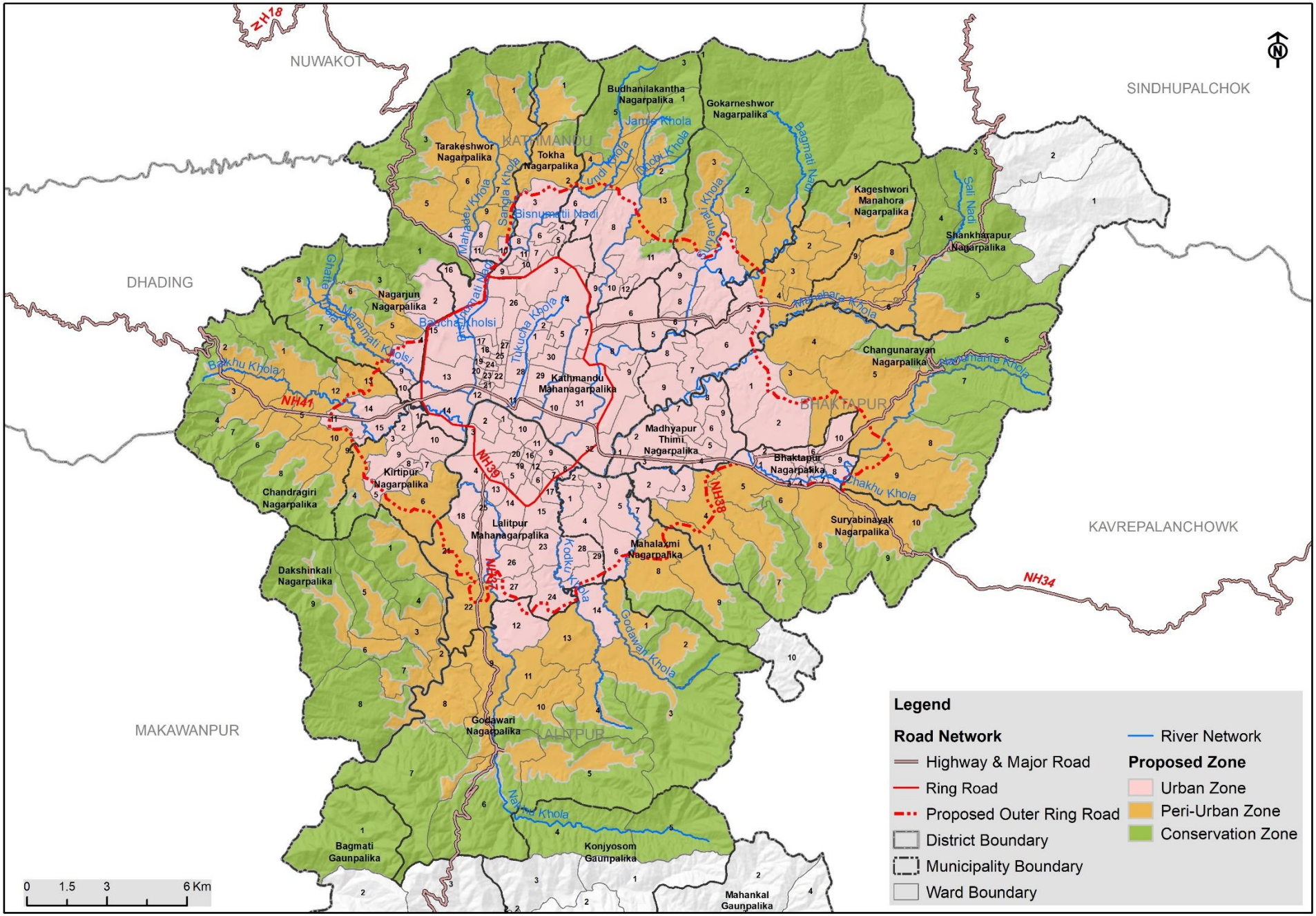


Figure 6-2: Proposed Land use Zonation of Kathmandu Valley overlaid with administrative boundary

Table 6-1: Proposed Land use Zonation of Kathmandu Valley

SN	Municipality Name	Municipality Area (SqKm)	Unit	Proposed Zone Name and Area			Total study area (SqKm)	Catchment area (SqKm)
				Conservation Zone	Peri-Urban Zone	Urban Zone		
1	Bagmati Gaunpalika	111.49	Sqkm	10.84	0.00	0.00	10.84	8.09
			%	9.72	0.00	0.00	9.72	7.26
2	Bhaktapur Municipality	6.89	Sqkm	0.00	0.00	6.89	6.89	6.89
			%	0.00	0.00	100.00	100.00	100.00
3	Budhanilkantha Municipality	34.80	Sqkm	15.84	8.93	10.03	34.80	34.80
			%	45.52	25.66	28.82	100.00	100.00
4	Chandragiri Municipality	43.92	Sqkm	21.23	19.12	3.57	43.92	40.48
			%	48.34	43.53	8.13	100.00	92.17
5	Changunarayan Municipality	62.98	Sqkm	23.60	30.89	8.49	62.98	62.98
			%	37.47	49.05	13.48	100.00	100.00
6	Dakshinkali Municipality	42.68	Sqkm	30.09	12.59	0.00	42.68	42.68
			%	70.50	29.50	0.00	100.00	100.00
7	Godawari Municipality	96.11	Sqkm	55.99	34.53	5.59	96.11	94.38
			%	58.26	35.93	5.82	100.00	98.20
8	Gokarneshwor Municipality	58.50	Sqkm	39.68	9.32	9.50	58.50	58.50
			%	67.83	15.93	16.24	100.00	100.00
9	Kageshwari Manohara Municipality	27.38	Sqkm	5.31	11.19	10.88	27.38	27.38
			%	19.39	40.87	39.74	100.00	100.00
10	Kathmandu Metropolitan City	49.45	Sqkm	0.00	0.00	49.45	49.45	49.45
			%	0.00	0.00	100.00	100.00	100.00
11	Konjyosom Rural Municipality	44.16	Sqkm	15.85	0.00	0.00	15.85	15.85
			%	35.89	0.00	0.00	35.89	35.89
12	Kritipur Municipality	14.76	Sqkm	1.45	6.83	6.48	14.76	14.76
			%	9.82	46.27	43.90	100.00	100.00
13	Lalitpur Metropolitan City	36.12	Sqkm	0.00	7.06	29.06	36.12	36.12
			%	0.00	19.55	80.45	100.00	100.00
14	Madhyapur Thimi Municipality	11.47	Sqkm	0.00	0.00	11.47	11.47	11.47
			%	0.00	0.00	100.00	100.00	100.00
15	Mahalaxmi Municipality	26.51	Sqkm	5.41	7.58	9.03	22.02	22.02

SN	Municipality Name	Municipality Area (SqKm)	Unit	Proposed Zone Name and Area			Total study area (SqKm)	Catchment area (SqKm)
				Conservation Zone	Peri-Urban Zone	Urban Zone		
			%	20.41	28.59	34.06	83.06	83.06
16	Nagarjun Municipality	29.85	Sqkm	17.13	7.24	5.48	29.85	27.52
			%	57.39	24.25	18.36	100.00	92.19
17	Shankharapur Municipality	60.21	Sqkm	24.77	11.30	0.00	36.07	30.32
			%	41.14	18.77	0.00	59.91	50.36
18	Suryabinayak Municipality	42.45	Sqkm	17.47	22.14	2.84	42.45	41.60
			%	41.15	52.16	6.69	100.00	98.00
19	Tarakeshwar Municipality	54.95	Sqkm	34.40	18.46	2.09	54.95	29.94
			%	62.60	33.59	3.80	100.00	54.49
20	Tokha Municipality	17.11	Sqkm	4.82	5.75	6.54	17.11	17.11
			%	28.17	33.61	38.22	100.00	100.00
Total (SqKm)		**871.79**		**323.88**	**212.93**	**177.39**	**714.20**	**672.34**

6.3. GOALS AND OBJECTIVES OF ZONE

6.3.1. Conservation Zone

❖ **Goal:**
Maintain and enhance the environmental and cultural ecosystem services of Rivers

❖ **Objectives:**
i) To conserve and enhance water resources and increase water discharge into rivers;
ii) To conserve and enhance forest biodiversity;
iii) To promote sustainable land use practices;
iv) To mitigate impact of geo-hazards in upstream areas;
v) To rehabilitate and conserve the cultural and heritage sites; and
vi) To promote sustainable nature base eco-tourism

6.3.2. Peri-urban Zone

❖ **Goal:**
Preserve river and cultural ecosystem with sustainable urban development

❖ **Objectives:**
i) To promote Sustainable Urban Development;
ii) To maintain and improve water quality and quantity;
iii) To increase water use efficiency to ensure sustainable withdraw;
iv) To renovate and conserve the cultural and heritage sites;
v) To mitigate impact of flood-hazards in river system;
vi) To revive Urban Ecosystem/Biodiversity; and
vii) To develop lively built-environment along River corridors

6.3.3. Urban Zone

❖ **Goal:**
Restore river ecosystem and preserve cultural heritage

❖ **Objectives:**
i) To improve water quality and sustain water discharge in rivers;
ii) To preserve historical, cultural and religious heritage;
iii) To mitigate impact of flooding and inundation;
iv) To revive encroached land and conserve natural course/flood plains; and
v) To develop lively built-environment along river corridors

CHAPTER-VII

7. STRATEGIES AND ACTIONS

7.1. STRATEGY

In context of the current situation and the vision of "Clean, green and healthy river system that is full of life and valued by all", four strategies have been formulated is presented in Table 7-1.

Table 7-1: Strategy for accomplishing the vision

Strategy no.	Major Strategy	Sub Strategies
Strategy-1	River conservation and Management	Sustainable land use management
		Promote Ecotourism
		Conservation of the land use to recharge water source
		Strengthen River Cleaning Program
		Management of Public Land along the River Corridor
		Disaster mitigation
		Development of corridor transport system along rivers
		Management of settlements residing within the Conservation Zone (Hill Shade Area of Kathmandu Valley)
Strategy-2	Cultural/Civilization rehabilitation	Reclaim, Rehabilitate and conserve the cultural and heritage sites along river
		Preservation of intangible heritage
Strategy-3	River/Water Quality and quantity improvement	Encourage organic farming
		Water source conservation to Increase ground water recharge and river discharge
		Management of Sewerage to prevent direct disposal into river
		Management of Solid waste disposal directly into river system
		Conservation and management of water sources
Strategy-4	Capacity building	Knowledge management
		Institutional strengthening
		Enhance community participation in BAP implementation

7.1.1. River Conservation and Management

7.1.1.1. Sustainable Land use Management

The land's position, geology, soil type and slope determine how land can manage effectively and efficiency to ensure it's sustainably. For instances, haphazard excavation of sand, stone and gravel can cause wider environmental impact, which instead can mitigate through proper Environmental impact assessment. Strengthening the monitoring mechanism will create an environment to regulate the haphazard mining.

Expansion of the land development (Plotting) in the marginal and fragile peripheral hill slope of valley has increased the erosion susceptibility for the short term and also increasing risk on settlement in the long-term. Such development should regulate with proper bylaws.

Similarly, intense tillage farming in the hill slope can accelerate soil loss process. On-farm erosion process can be mitigated using proper farming practices (Figure 7-1 and Table 7-2). Farming methods that can reduce soil erosion include terracing, contour cropping, windbreaks, and no-till planting or agroforestry.

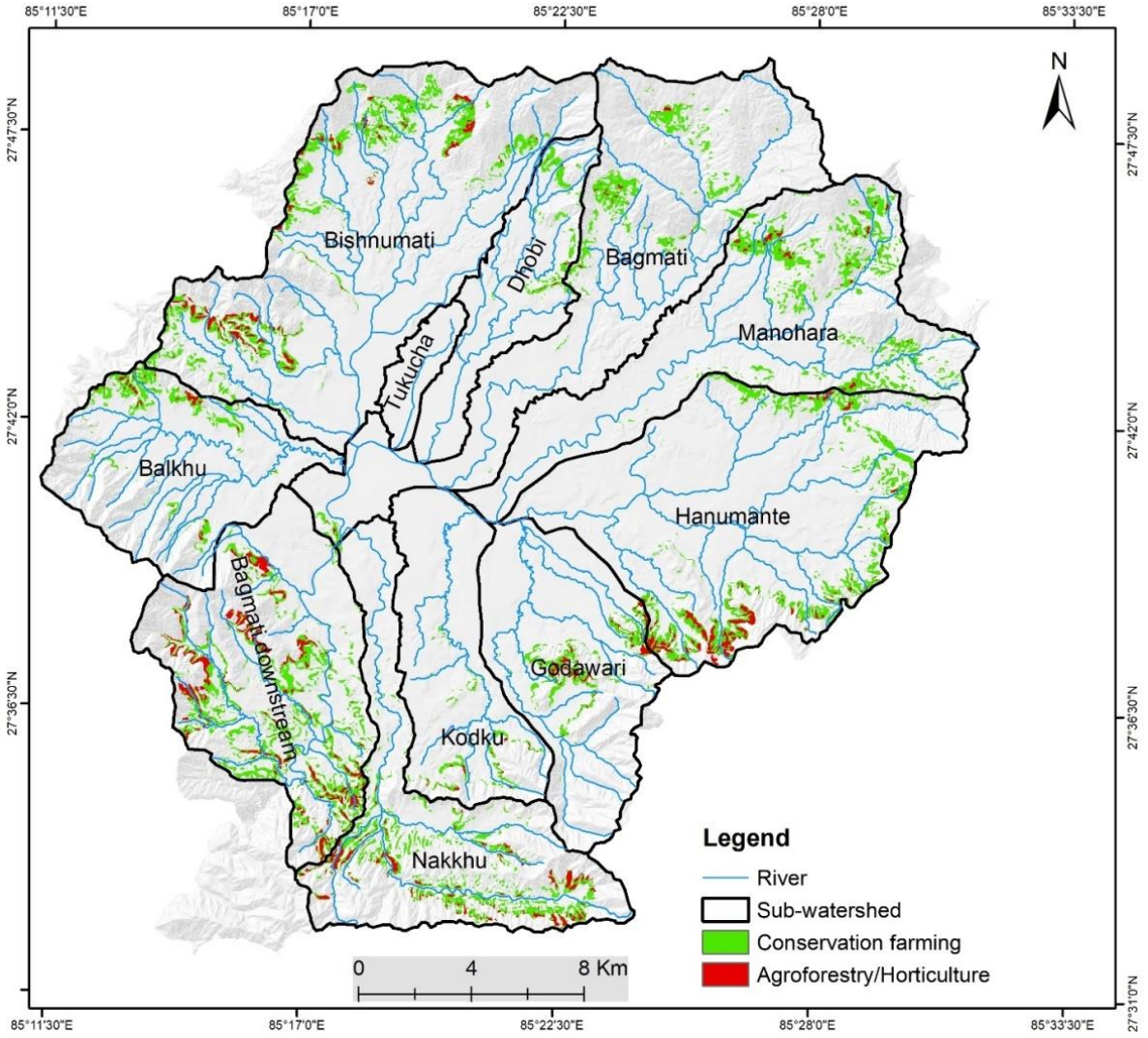


Figure 7-1: Proposed conservation farming area

Table 7-2: Proposed Location of conservation farming area

Name of River	Area (ha)	
	Conservation farming	Agroforestry
Bishnumati River	754.92	1,571.40
Balkhu Khola	250.02	351.00
Dhobi Khola	114.57	40.50
Hanumante Khola	703.17	1,558.80
Nakkhu Khola	520.38	1,414.80
Bagmati downstream	830.07	2,871.00
Bagmati Khola	349.47	142.20
Kodku Khola	86.04	104.40
Manahara River	620.55	380.70
Godawari Khola	217.53	558.00

Since surface discharge of rivers are in decreasing trend and likelihood of further reduction is higher under business as-usual case, it will be mindful to shift the surface irrigation to

alternatives in the peri- urban zone. Moreover, conservation of existing water sources is equally important.

Control and mitigations of soil erosion, gullies advancement and landslide are the prime strategies for disaster risk reduction in the conservation areas whereas, focus should be given to sediment management and flood mitigation in peri-urban zone. Urban flooding is the key issues on urban zone.

Sustainable land management will also contribute to reduce soil erosion, whereas, both preventing and controlling measures should implement to mitigate gully erosion (Figure 7-2, Table 7-3). In most cases gullies can be prevented by good land management practices aimed at maintaining even infiltration rates and a good plant cover whereas, structures measures might also be required to prevent damaging water flow and head ward erosion.

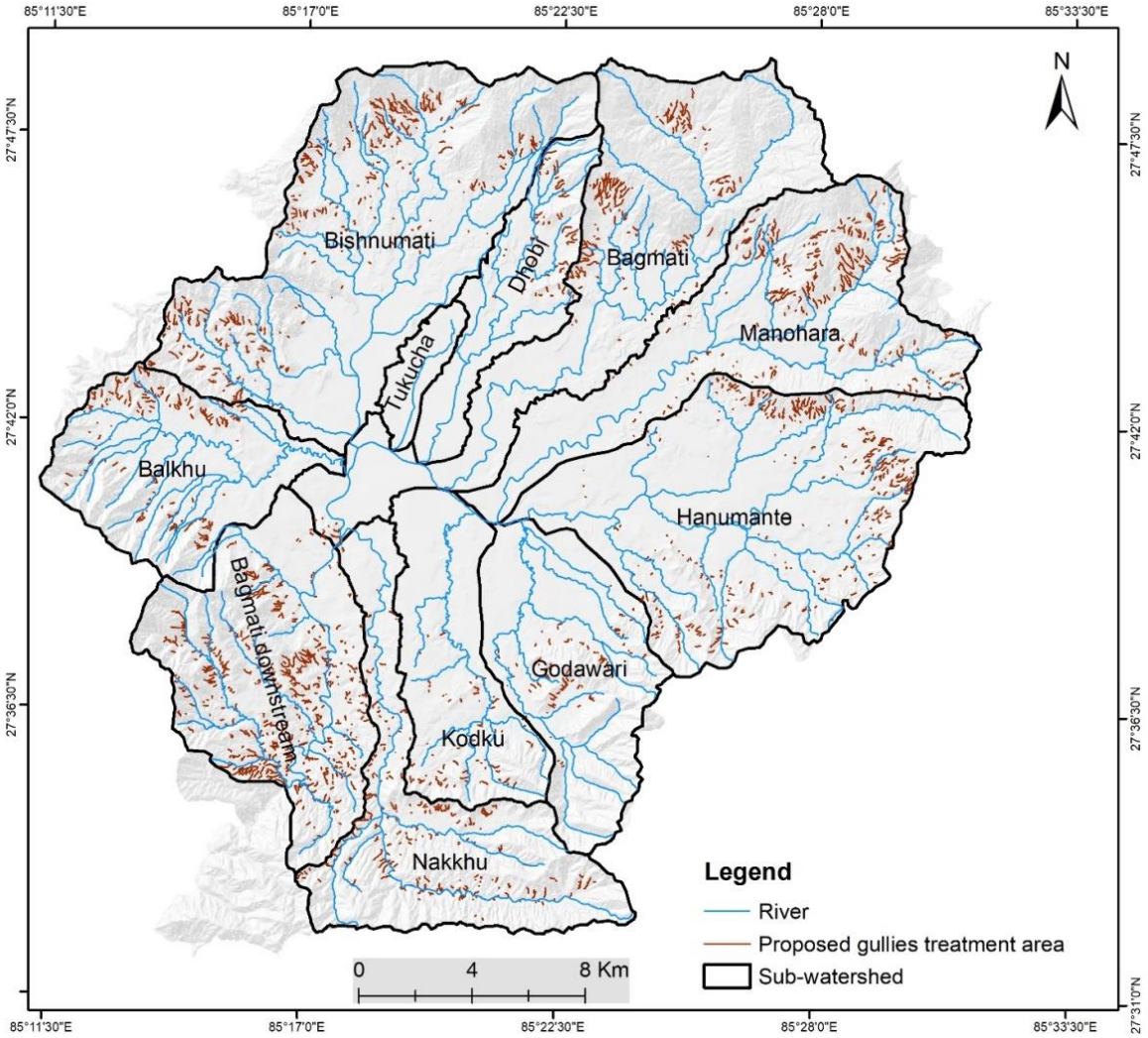


Figure 7-2: Proposed gullies treatment area

A variety of options such as grass chutes, pipe structures, rock chutes, drop structures, check dam and others can be used to mitigate gullies erosion. But focus should also be given to enhance the infiltration capacity because the same region is also the source of ground water of Kathmandu valley.

Table 7-3: Proposed gullies treatment area

Row Labels	Priority (P1)		Priority (P2)		Priority (P3)		Count	Total length (m)
	Count	Length (m)	Count	Length (m)	Count	Length (m)		
Bagmati River	34	7571.61	74	13273.24	66	12268.25	174	33113.10

Row Labels	Priority (P1)		Priority (P2)		Priority (P3)		Count	Total length (m)
	Count	Length (m)	Count	Length (m)	Count	Length (m)		
Bagmati River downstream	142	18091.27	163	24780.23	262	39342.51	567	82214.02
Balkhu Khola	31	4283.78	57	8517.22	105	14894.73	193	27695.74
Bishnumati River	85	11811.44	134	20234.64	200	28897.27	419	60943.35
Dhobi Khola	12	1344.33	13	2435.25	46	7798.84	71	11578.43
Godawari Khola	6	526.128	22	1905.39	58	6994.68	86	9426.20
Hanumante Khola	43	7018.16	94	15423.84	167	26474.79	304	48916.80
Kodku Khola	10	881.57	18	1701.35	49	6295.67	77	8878.60
Manohara River	61	8835.09	84	15574.38	129	26483.29	274	50892.77
Nakkhu Khola	36	3866.22	62	7531.18	111	17219.07	209	28616.48
Grand Total	**460**	**64229.62**	**721**	**111376.75**	**1193**	**186669.15**	**2374**	**362275.52**

Considering the soil erosion and landslide susceptibility in the upstream, sedimentary trappers were proposed in the following locations (Figure 7-3 and Table 7-4).

Table 7-4: Proposed Location of sedimentary trappers

S. n.	Lat	Lon	Municipality	Ward	ZONE	Sub-watershed	Priority
1	27.55214	85.32458	Konjyosom Gaunpalika	4	Conservation Zone	Nakkhu Khola	P2
2	27.56591	85.34554	Godawari Nagarpalika	5	Conservation Zone	Nakkhu Khola	P2
3	27.57004	85.31266	Godawari Nagarpalika	6	Peri-urban Zone	Nakkhu Khola	P1
4	27.58918	85.2752	Dakshinkali Nagarpalika	8	Conservation Zone	Bagmati downstream	P2
5	27.6048	85.264	Dakshinkali Nagarpalika	8	Conservation Zone	Bagmati downstream	P2
6	27.60622	85.36816	Godawari Nagarpalika	3	Peri-urban Zone	Godawari Khola	P2
7	27.61184	85.27638	Dakshinkali Nagarpalika	6	Peri-urban Zone	Bagmati downstream	P2
8	27.65084	85.27514	Dakshinkali Nagarpalika	1	Conservation Zone	Bagmati downstream	P2
9	27.65966	85.4604	Suryabinayak Nagarpalika	10	Peri-urban Zone	Hanumante Khola	P2
10	27.66143	85.44175	Suryabinayak Nagarpalika	8	Peri-urban Zone	Hanumante Khola	P2
11	27.68224	85.2612	Chandragiri Nagarpalika	15	Urban Zone	Balkhu Khola	P2
12	27.70495	85.48221	Changunarayan Nagarpalika	6	Conservation Zone	Hanumante Khola	P1
13	27.70596	85.50125	Changunarayan Nagarpalika	6	Conservation Zone	Hanumante Khola	P2

S. n.	Lat	Lon	Municipality	Ward	ZONE	Sub-watershed	Priority
14	27.72182	85.49423	Shankharapur Nagarpalika	5	Conservation Zone	Manahara River	P1
15	27.72745	85.4401	Shankharapur Nagarpalika	9	Peri-urban Zone	Manahara River	P2
16	27.72795	85.51239	Shankharapur Nagarpalika	5	Conservation Zone	Manahara River	P2
17	27.74185	85.39073	Gokarneshwor Nagarpalika	4	Urban Zone	Bagmati River	P2
18	27.7443	85.47968	Shankharapur Nagarpalika	5	Peri-urban Zone	Manahara River	P1
19	27.75209	85.42275	Gokarneshwor Nagarpalika	1	Peri-urban Zone	Bagmati River	P2
20	27.7643	85.36472	Budhanilakantha Nagarpalika	2	Conservation Zone	Dhobi Khola	P1
21	27.78311	85.35664	Budhanilakantha Nagarpalika	5	Peri-urban Zone	Bishnumati River	P2
22	27.78762	85.32447	Tokha Nagarpalika	1	Peri-urban Zone	Bishnumati River	P2
23	27.79216	85.41529	Gokarneshwor Nagarpalika	1	Conservation Zone	Bagmati River	P1

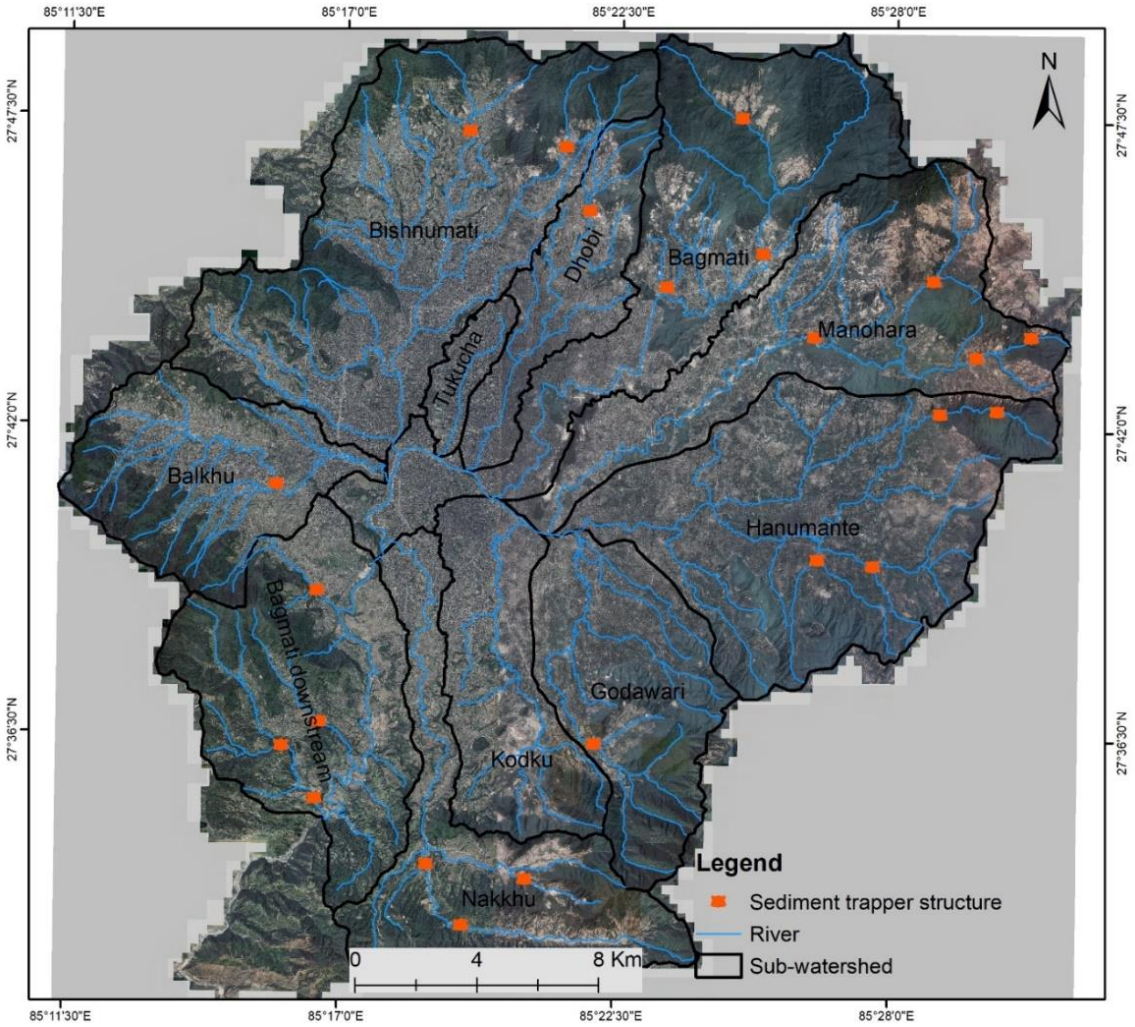


Figure 7-3: Proposed locations for sedimentary trappers

7.1.1.2. Management of Public Land along the River Corridor

Traditional settlement in KV were scattered, which were combined due to rapid urbanization as a result of high influx of internally displaced people during Maoist insurgency. KV is now a single compact settlement in the core and scattered settlements are still dominant without any planning. On the process of settlement growth due to lack of long-term planning, settlements were expanded in inevitable areas as well which have caused problem in different aspects of KV such as environment, ecology, economic as well social context.

Rural-urban migration has resulted in rapid growth of slums and squatter settlements in KV. Marginalized group and pro poor population have forced for encroachment of prime land of urban core for better urban services. The squatter settlement in Kathmandu started early in 1950s when rural migrants moved into city for employment and better services. With the pace of urbanization, squatters also have increased and these squatters have resided mostly along the river bank. The squatter settlement along the river bank have encroached the riparian land along the river which has affected in ecology as well the environmental condition of the area.

KVDA working on the urban development on jurisdiction of KV also has taken the vision to make the river free from informal settlements. With the changing dyanamics of situation the approaches for management of informal settlement have been changed around the world. "*National approaches to slums, and to informal settlements in particular, have generally shifted from negative policies such as forced eviction, benign neglect and involuntary resettlement, to more positive policices such as self-help and in situ upgrading, enabling and rights-based policies*". (UN-Habitat, 2003).

For minimizing the growth of informal settlement and for conservation of riparian land, river banks need to be cleared and green area needs to be developed along the flood prone areas (i.e. ROR) of these river banks for recharging the water. Different approaches for management of informal settlements are described briefly below –

- Forced Evictions
  This involves clearance through violent force and large-scale slum demolition without any alternative or choice of population. This process of approaching leaves them homeless and hopeless aggravating the circle of proverty, discrimation and social exclusion.
  But in some cases, if the informal settlement has been developed to occupy valuable land in the city center this approach can be applied with better study of the condition.
- Clearance and Relocations
  This process involves clearance of the settlements which are usually located in the center of the cities for the beautification of the area and movementof the settlement to a new location usually miles away from their original location. The settlement in the flood prone areas is in risk, so the area can be relocated in the safe area and the area can be developed for conservation of riparian land.
- On-Site upgrading
  This approach includes the on site upgradation of the informal settlement. This might be done from different methods such as site and services, on site redevelopment or land sharing concept. In this approach, the site will be managed with better infrastructures and services. In most of the cases, the land has planned to be shared with the concept of multistorey apartments, so that more lands can be cleared and planned for the better uses.

The detail inventory of existing informal settlements needs to be prepared and these informal squatter settlements needs to be managed through different approaches based on each situation.

7.1.1.3. Management of settlements residing within the Conservation Zone

Besides the squatters in urban area, in rural areas also the hill slopes and the forest area has been encroached for settlement development. Before the declaration of National Park, four

settlements were residing within the forest area of SNNP which was not resettled after overtaking the area from national park. The expansion of population in these settlements have resulted in encroachment of forest and negatively impact the ecology of forest. So, these settlements need to be relocated.

Table 7-5: Proposed settlements for relocation

Settlement	HH
Mulkharka	187
Okharein	167
Kunegaun	45
Chilaune	70
Total	469

7.1.1.4. Disaster mitigation

The hydrological model system of Bagmati River and its tributaries prepared for computation of 50 years return period flood discharge on HEC-HMS modelling software is presented in Figure 7-4 (See Supplementary Volume II: Hydrological and Flood Modelling Report).

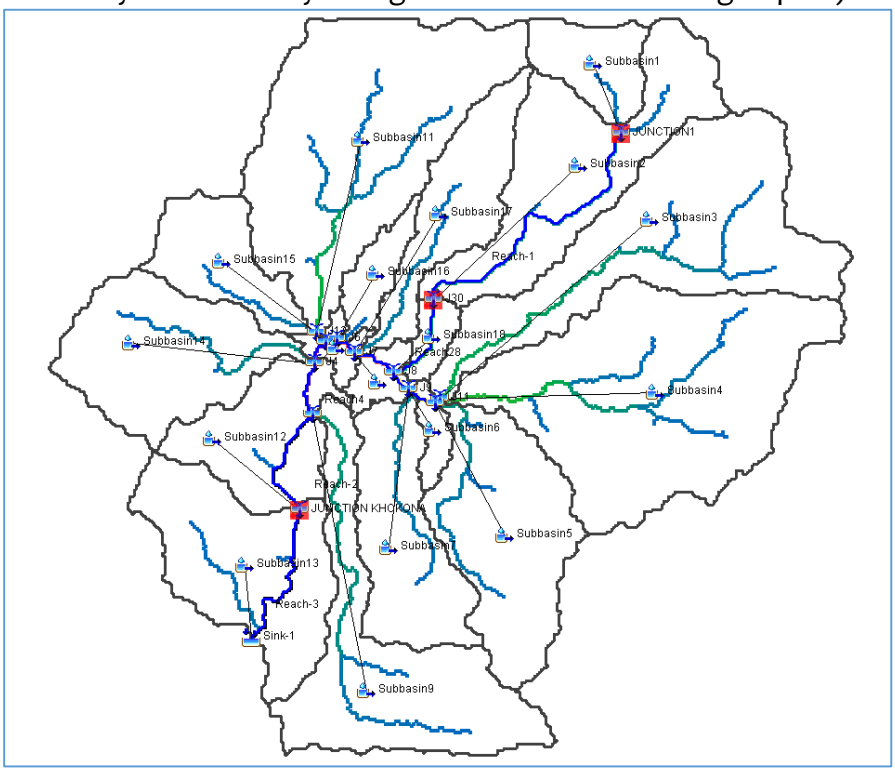


Figure 7-4: Hydrological System of Bagmati River and its Tributaries based on 3D modeling in HEC-HMS Software

Minimum width of natural waterway of the river should be preserved with the hydraulic consideration for the river to allow its flood to pass unhindered with sufficient space. The recommended waterway width shall incorporate natural river channel and floodway over the banks (**Table 7-6**).

Table 7-6: Summary of 50 Years Return Period Precipitation, Flood Discharge and Required Waterway Width

S. N.	River	River Stretch	50 yrs Return Period Precipitation (mm)	50 yrs Return Period flood discharge (m^3/s)	Required waterway for 50 years return period flood (m)
1	Bagmati Khola	Baghdwar to Nagmati Khola Junction	156.21	30.30	26.15

S. N.	River	River Stretch	50 yrs Return Period Precipitation (mm)	50 yrs Return Period flood discharge (m^3/s)	Required waterway for 50 years return period flood (m)
		Nagmati Khola Junction to Suryamati Khola Junction		90.28	45.13
		Suryamati Khola junction to Manohara Khola Junction		132.80	54.74
		Manohara Khola Junction to Dhobi Khola Junction		626.90	118.93
		Dhobi Khola Junction to Tukucha Khola Junction		677.20	123.61
		Tukucha Khola Junction to Bishnumati Khola Junction		688.40	124.63
		Bishnumati Khola Junction to Balkhu Khola Junction		867.40	139.90
		Balkhu Khola Junction to Nakkhu Khola Junction		971.50	148.05
		Nakkhu Khola Junction to Katuwal Daha		1097.50	157.36
2	Bishnumati Khola	Origin to Lundi Khola Junction	154.29	16.05	19.03
		Lundi Khola Junction to Sangla Khola Junction		49.31	33.36
		Sangla Khola Junction to Mahadev Khola Junction		86.28	44.12
		Mahadev Khola Junction to Baucha Khola Junction		144.46	57.09
		Baucha Khola Junction to Manamati Khola Junction		160.70	60.21
		Manamati Khola Junction to Bagmati Khola Junction		205.80	68.14
3	Manohara Khola	Origin to Salambu Devi Temple area	144.12	58.68	36.39
		Salambu Devi Temple area to Hanumante Khola Junction		125.90	53.30
		Hanumante Khola Junction to Kodku Khola Junction		394.40	94.33
		Kodku Khola Junction to Bagmati Khola Junction		495.40	105.72
4	Hanumante Khola	Origin to Chakku Khola Junction	151.13	38.49	29.47
		Chakku Khola Junction to Godavari Khola Junction		163.70	60.77
		Godavari Khola Junction to Manohara Khola Junction		289.10	80.76
5	Dhobi Khola	Origin to Jamle Khola Junction	143.09	6.26	11.89
		Jamle Khola Junction to Bagmati Khola Junction		46.60	32.43

S. N.	River	River Stretch	50 yrs Return Period Precipitation (mm)	50 yrs Return Period flood discharge (m^3/s)	Required waterway for 50 years return period flood (m)
6	Suryamati Khola	Origin to Bagmati Khola Junction	156.21	30.10	26.06
7	Nakkhu Khola	Origin to Bagmati Khola Junction	188.35	104.70	48.60
8	Balkhu Khola	Origin to Balambu area	237.93	91.57	45.45
		Balambu Area to Bagmati Khola Junction		134.30	55.05
9	Sangla Khola	Origin to Bishnumati Khola Junction	154.29	39.43	29.83
10	Mahadev Khola	Origin to Bishnumati Khola Junction	154.29	44.70	31.76
11	Chakku Khola	Origin to Hanumante Khola Junction	151.13	48.38	33.04
12	Manamati Khola	Origin to Bishnumati Khola Junction	162.07	45.10	31.90
13	Baucha Khola	Origin to Bishnumati Khola Junction	154.29	19.07	20.74
14	Lundi Khola	Origin to Bishnumati Khola Junction	154.29	5.68	11.32
15	Jamle Khola	Origin to Dhobi Khola Junction	143.09	3.22	8.52
16	Tukucha	Origin to Bagmati Khola Junction	143.09	16.50	19.29
17	Kodku Khola	Origin to Manohara Khola Junction	188.35	97.00	46.78
18	Godavari Khola	Origin to Hanumante Khola Junction	177.25	106.40	49.00

The waterway width computed in Table 7-6 for respective river in different stretches shall be left without construction and is required to set the width of river to avoid the flooding. For narrow river stretches, it is recommended to construct extensive river training structures and flood embankments to confine the flood discharge within limited width of river waterway, which needs to be finalized and designed with detail survey and planning in particular stage.

Based on detail site assessment and model based flood map, areas with higher risk and vulnerability during 50 years return period flood event are identified. Due to increased urbanization, river encroachment in most of Bagmati river tributaries and changes in land use and land cover pattern over the years; the threat and risk of the urban flooding has increased in Kathmandu Valley area. The hydraulic simulation tool (HEC-RAS) has been used to prepare the flood inundation map of Kathmandu valley river system for 50 years flood discharge computed using hydrological model which has been presented in **Figure 7-5**.

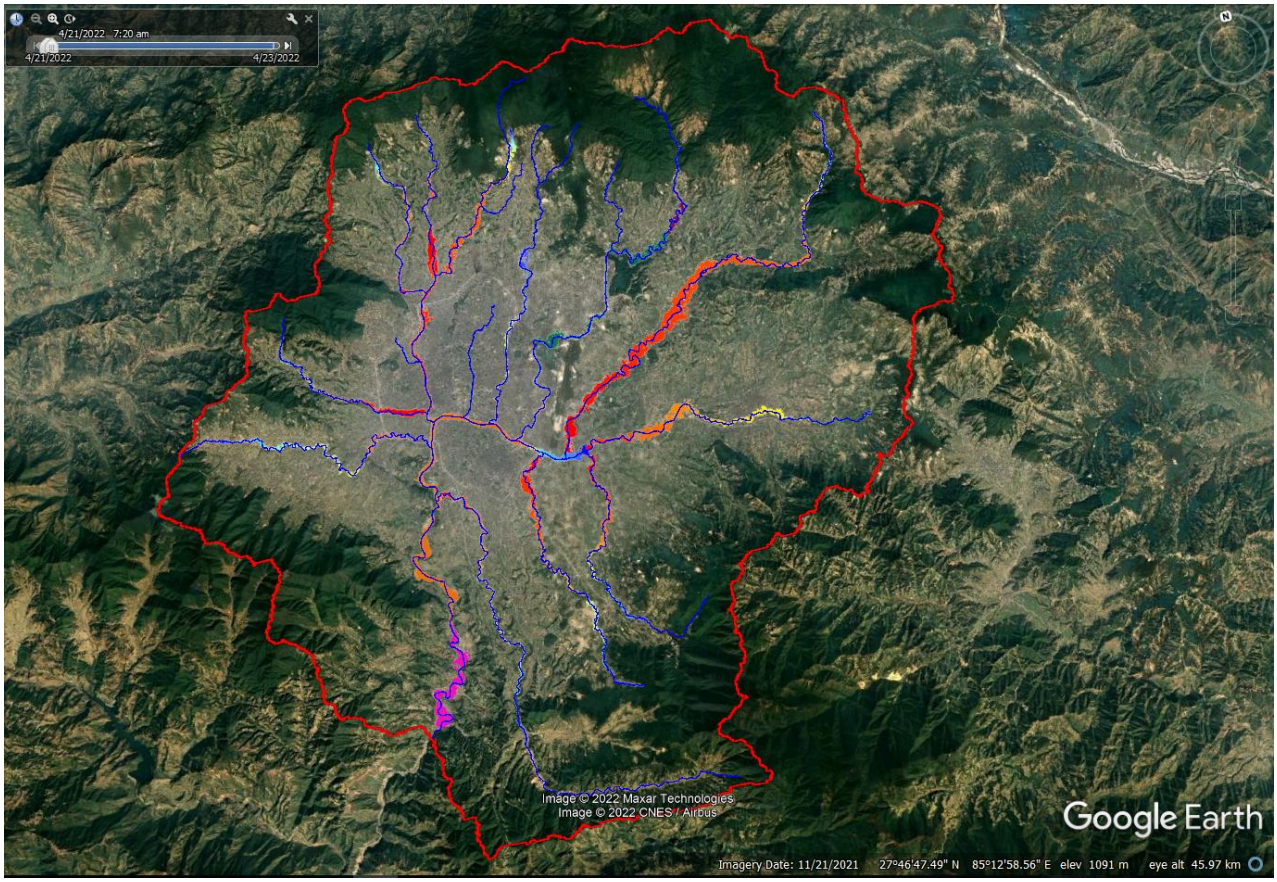


Figure 7-5: Model Based Flood Inundation Map for 50 years return period flood of Bagmati River System in Kathmandu Valley

Based on hydrological modelling, field survey and site visit; most of the tributaries of Bagmati river system are not sufficient in width and depth for safely passage of 50 years return period flood. Hence, it is recommended to carry out river training works such as retaining wall and flood embankments to avoid the possible impacts of flood to the adjacent lands in critical section and narrow width area. It is recommended to increase the river width where backwater effect exitst due to the narrower river width. Detail contour and cross section survey and river flow hydraulic simulation shall require before planning and designing the river training works in any river stretch to consider confluence effect at the confluence region and backwater effect due to narrow and non-uniform river sections, culvert and bridge pier foundations in different rivers. Based on GIS inventory system of constructed river training works in Bagmati river system and site assessment, the tentative length of river training works to be carried out in different river as per the zoning are presented in Table 7-7.

Table 7-7: Estimated Length of River Training Works in Different River System of Bagmati Basin

S.n.	River	Estimated length of River Training Works					
		Zone					
		Urban		Peri-Urban		Conservation	
		Left (km)	Right (km)	Left (km)	Right (km)	Left (km)	Right (km)
1	Hanumante River	8.17	8.06	3.74	3.64	0.19	0.19
2	Manohara River	7.34	8.03	9.04	9.34	-	-
3	Godawari Khola	7.22	7.17	2.36	1.98	0.13	0.13
4	Nakkhu Khola	1.19	1.19	9.16	9.42	8.21	8.39
5	Suryamati Khola	1.00	0.90	2.47	2.57	-	-
6	Bishnumati River	2.36	1.36	1.20	1.35	-	-
7	Dhobi Khola	-	-	1.95	1.93	-	-
8	Sangla Khola	-	-	2.50	3.83	-	-
9	Mahadev Khola	0.19	0.20	3.70	3.96	-	-

S.n.	River	Estimated length of River Training Works					
		Zone					
		Urban		Peri-Urban		Conservation	
		Left (km)	Right (km)	Left (km)	Right (km)	Left (km)	Right (km)
10	Manamati Khola	1.16	0.72	3.51	3.96	0.24	0.24
11	Balkhu Khola	5.06	4.07	5.87	6.69	-	-
12	Bagmati River	6.67	8.93	18.75	19.07	-	-
13	Jamle Khola	-	-	2.46	2.46	-	-
14	Lundi Khola	0.75	0.66	2.27	2.30	-	-
15	Kodku Khola	4.76	4.68	6.59	6.19	-	-
16	Baucha Khola	0.46	0.29	-	-	-	-
17	Ghatte Khola	-	-	0.79	0.80	-	-
18	Chakhu Khola	1.15	0.13	1.46	1.46	-	-

Based on the detail assessment of narrow width sections in critical areas of Bagmati Khola and its tributaries, the recommended height of the river training works (stone masonry wall on river banks) from river ground level in Bagmati Khola and its tributaries are presented Table 7-8.

Table 7-8: Recommended for River Training Works

S.N.	River Name	Recommended Height of River Training Works (Meters)	Remarks
1	Hanumante Khola	2.5-4.2	Based on Detail Hydrological Modeling and Cross Section Survey of Narrow Section and River Confluence Area
2	Manohara Khola	1.7-4.8	
3	Godawari Khola	2.34-3.8	
4	Kodku Khola	1.2-5.2	
5	Nakhu Khola	1.93-4.26	
6	Suryamti Khola	1.58-3	
7	Bishnumati Khola	1.5-3.75	
8	Dhobi Khola	1.53-3.8	
9	Sangla Khola	1.21-3.13	
10	Mahadev Khola	1.75-3.1	
11	Manamati Khola	1.5-4.06	
12	Balkhu Khola	2.45-3.46	
13	Bagmati Khola	1.78-4.94	

Urban flood management in the Kathmandu Valley requires a comprehensive strategy that addresses the complex challenges arising from rapid urbanization, inadequate drainage systems, and vulnerability to climatic events. Here are key strategies to manage urban floods in the Bagmati River system:

1. **Flood-resilient urban planning and implementation**
    - Detail inventories of river systems and restoration of encroachment area: Explore the historical Khola/kholchi and Raj Kulo and map in detail using the inventories. Monitor changes over time to detect new encroachments. Identify instances of illegal construction or land use violating established guidelines and restore the original channel flow.
    - Land use planning: Implement and enforce zoning regulations to prevent construction in flood-prone areas with a provision of allocated space for green infrastructure and water retention zones.
    - Infrastructure Planning: Plan and implement infrastructure projects that restore the river's natural flow while meeting the needs of the community, considering sustainable urban development practices that integrate with restoration efforts.

- Promote Climate-Resilient Infrastructure: Ensure critical infrastructure is climate-resilient by enforcing construction standards that consider climate change impacts on extreme weather events.

2. **Improved Drainage Systems**
   - Stormwater Management: Regularly clean and maintain existing drains and waterways together with investment in modern stormwater drainage systems to efficiently manage rainfall runoff.
   - Citizen Reporting Systems: Encourage community involvement in monitoring and maintaining local drainage systems. Also, implement platforms for citizens to report drainage issues, blockages, and potential flood risks.
   - Riparian Zone Protection: Protect and restore natural riparian zones along rivers and water bodies, through the implementation of green belts and buffer zones to absorb excess water.
3. **Waste Management**
   - Proper Waste Disposal: Implement effective waste management practices to prevent blockages in drains together with regular cleaning of stormwater drains and sewer systems.
   - Reduce Single-Use Plastic: Promote initiatives to reduce the use of single-use plastics to prevent clogging of drains in combination with community engagement in waste reduction campaigns.
4. **Cross-Boundary Collaboration**
   - Regional Cooperation: Collaborate with neighboring areas and municipalities on shared flood management strategies through effective river management hubs to share information, resources, and best practices for effective flood control.
   - Government and NGO Partnerships: Foster partnerships between government agencies, non-governmental organizations (NGOs), and local communities for integrated flood management.

7.1.1.5. Development of corridor transport system along rivers

The functional hierarchy of the river corridor road (Motorable or pedestrian) network is mainly concerned with the idea of the preservation of river corridors in the conservation zone and the utilization of river these corridors for mobility means in the urban zone and peri urban zone. Road development is always related to the creation of new places of business which results in the increasing environmental overburden to the river ecology as well as the disturbance of the river morphology. Therefore, the strategy shall include the restrictions on the development of the road corridors along river banks. On the other hand, the existing river corridor roads have been considered as the means of provisions for easing the traffic flow hence reducing the congestion along major roads in urban zone. The strategy shall be aimed at the management of these roads so as to curb the negative impact on the river ecology.

Roads along the river corridors in Kathmandu Valley have been increasingly developed in the past decades. The total length of the road along these river corridors is found about 162 km. The existing road length along the river corridors located in the conservation, peri-urban and urban zones are shown in **Figure 7-6**.

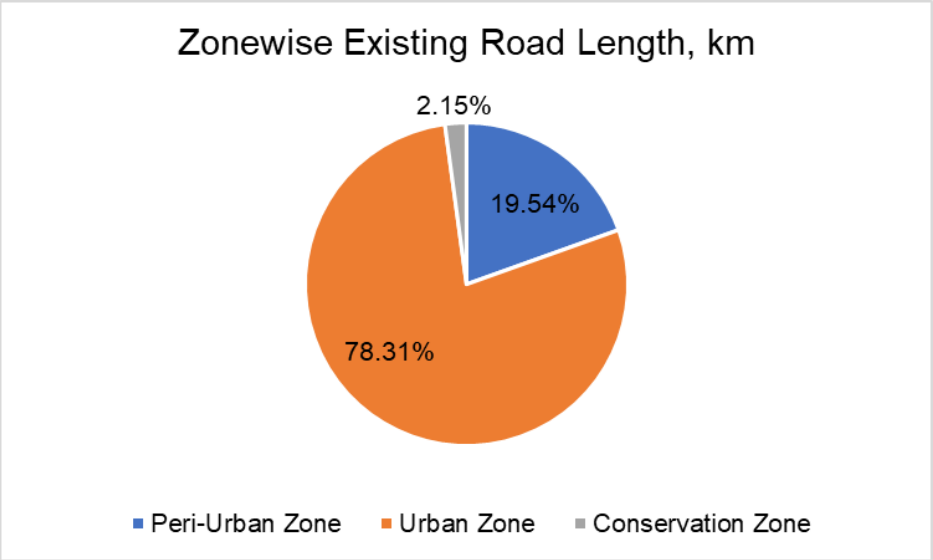


Figure 7-6: Percentage of the road length located in the zones

In line with the development of river-corridor roads in Kathmandu, most of them have been heavily congested. Furthermore, these corridors have become places of traffic attraction due to the new development of the built environment. This newly opened built environment includes restaurants, vehicle repairing workshops, markets as well as other recreational centers. These circumstances are gradually becoming a threat to the river ecology. The newly developed physical environment would not support the vision of the Bagmati Action Plan, i. e. preservation of river systems with a green environment.

The concentration of human activities along the river corridor is mainly caused by the development of road corridors. The zoning of the Kathmandu Valley for the purpose of conservation of river systems thereafter the overall Bagmati civilization shall be considered during the planning of river corridor roads in those zones. The river corridor road network, within the urban zone, has more functional for providing mobility. In the rural zone, river corridor roads shall be considered for the provision of connectivity to the nearly heritage sites, and historical settlements. The roads along with the river corridors in the conservation zone are not desirable. Most of the river corridors in the conservation zone have a steep gradient (river profile). Therefore, road development would require more physical intervention in terms of huge earthwork as well as massive construction for slope protection. These would be an alarming environmental threat to the river system. Therefore, river corridors in the conservation zone shall be free from any river corridor roads. This zone is the major environmental asset of the Kathmandu valley. The physical development in this zone may be limited to the construction of foot trails and cycle lanes with due compliance with the environmental regulations. The river corridor road network hierarchy can be developed with the proposed zoning system in this initiative as shown in the figure below.

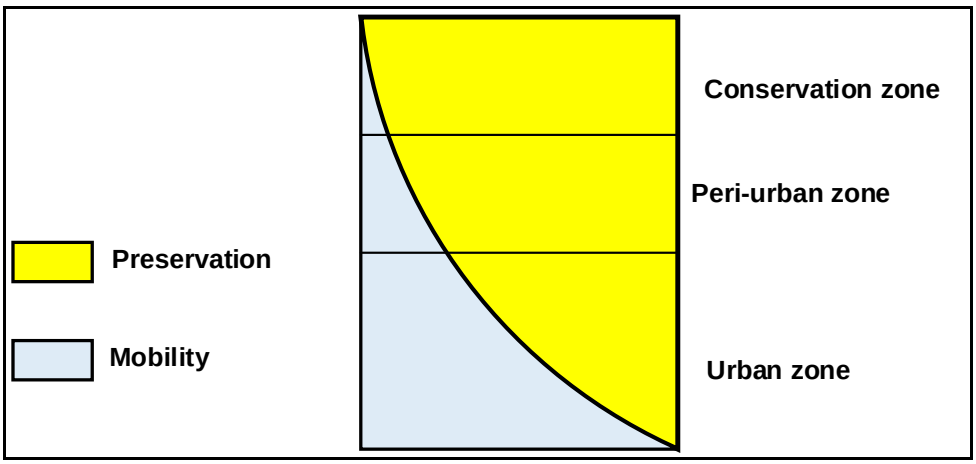


Figure 7-7: Hierarchy of River Corridor Road Network and functions

The functional hierarchy of the river corridor road network is mainly concerned with the idea of the preservation of river corridors in the conservation zone and the utilization of river these corridors for mobility means in the urban zone. Road development is always related to the creation of new places of business which results in the increasing environmental overburden to the river ecology as well as the disturbance o the river morphology. Therefore, the strategy shall include the restrictions on the development of the road corridors along river banks. On the other hand, the existing river corridor roads have been considered as the means of provisions for easing the traffic flow hence reducing the congestion along major roads in Kathmandu. The strategy shall be aimed at the management of these roads so as to curb the negative impact on the river ecology. Therefore, proper asset management plans shall be developed and implemented for these roads in the future. Similarly, BAP shall include the discouraging statements for the development of industrial setup including the vehicle repairing workshop along the entire river corridors. At the same time, BAP shall support the concerned local authorities in the development of river bank greenery initiatives.

Another aspect of the accessibility to the cultural heritage sites shall also be addressed in the formulation of the BAP. The river corridor roads shall be developed as the means of connectivity to such places. However, these heritage routes shall be specifically managed for the objectives of reliable access by the provision of public transport.

Road development along the river corridors in Kathmandu has been carried out by the Department of Roads (Road Division Offices), and Municipalities and High-Powered Committee for Integrated Development of the Bagmati Civilization (HPCIDBC). The multi-sectoral coordination among the stakeholder is one of the major challenges for the development and management of the road assets along with the river systems. Therefore, the issues of coordination and the investment strategy development for the development of the smart corridor roads is considered the main task in the proposed action plan.

The study found that most of the road along the river corridors has been developed without consistent geometric standard and cross-sections. Therefore, the improvement of road geometry, as well as cross-section, may be taken as one of the actions for the better functional requirement of corridor roads. River corridor is shortage and alternative network so it is busiest road network in urban settlement. So, it must be safe and high level of mobility. Road design must follow the urban road standard-2076 & Nepal Road Standard-2070 for geometric design and Flexible Pavements design Guideline- 2021 (MoPIT) & Rigid Pavements design Guideline – 2021 (MoPIT) must follow for Pavement design. Corridor road has low regural and periodic maintenance road as per site observation. Lot of failure has observed on pavement of road, so regular observation and assest management plan need to be prepared. All the services like electricity, telephone, water supply, sewer waste shall be made underground in corridor road.

The pedestrian sidewalks, and cycle lanes could be taken as important elements for the road cross-section. Similarly, the pedestrian rest places and toilet facilities could be an essential item of the roadside development. Footpath constructed in corridor road has not any standard of footpath such as width of footpath, height of kerb stone, kerb ramp etc. Most of the footpath of corridor Road has encroached by service utilities such as cabinate of NEA etc. and some place green belt has constructed in Non-standard footpath, which create following issue

- No space for Pedestrian
- Congession in road way
- Un-safety Road
- Low level of pedestrian mobility footpath
- Non universal friendly footpath

Footpath design must follow the IRC: 103-2012 and Guidelines for facilities for Blind and Vision Impaired Pedestrians-2018 (MoPIT).

Following river corridor (Table 7-9) will be proposed for developing and upgrading within 20 years as per standard.

Table 7-9: Proposed River Corridor

River Corridor	New Construction (km) including Both Side		Upgrading (km) including Both Side	
	Urban Zone	Peri Urban Zone	Urban Zone	Peri Urban Zone
Bagmati River	14.00	33.00	10.00	8.45
Bishnumati River	5.00	5.00	9.00	2.54
Manahara Khola	18.00	22.00	6.00	-
Hanumante Khola	12.00	10.00	12.00	3.50
Balkhu Khola (Indramati)	12.00	14.00	2.00	3.00
Nakhu Khola	4.00	14.00	13.00	-
Rudramati (Dhobikhola)	-	3.00	-	-
Godawari Khola	12.00	10.00	2.00	2.24
Mahadev Khola	-	8.00	3.00	4.22
Sangla Khola	-	10.00	-	-
Kodku Khola	16.00	9.00	4.00	-
Bhaucha Khola	-	-	2.00	-
Jamle Khola	-	13.00	-	-
Manamati Khola	5.00	-	2.00	1.00
Suryamati Khola	5.00	-	-	-
Total	**103.00**	**151.00**	**65.00**	**24.95**

Typical cross section of corridor roads are recommended as following

S. n.	Width of Roadway	Cross section
1	4m	Private Proterty line + Shoulder (1m) + Carriage way (3m) + River Edge
2	5m	Private Proterty line + Footpath (1.5m) + Carriage way (3.5m) with one side surface drain + River Edge
3	6m	Private Proterty line + Footpath (1.5m) + Carriage way (4.5m) with one side surface drain + River Edge
4	7m	Private Proterty line + Footpath (1.5m) + Carriage way (5.5m) with one side surface drain + River Edge
5	8m	Private Proterty line + Footpath (2m) + Carriage way (6m) with one side surface drain + River Edge
6	9m	Private Proterty line + Footpath (2m) + Carriage way (7m) with one side surface drain + River Edge
7	10m	Private Proterty line + Footpath (2.5m) + Carriage way (7.5m) with one side surface drain + River Edge

For cycle lane along river corridor, extra space is required as per IRC: 11 - 1962: The design and Layout of Cycle Track.

Following provisions are recommended for traffic management along the river corridor.

- Installment of Traffic Sign, Signal and information Board along corridor road network
- Uni-directional or multi-directional traffic permission as per carriage way width and traffic volume with crossing structures at fixed interval.
- Installment of Street light along corridor road network and sufficient lighting on underpass.
- Not provide to route permit for public vehicle, required bus stop at 300m to 500m interval if provide the route permit for public vehicle.
- Permission of movement of vehicles and speed limit as per carriage way width as per following.

S. n.	Width of carriage way	Allowable Vehicle Type	Speed Limit (km/hr)
1	6m or less than 6m	Light Vehicles and Medium Vehicles	20
2	More than 6m	Heavy Vehicles	30

7.1.2. Cultural/Civilization rehabilitation

The sacred landscape of Kathmandu valley is intertwined with its riverine culture. Water is venerated in Nepal Mandala as divine, life giving, and life maintaining substance. It is regarded as the counterpart on earth of amrita, the immortalizing elixir of the gods. This relation with sacred water is especially visible in innumerable tirthas often located near water - on the banks and confluences, at ponds and pools, at springs and even at seemingly mundane wells. Pilgrimage to these tirthas and bathing in these waters are considered the most compelling religious activities. (Slusser, 1998).

Of all the valley rivers Bagmati is considered the most sacred and is studded with holy places and tirthas. The other illustrious rivers with wondorous legends and endowed with numerous holy places are mainly Vishnumati, Manohara and Hanumante. This study has considered 30 holy places and tirthas along these rivers for detailed study to understand the context of their sitting, their relation with the other cultural sites and settlements as well as to understand the intangible attributes associated with these sacred places. The cultural sites situated along the river are often places of cremation where the dying and dead come to be in communion with the sacred water. Besides its association with death rituals, these are the places to seek blessings in the form of offsprings, cure from diseases and for good fortune. This clearly indicate the intricate relation the valley dwellers share with their sacred water.

This study has tried to see the physical context of these heritage sites and find the linkages with the intangible heritages. This attempt has put forth a clearer picture that the heritage sites along these rivers do not sit in isolation or oblivion with the settlements lying in their proximity rather there is complex relationship of these sites with the settlements and the people living there. These relationships often come alive when people move through these spatial arrangements, and during jatras and festivals.

This tangible – intangible interrelationships clearly indicate that the built features when seen in isolation do not convey meaning of its sitting in a larger context and also when addressing its issues in isolation will not help in addressing the cultural issues of the larger context, as such it becomes essential to identify, understand and address the issues of the cultural landscape as a whole. These cultural landscapes are often understood as areas that have evolved through time and represent the combined activity of nature and man. In Kirata period the sitting of the pringga and pitha is a good example of culture and landscape relationship. Cultural historians see the yearly festivals like Khat jatras were carried out to address the issues of urban and natural resources of pringga and pitha respectively. The jatra of Kankeshwari of Kathmandu, Balkumari of Patan are such examples which try to illustrate the interdependency of urban culture and natural hinterlands. Similarly the landscape extending from Shankhamul ghat to Kumbeshwara temple is a conglomeration of cultural heritage of different religions and time periods as well as the expressions of people who inhabited the area. In general the cultural sites and their intangible expressions spread over space and time lend regional identity. This very idea of identity associated with cultural practices even in the contemporary society can be a guiding force to restore and revitalize the cultural landscapes and their attributes. In this aspect the strategy should focus on reviving the local guthis and committees to ensure the regular maintenance, sustainable use and conservation of tangibal and intangitable heritage.

The cultural landscape are areas that have evolved through time and represent the combined activity of nature and man. In Kirata period the sitting of the pringga and pitha were such that the yearly cultural activity were carried out to address the issues of urban and natural resources of pringga and pitha respectively. In our current context of study, these landscapes have various built features which come alive with socio-cultural activities in different times of the year. The

built features when seen in isolation do not convey meaning of its sitting in a larger context and also when addressing its issues in isolation will not help in addressing the cultural issues of the larger context, as such it becomes essential to identify, understand and address the issues of the cultural landscape as a whole.

7.1.3. River/Water Quality and quantity improvement

7.1.3.1. Conservation and management of water sources

To maintain the ground water aquifer in the valley floor, water conservation across the foothill and upper hill slope is crucial. There are several measures which can help to retain the surface runoff for certain period and improve infiltration capacities. The present study has figured out some potential sites for water sources development and these are mainly located in the peripheral hilly terrain of the valley. There are four different types of potential interventions identified for the upgradation of surface and groundwater in the valley:

i) Rain water harvesting ponds in small scale
ii) Water retaining reservoirs/ponds
iii) Reservoir dams along large rivers
iv) Artificial groundwater recharge wells or ponds

A. Rain Water Harvesting Ponds

The process of rainwater harvesting involves the collection and the storage of rainwater that run off naturally through creating small storage structures along the flow path. These ponds are small in size but can contribute nearby stream flow, wells, stone spouts, etc. Similarly, these types of ponds constructed at streambed also help to retain flash floods during rainy seasons. The potential sites for the rain water harvesting ponds have been selected based on the following characteristics:

a) Naturally depressed area or suitable for excavation in highland
b) Streambed of ephemeral stream or close to stone spouts
c) Moderate to high capacity of reservoir with low height of dam
d) Bare and swampy land
e) Non-disturbing places even within residential area
f) Strong and fresh rock/soil type at the proposed site of dam construction

Owing these facts, forest edge surrounding the valley and having 3-5th order streams are selected as potential sites for rainwater harvesting ponds (**Figure 7-8**). Since rainwater harvesting ponds requires regular maintenance, ownership from local stakeholders is essential. For this, a cycle lane connecting proposed ponds is recommended which will not only promote eco-tourism but also improve ownership from local peoples including local governments. This integrated approach might also support to conserve and enhance local biodiversity.

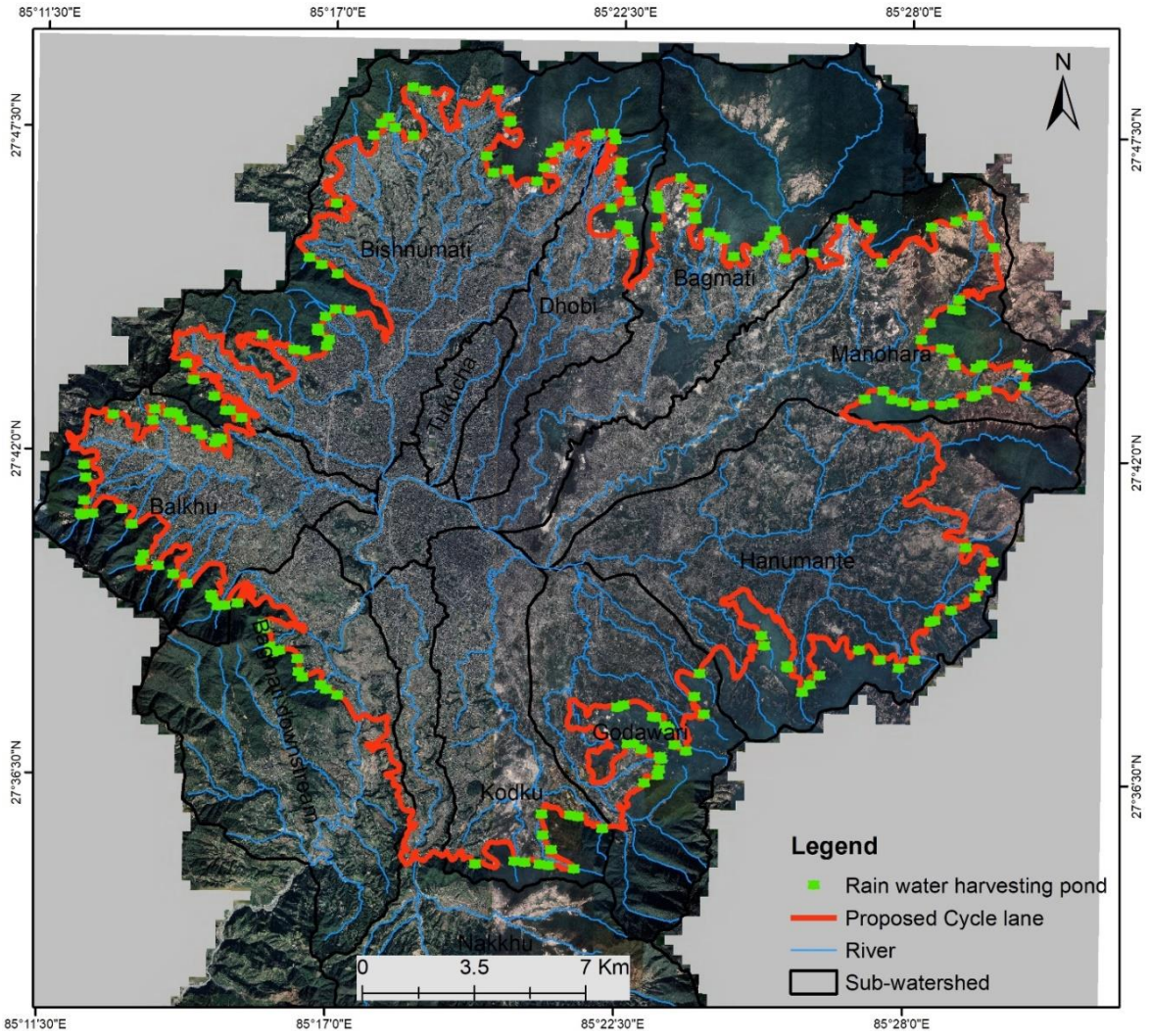


Figure 7-8: Proposed Rain water harvesting ponds

B. Water Retaining Ponds/Reservoir

The potential sites for the water retaining reservoirs have been selected based on the following characteristics:

a) Naturally depressed area in highland
b) Flat to very low slope ratio in the upstream of the proposed dam site
c) Large capacity of reservoir with low height of dam
d) Bare and swampy land
e) Distant from the residential area
f) Narrow gorge like outlet bounded by bedrocks
g) Strong and fresh rock/soil type at the proposed site of dam construction

There are 15 potential sites identified from the field for the water retaining reservoirs (**Figure 7-9 and Table 7-10).**

C. Water reservoir dam

The potential sites for the reservoir dams along rivers have been selected based on the following characteristics:

a) Moderate to large catchment of the river
b) Perennial streams in highland
c) Flat to very low slope ratio in the upstream of the proposed dam site
d) Large capacity of reservoir with low height of dam
e) Bare, grassy, or rocky terrain
f) Distant from the residential area
g) Narrow gorge like outlet bounded by bedrocks

h) Strong and fresh rock/soil type at the proposed site of dam construction

There are 8 potential sites identified from the field for the reservoir dams along rivers (**Figure 7-9**). A summary table describes the salient features of these potential sites.

D. Artificial Groundwater Recharge Wells or Ponds

The construction of artificial groundwater recharge wells is essential to contribute the shallow and deep aquifers of the valley in an effective way. These types of wells can be constructed differently to recharge the shallow and deep aquifer in a separate way. The potential sites for the construction of artificial groundwater recharge wells have been selected on the basis of following characteristics:

a) Old floodplain near to major river channel
b) Foothill of peripheral mountains
c) Naturally groundwater recharge zone
d) Distant from dense residential area
e) Distant from highly polluted water and dumping sites

There are 8 potential sites for the construction of artificial groundwater recharge wells identified from the field (Figure 7-9 and Table 7-11).

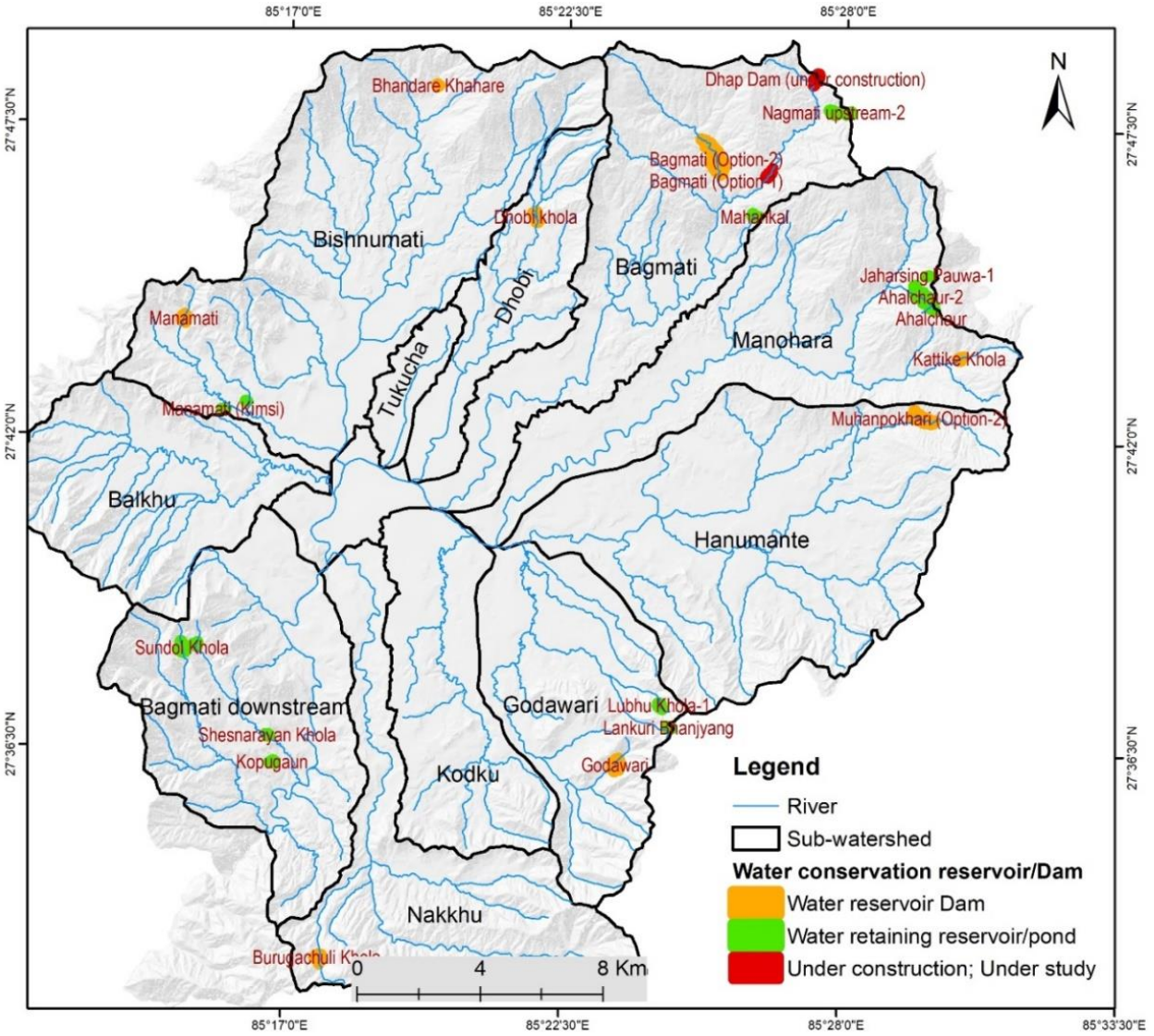


Figure 7-9: Potential sites for water recharge structures

Table 7-10: Location of Proposed Water Reservoir/ pond and Reservoir dam

S. n.	Khola	Lon	Lat	Area (ha)	Volume (m3)	Height (m)	Max Width (m)	Land cover	Activities	Priority	Remarks
1	Bagmati	85.423399459	27.782734001	24.0	5485592.3	80	200.0	Forest	Water reservoir Dam	P1	Shivapuri Nagarjune National Park
2	Nagmati upstream-1	85.467387521	27.796650849	1.5	55000.0	20	80.0	Wetland & forest	Water retaining reservoir/pond	P3	Shivapuri Nagarjun NP
3	Nagmati upstream-2	85.462300775	27.796954149	2.5	179987.6	30	80.0	Forest	Water retaining reservoir/pond	P3	
4	Mahankal	85.436582701	27.766199774	1.3	78048.7	20	60.0	Forest	Water retaining reservoir/pond	P2	
5	Dhobi khola	85.364306723	27.765088420	3.6	238452.4	25	70.0	Park and private land	Water reservoir Dam	P1	Existing park will be inundated partially & some issues of private land
6	Bhandare Khahare	85.331397816	27.803421612	0.6	43298.0	24	40.0	Forest	Water reservoir Dam	P2	Shivapuri Nagarjun NP
7	Manamati	85.248663845	27.734068899	3.4	569961.8	50	160.0	Occupied land/ Cultivation and some houses	Water reservoir Dam	P3	Private land shall be acquired and reservoir lies on National park
8	Manamati (Kimsi)	85.262180510	27.707571720	0.7	18870.5	12	50.0	Forest	Water retaining reservoir/pond	P1	
9	Sitapaila	85.269593285	27.709985533	0.3	6284.8	10	30.0	Forest	Water retaining reservoir/pond	P1	
10	Sundol Khola	85.249480143	27.637302864	4.7	862675.8	50	120.0	Forest & Wetland	Water retaining reservoir/pond	P2	
11	Panim Khola	85.254071971	27.638339215	1.2	33782.9	20	70.0	Forest	Water retaining reservoir/pond	P1	
12	Shesnarayan Khola	85.278102153	27.612064131	0.8	65706.5	20	60.0	Forest	Water retaining reservoir/pond	P1	
13	Kopugaun	85.279856969	27.604132453	1.1	34136.9	10	70.0	Forest	Water retaining reservoir/pond	P1	
14	Burugachuli Khola	85.295877690	27.546793399	3.6	537134.0	50	140.0	Forest	Water reservoir Dam	P3	
15	Godawari	85.393032179	27.604472377	8.6	101132.3	40	200.0	Grazing land and forest	Water reservoir Dam	P2	Reservoir enlarge through excavation & artificial waterfall at inlet

S. n.	Khola	Lon	Lat	Area (ha)	Volume (m3)	Height (m)	Max Width (m)	Land cover	Activities	Priority	Remarks
16	Lankuri Bhanjyang	85.410353394	27.615696234	0.8	137145.8	30	60.0	Forest	Water retaining reservoir/pond	P1	
17	Lubhu Khola-1	85.407291886	27.622099280	1.9	100993.3	40	90.0	Forest	Water retaining reservoir/pond	P2	
18	Muhanpokhari	85.492598024	27.707274627	10.9	1682836.1	60	170.0	Forest	Water reservoir Dam	P2	
19	Kattike Khola	85.504962596	27.724954741	1.3	192463.5	50	60.0	Forest	Water reservoir Dam	P2	Series of siltation dams are required in the upstream
20	Ahalchaur	85.495393072	27.740133946	2.6	150721.7	18	70.0	Forest & Wetland	Water retaining reservoir/pond	P1	
21	Ahalchaur-2	85.492101254	27.743042911	7.4	558834.5	30	90.0	Abandoned cultivated land, Wetland & Forest	Water retaining reservoir/pond	P1	Drinking water supply and private land
22	Jaharsing Pauwa-1	85.493975179	27.749198294	0.2	4569.9	6	25.0	Forest	Water retaining reservoir/pond	P1	
23	Jaharsing Pauwa-2	85.489836880	27.746061919	0.7	31473.1	1	40.0	Abandoned cultivated land & forest	Water retaining reservoir/pond	P2	

Table 7-11: Location of Proposed Recharge Well

S. n.	Name	Municipality	Ward	Longitude	Latitude	Priority
1	Bagmati River	Gokarneshwor Nagarpalika	1	85.421616	27.753105	P1
2	Bishnumati River	Nagarjun Nagarpalika	8	85.247533	27.732093	P1
3	Bishnumati River	Tokha Nagarpalika	1	85.330838	27.802748	P1
4	Godawari Khola	Mahalaxmi Nagarpalika	9	85.386112	27.635970	P2
5	Godawari Khola	Godawari Nagarpalika	3	85.379799	27.597252	P2
6	Hanumante Khola	Suryabinayak Nagarpalika	4	85.405140	27.647386	P2
7	Hanumante Khola	Changunarayan Nagarpalika	7	85.470123	27.696099	P2
8	Manahara River	Changunarayan Nagarpalika	6	85.480812	27.717681	P1

A summary table in **Annex V** describes the salient features of these potential sites.

E. Revitalization of traditional and local water storage

The disruption of Raj kulo is mainly caused by road construction (for e.g the construction of ring road) and construction of houses in the land through which these raj kulo passed. This disruption in turn led to the drying up of water bodies and consequently the drying of hitis. The other cause of decay of water bodies is encroachment, for instance a ward office building is built over a water body in Thimi historic settlement, similarly in Sunakothi, Kvey Lachi water body was buried and a sattal was constructed over it. The massive ones are the construction of civil mall and Chaya complex, both stand on historic water bodies. The hitis are also encroached in the name of development like in case of Bhotahiti where the hiti was buried during the road construction. Looking into the sensitiveness of the issue, World Monument Fund (WMF) has put hitis on its 2022 World Monument watch list.

Besides mourning the loss of such important historic infrastructure, there is an urgent need to form strategy to preserve what is left with us. This not only complies with the conservation philosophy but the revitalization of such water related infrastructure can actually help address the present day social and environmental problems. For instance, in the current scenario the urban areas are facing acute shortage of drinking water and the restoration of raj kulo will not only help bring water for irrigation purpose but will bring the hitis back to life fetching good supply of drinking water to the residential quarters of historic cities. Such situations will lessen the dependency of these historic settlements on new water sources like Melamchi for drinking water supply. On the other side the recognition of these ancient sources of water means policies will be put in place to protect the watershed.

Similarly in case of water bodies, its revitalization will not only add to urban aesthetics, for e.g. Pimbahal pond of Patan but can also function as a local climate regulator to minimize the impact of urban heat island effect. In cases of historic areas that are interconnected by narrow alleys that prohibit the access of vehicles like fire brigades these water bodies are reliable sources of water for fire fighting purposes. Such indicators verifying the usefulness of these historic infrastructures in the contemporary society are guiding forces to identify major water infrastructure within the valley and restore them to revitalize the traditional core areas.

The other important aspect of these historic water infrastructures is its sustainable water management system. “The infrastructure development alone can not be sufficient for water management. Values, customs and rituals have equally important role (Khaniya, 2005).” In this

aspect the strategy should focus on reviving the local guthis and committees to ensure the regular maintenance and sustainable use of these infrastructures.

7.1.3.2. Management of Sewerage to prevent direct disposal into river

Total Sewerage Generation

The sewage generation consists of i) Domestic sewage, ii) Non-domestic sewage consisting of industrial and commercial sewage and iii) infiltration. The total quantity of sewage generation is the sum of domestic, non-domestic and infiltration. Based on the population forecast for 2042, total sewerage flow, existing WWTP serving discharge and net inflow (lit/day, after deduction) have been calculated (**Annex IV**). The calculation is made for separate sewerage system (excluding storm water) with following assumptions:

Water consumption rate	120	lpcd
Sewage flow (80% of water consumption)	96	lpcd

Source: KVWMP, KUKL 2022

With the population forecast of 5.89 million, the total sewerage generation in Kathmandu valley service area is 679.11 MLD in 2042 (Table 7-12).

Table 7-12: Total sewerage generation of Local Unit for 2042

Local Unit	Total sewerage generation (MLD)
Kathmandu Metropolitan City	135.59
Lalitpur Metropolitan City	48.07
Bhaktapur Municipality	12.64
Kritipur Municipality	17.15
Madhyapur Thimi Municipality	34.28
Gokarneshwor Municipality	40.97
Budhanilkantha Municipality	54.05
Kageshwari Manohara Municipality	40.10
Trakeshwar Municipality	45.57
Tokha Municipality	34.74
Nagarjun Municipality	34.74
Chandragiri Municipality	41.19
Dakshinkali Municipality	4.32
Shankharapur Municipality	5.89
Changunarayan Municipality	26.65
Suryabinayak Municipality	41.50
Godawari Municipality	22.71
Mahalaxmi Municipality	35.71
Konjyosom Rural Municipality	1.45
Bagmati Rural Municipality	1.79
Total	**679.11**

Following location is proposed for centralized municipal level WWTP based on topography, discharge point and population catchment. DEWATs are recommended within the community level upto 1 MLD capacity as per land availability and topography, which decreses the load in centralized municipal level WWTP. It is recommended that 20% of the sewage generated shall be treated by DEWATs. DEWATs provides the possibility of a nature-based, low-cost and sustainable wastewater treatment.

Table 7-13: Proposed New centralized municipal level WWTP

SN	Municipality	Local Unit Level	Ward No.	Zone	Lat	Long
1	Dakshinkali	Nagarpalika	3	Peri-urban Zone	27.61	85.28
2	Lalitpur	Mahanagarpalika	22	Peri-urban Zone	27.61	85.30
3	Godawari	Nagarpalika	12	Urban Zone	27.62	85.31

SN	Municipality	Local Unit Level	Ward No.	Zone	Lat	Long
4	Godawari	Nagarpalika	14	Urban Zone	27.63	85.35
5	Kirtipur	Nagarpalika	6	Peri-urban Zone	27.65	85.29
6	Mahalaxmi	Nagarpalika	5	Urban Zone	27.66	85.36
7	Mahalaxmi	Nagarpalika	2	Urban Zone	27.67	85.34
8	Madhyapur Thimi	Nagarpalika	1	Urban Zone	27.67	85.35
9	Suryabinayak	Nagarpalika	2	Urban Zone	27.67	85.36
10	Kirtipur	Nagarpalika	4	Peri-urban Zone	27.67	85.26
11	Suryabinayak	Nagarpalika	5	Peri-urban Zone	27.67	85.40
12	Changunarayan	Nagarpalika	2	Urban Zone	27.68	85.41
13	Chandragiri	Nagarpalika	15	Urban Zone	27.69	85.27
14	Kageshwori Manahora	Nagarpalika	9	Urban Zone	27.70	85.37
15	Nagarjun	Nagarpalika	9	Urban Zone	27.70	85.28
16	Kathmandu	Mahanagarpalika	16	Urban Zone	27.73	85.31
17	Budhanilakantha	Nagarpalika	9	Urban Zone	27.73	85.35
18	Shankharapur	Nagarpalika	9	Peri-urban Zone	27.73	85.44
19	Tokha	Nagarpalika	9	Urban Zone	27.74	85.31
20	Tarakeshwor	Nagarpalika	4	Urban Zone	27.74	85.30
21	Budhanilakantha	Nagarpalika	6	Urban Zone	27.76	85.34
22	Kathmandu	Mahanagarpalika	11/12	Urban Zone		

Land Requirement for Sewerage Treatment Plant

With the estimation of total sewerage generation in Katmandu valley service area for 2042, the total land requirements for sewerage treatment plants have also been calculated for each Metropolitan City, Municipality and Rural Municipality within the valley (**Annex IV**).

The total land requirement for sewerage treatment plant is estimated to be 76.9 ha (768,768 m^2). WWTP has been proposed based on the topographic features of the land. An assumption has been made to propose at least one WWTP at each municipality. Area required for WWTP has been calculated considering whole municipal population in the forecasted year. Tentative location has been marked in the map, before implementation exact location is to be worked out for further DPR. Land acquire for WWTP is very challenging job at present situation, as per the availability of land small scale WWTP can also be constructed and for the small scale community level on site sanitation like septic tank at house level or community level can also be constructed.

7.1.3.3. Management of Solid waste disposal directly into river system

Following recommendation are proposed for Management of Solid waste disposal directly into river system

i) Discourage dumping of garbage, plastics, construction wastes and other unused items in the rivers through awareness campaigns and strengthening of waste management system.
   - Strengthen waste management system at municipal level

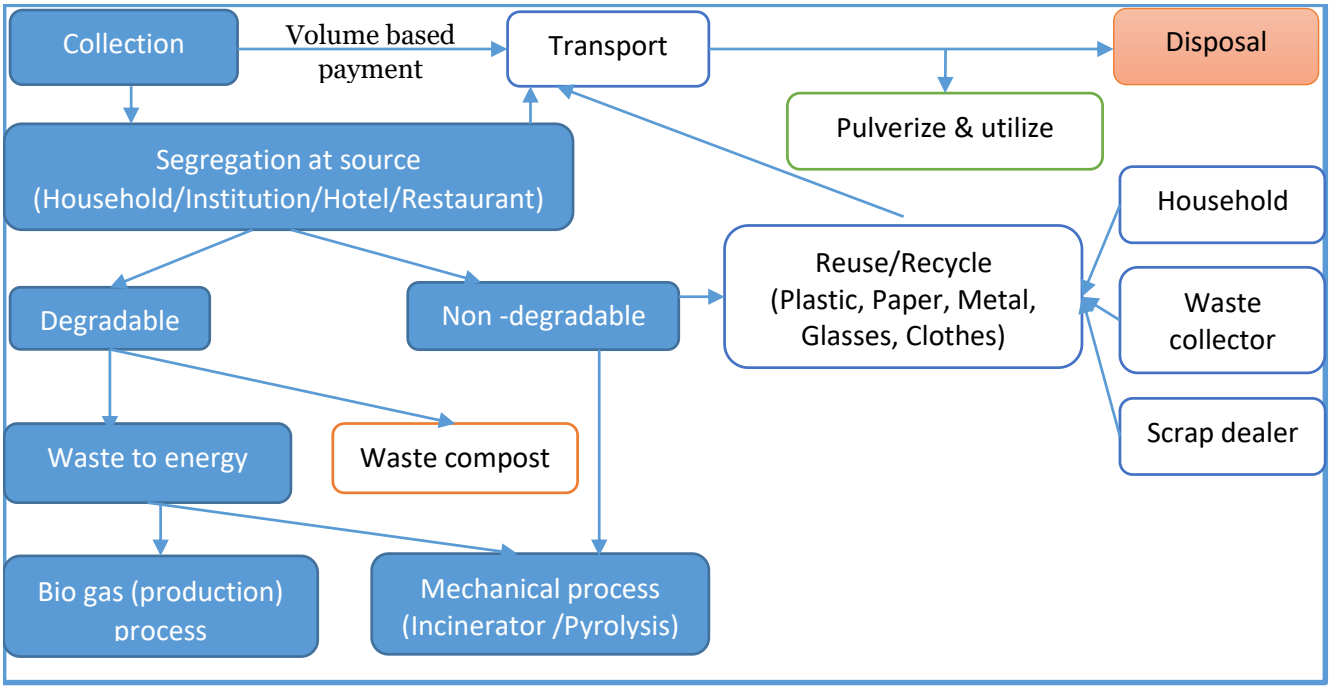


Figure 7-10: General solution for municipal waste management

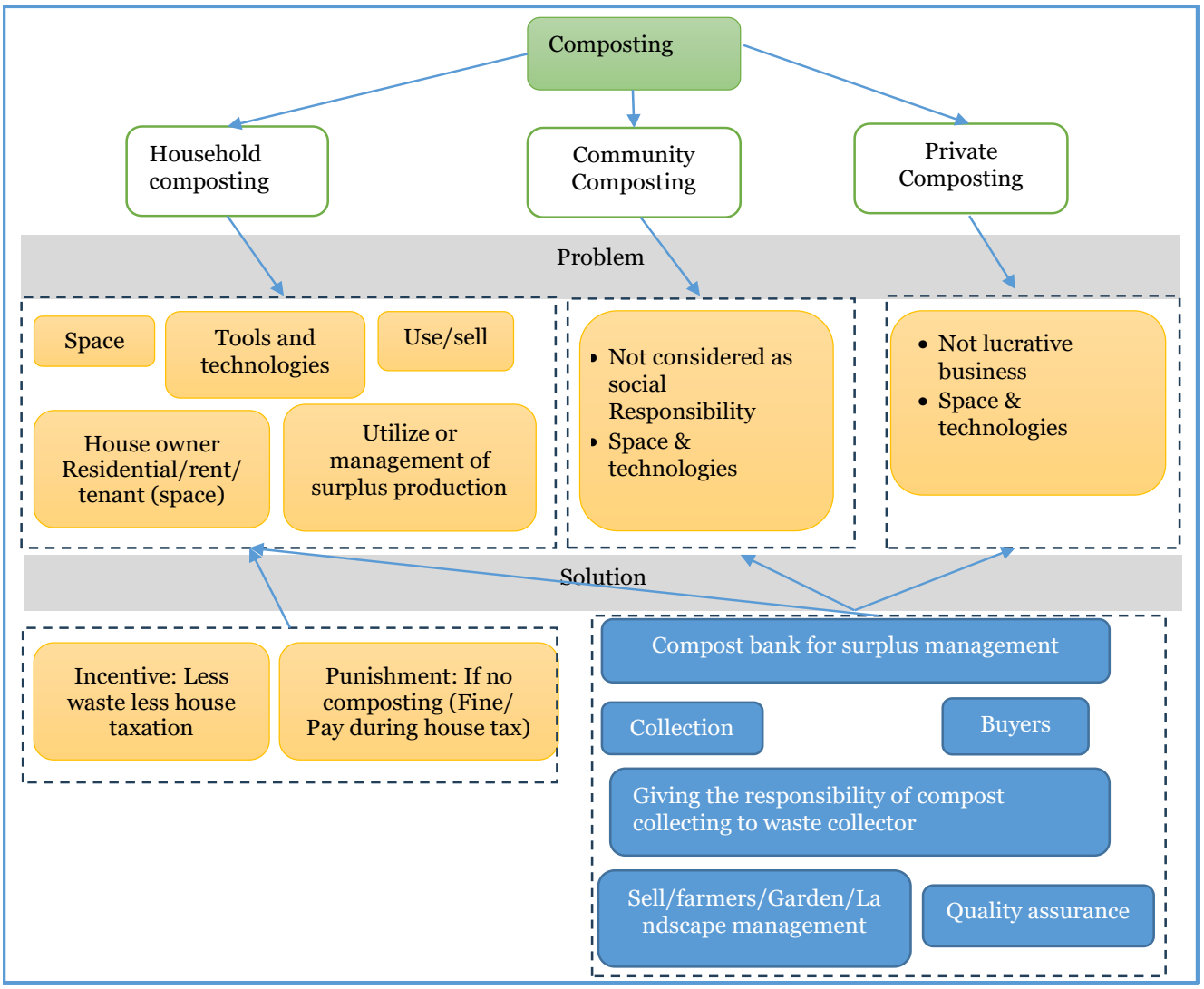


Figure 7-11: Composting technologies

- Promote household and community level waste management system including composting with the involvement of private sector. Adoption of segregation of waste at source. Campaign on "My waste my responsibility".

- Public awareness programs for waste management and avoid discharge of garbage, plastics, construction wastes and other unused items directly into the rivers through creation and activation of different groups as eco-clubs, youth club, women group etc., developing and disseminating advocacy messages and materials. The awareness programs should be conducted periodically at different locations.

ii) Ensure the provision of waste water treatment system for all commercial buildings and housing colonies

iii) Discourage settlement development/expansion in upstream region of Bagmati River and its tributaries. Carry out restoration activities at degraded landscapes.

7.1.4. Capacity building

Following action are recommended for capacity buiding.

1. Knowledge management

- Enhance scientific research/ upgrade technical capacity/recognize the innovativeness of youth in related field of Bagmati Civilization and improvement
- Development curricula on Bagmati Civilization for school level
- Provide research grants in related field of Bagmati Civilization and improvement for graduate and post graduate students
- Establishment of digital database management system
- Support domestic technology development for preservation and conservation of natural cultural heritage of Bagmati

2. Institutional strengthening

- Reduce waste generation through prevention, reduction, recycling, reuse in collaboration with local government
- Training for capacity improvement for procurement, GIS, design & management of infrastructure
- Exposure visit (national/International) for knowledge sharing
- Preparation of urban design guideline for each local government in the valley
- Development and Operation of Assets Management System
- Mid Term review of Bagmati action plan

3. Community Engagement

- Community Meetings: Conduct regular meetings with local communities residing along the Bagmati River to seek feedback, discuss concerns, and involve residents in decision-making processes.
- Awareness Campaigns: Implement awareness campaigns to educate the community about the importance of river cleanliness.
- Formation of Community Groups: Establish community-based groups dedicated to river cleanliness and cultural activities. Provide training on waste management practices and river conservation. Offer incentives, such as recognition or small rewards, for active community involvement in river cleaning initiatives.

4. Ward Office Collaboration

- Joint Planning Sessions: Collaborate with ward offices in the development of a comprehensive plan for river cleaning and cultural activities. These will identify specific roles and responsibilities for both the community and ward offices.
- Resource Mobilization: Work with ward offices to explore potential funding sources and partnerships in mobilizing resources for cleaning tools, waste disposal infrastructure, and cultural event organization.
- Regular Coordination Meetings: Schedule regular coordination meetings between community leaders, residents, and ward office representatives.

- Periodic River Cleaning: Plan regular, scheduled river cleaning events in collaboration with community groups and ward offices and ensure proper waste segregation and disposal.

5. Cultural and Recreational Activities

- Community Festivals: Organize cultural festivals and events along the Bagmati River to promote a sense of community and pride. Showcase local talent, traditions, and art.
- Collaborative Events: Foster a sense of community through shared cultural experiences through partnering with local artists, musicians, and cultural groups for collaborative events.
- Public Art Installations: With the involvement of the communities, install public art along the river, showcasing local creativity and promoting cultural identity.
- Communication and Outreach: Use various communication channels to disseminate information about upcoming events, achievements, and ongoing initiatives. For this, both traditional and digital media can be employed for wider reach.

6. Long-term Sustainability

- Capacity Building Programs: Foster a sense of ownership for the sustained success of initiatives through implementing programs for continuous capacity building, empowering community leaders and local authorities.
- Partnerships and Networking: Foster partnerships with NGOs, environmental organizations, and governmental bodies to enhance resources and expertise. Join municipal or valley networks focused on river conservation, shall be formulated.
- Research and Innovation: Encourage research on sustainable practices for river cleaning and community engagement. Also, embrace innovative solutions and technologies to improve the efficiency of initiatives.

7.2. BYLAWS

River channels, riverbank areas, and floodplains are rich ecological areas, providing habitat for a diverse array of birds, fish, plants, and animals. Floodplains are important natural flood storage areas that if left undeveloped, can help prevent flood damages and save lives in the event of a major flood. However, rivers are under considerable development pressure for a variety of uses, including housing developments, dams and hydroelectric facilities, and recreational activities. So, for protection of river control and flood protection assets, bylaws for river need to be developed based on the hydrological study.

From the hydrological study, the minimum waterway width on basis of 50 years period flood has been recommended (Refer Study report). The water width has been calculated from hydrological analysis, so the width of right of way of river has been adopted similar as Bylaws, 2064. But if water width in cadastral is less than proposed water width then the land acquisition is recommended for river and flood protection.

Table 7-14: Proposed waterways and ROW from river edge

S.N.	River Name	River Stretch	Proposed Water Way (m)	ROW from river edge (m)
1	Bagmati Khola	Baghdwar to Nagmati Khola Junction	26.15	20
		Nagmati Khola Junction to Suryamati Khola Junction	45.13	
		Suryamati Khola junction to Manohara Khola Junction	54.74	
		Manohara Khola Junction to Dhobi Khola Junction	118.93	

S.N.	River Name	River Stretch	Proposed Water Way (m)	ROW from river edge (m)
		Dhobi Khola Junction to Tukucha Khola Junction	123.61	
		Tukucha Khola Junction to Bishnumati Khola Junction	124.63	
		Bishnumati Khola Junction to Balkhu Khola Junction	139.90	
		Balkhu Khola Junction to Nakkhu Khola Junction	148.05	
		Nakkhu Khola Junction to Katuwal Daha	157.36	
2	Bishnumati Khola	Origin to Lundi Khola Junction	19.03	20
		Lundi Khola Junction to Sangla Khola Junction	33.36	
		Sangla Khola Junction to Mahadev Khola Junction	44.12	
		Mahadev Khola Junction to Baucha Khola Junction	57.09	
		Baucha Khola Junction to Manamati Khola Junction	60.21	
		Manamati Khola Junction to Bagmati Khola Junction	68.14	
3	Manohara Khola	Origin to Salambu Devi Temple area	36.39	20
		Salambu Devi Temple area to Hanumante Khola Junction	53.30	
		Hanumante Khola Junction to Kodku Khola Junction	94.33	
		Kodku Khola Junction to Bagmati Khola Junction	105.72	
4	Hanumante Khola	Origin to Chakku Khola Junction	29.47	20
		Chakku Khola Junction to Godavari Khola Junction	60.77	
		Godavari Khola Junction to Manohara Khola Junction	80.76	
5	Dhobi Khola	Origin to Jamle Khola Junction	11.89	9
		Jamle Khola Junction to Bagmati Khola Junction	32.43	
6	Suryamati Khola	Origin to Bagmati Khola Junction	26.06	4
7	Nakkhu Khola	Origin to Bagmati Khola Junction	48.60	12
8	Balkhu Khola	Origin to Balambu area	45.45	10
		Balambu Area to Bagmati Khola Junction	55.05	
9	Sangla Khola	Origin to Bishnumati Khola Junction	29.83	10
10	Mahadev Khola	Origin to Bishnumati Khola Junction	31.76	10
11	Chakku Khola	Origin to Hanumante Khola Junction	33.04	4
12	Manamati Khola	Origin to Bishnumati Khola Junction	31.90	4

S.N.	River Name	River Stretch	Proposed Water Way (m)	ROW from river edge (m)
13	Baucha Khola	Origin to Bishnumati Khola Junction	20.74	4
14	Lundi Khola	Origin to Bishnumati Khola Junction	11.32	4
15	Jamle Khola	Origin to Dhobi Khola Junction	8.52	4
16	Tukucha	Origin to Bagmati Khola Junction	19.29	4
17	Kodku Khola	Origin to Manohara Khola Junction	46.78	10
18	Godavari Khola	Origin to Hanumante Khola Junction	49.00	4

Note:

- If water width in cadastral is less than proposed water width then the land acquisition is recommended to maintain water width.
- In case of developed River Channel, if the water width is less than proposed water width then additional 20m set back is required (Supreme Court Decision, 2078/11/29).

Besides the byelaws for Right of River based on hydrological modelling, the byelaws proposed should also address for planning permit and building bye- laws. Some of the issues to be addressed in Planning and Building Byelaws on aspect of conservation and management of Bagmati are mention as below.

- Urban design concept should be studied and introduced in bylaws along river corridor so as to preserve cultural heritage landscape and design.
- Building type generating heavy quantity of solid and liquid waste such and vehicle workshops and garages, industries, hospitals etc should be closely monitored. These types of buildings should have their own waste management system within their premises.
- Plotting permit should be restricted in sloppy land of conservation zone so it supports in water recharge of the valley area.
- Regulate sand/stone/soil (quarry site) mining from KV area.

7.3. ACTION PLAN

7.3.1. Activities/Actions

The activities and actions are proposed for; conservation zone, peri-urban zone and urban zone.

7.3.1.1. Conservation Zone

The strategies and actions for Conservation zone prioritizes ecotourism promotion through cycling/hiking trail; water source conservation; enhance groundwater recharge through rainwater storage/harvesting ponds, water reservoir dams; sustainable landuse management through terrace improvement; promotion of organic farming; relocation of some settlements; gully control and sediment trapping; and reclamation, rehabilitation and preservation of cultural heritages.

Table 7-15: Actions for Conservation zone

Strategy	Sub Strategies	Action	Indicator
River conservation and Management	Promote ecotourism	Study and development of Cycling/Hiking trail along the foot hill of the valley	Cycling Track and Hiking Trail along the foot hill of the valley constructed
		Establishment of waste management services along trekking/cycling routes	Waste management services eastablished along trekking/cycling routes
	Conservation of the land use to recharge water source	Relocation of existing settlement of SNP area - Mulkharka Settlement (187 HH), Thulo/Sano Chilaune (70 HH), Okhreni (167 HH) and Kunegaun (45 HH)	No settlements seen within SNP
		Identify and study the existing settlement within Conservation Zone area and prepare the development modality of identified settlements.	Upgraded the development status/level of Settlement within conservation zone
	Sustainable land use management	Terrace improvement and promote multiyear crop cultivation	Multiyear crop cultivation increased
		Regulate land development/plotting through bylaws	Followed the bylaws by land development/plotting project
		Replacement of pine with broad leave forest 321Ha; Godawari-75 Ha, Hanumante-210 Ha , Nakkhu-23 Ha, Bagmati downstream-13 Ha	Covered by Broad leave forest increased
		Construction of check dams for Gully control	Number of check dams for Gully control increased
		Construction of sediment trapping structures	Number of sediment trapping structures increased
	Disaster mitigation	Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate	Length of River protected and number of Ghat structure increased

Strategy	Sub Strategies	Action	Indicator
Cultural/Civilization Rehabilitation	Reclaim, rehabilitate and conserve the cultural and heritage sites along river	Restoration of cultural monuments and sites including approach trail - Tarkeshwar Mahadev, Bajrayogini, Bagdwar, Vishnu dwar and Mahadev Pokhari	Restored and conserved the cultural monuments and sites
		Revival and preservation of Historic Manichud daha, Shankharapur including associated features	Historic daha revived
	Preservation of intangible heritage	Revival and preservation of cultural trails (Sundarijal to Bagdwar, Kotval daha trail, Sankhu to Bajrayogini to Manichud daha, Mahadev Pokhari - Nagarkot trail and Tarkeshwar Mahadev trail	Cultural trails functioned and preserved
River/Water Quality and Quantity Improvement	Encourage organic farming	Promote/encourage urban organic farming through production based subsidy	Urban organic farming increased
		Discourage chemical fertilizer and chemical pesticide with alternatives	Used organic fertilizer
	Conservation and management of water sources	Construction of rain water storage/ harvesting ponds	Number of rain water storage/ harvesting ponds constructed
		Implementation of Nagmati Multipurpose dam Project	Complted the Nagmati Multipurpose dam Project
		Development of Water reservoir dam and water retaining ponds/reservoir	Number of Water reservoir dam and water retaining ponds/reservoir constructed
		Salix plantation along river banks and dhap areas	Length of Salix plantation increased
		Conservation and management of existing water sources	Existing water sources protected

7.3.1.2. Peri-urban Zone

The strategies and actions for Peri-Urban zone prioritize river cleaning; management of public land; enhance water recharge; promotion of organic farming; implementation of Right of River Way to conserve river area; river training works with bioengineering; development of corridor transport system along rivers; management of Sewerage to prevent direct disposal into river through construction of interceptors and WWTPs; control of direct disposal of solid waste into river by strict law implementation; sustainable landuse management; and reclamation, rehabilitation and preservation of cultural heritages.

Table 7-16: Actions for Peri-Urban zone

Strategy	Sub Strategies	Action	Indicator
River conservation and Management	Strengthen River Cleaning Program	Periodic cleaning of rivers	Solid waste and sludge reduced in river
		Mass movement for cleaning campaign in collaboration with local government and community	Activities of cleaning campaign increased

Strategy	Sub Strategies	Action	Indicator
		Promote corridor walkathon in each river	Corridor walkathon route and infrastructure developed
	Management of Public Land along the River Corridor	Verification and Inventory of illegally encroached land along river banks	Illegally encroached land along river banks recorded
		Relocation of verified squatters of squatter settlement - Khandpakha, Palpakot, Narayanthan, Maijubahal, Khadgabhadrakali, Mandikhatar, Ramhiti along the river bank	Number of squatters resettled and managed
		Establish and maintain Child friendly park along River (Open Space & greenery management)	Number of Child friendly park constructed
		Establish and maintain Youth Friendly Park along river (with Gym equipment)	Number of Youth friendly park constructed
		Establish and maintain Old age friendly park along River (Open Space with Yoga facility)	Number of Old age friendly park constructed
		Salix plantation along river corridor area	Length of Salix plantation increased
	Disaster mitigation	Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate	Length of River protected and number of Ghat structure increased
	Sustainable land use management	Construction of sediment trapping structures	Number of sediment trapping structures constructed
		Promote alternative practices to surface water irrigation	New practices for surface water irrigation observed
	Development of corridor transport system along rivers	Construction of pedestrian and environment friendly smart corridor road network (about 151 km) including road furniture and junction improvement along rivers beyond Proposed Waterway	New pedestrian and environment friendly river road corridor constructed Mobility increased
		Upgrading of existing corridor road network (about 25 km) to pedestrian and environment friendly smart corridor road including road furniture and junction improvement	All existing river road corridor upgraded to pedestrian and environment friendly with high mobility
		Construction of Universal Smart pedestrian bridges at maximum 500m interval in Bagmati River (27),	Number of of Universal Smart pedestrian bridges constructed

Strategy	Sub Strategies	Action	Indicator
		Bishnumati River (1), Hanumante River (1), Nakhu Khola (8), Balkhu Khola (3), Manahara Khola (15), Khodku Khola (2), Mahadev Khola (1), Godawari Khola (2), Manamati Khola (3), Sangle Khola (3), Suryamati Khola (3)	
Cultural/Civilization Rehabilitation	Reclaim, rehabilitate and conserve the cultural and heritage sites along river	Restoration of cultural monuments and sites including approach trail	Number of cultural monuments and sites restored
		Development of Ghat and Bhakari including metal chain using traditional construction technology beyond the proposed waterway with conserving the existing monuments and sites	Number of Ghat and Bhakari constructed
		Construction of small dam across the river for storage of water of river surface for ritual activities at Salinadi (Madhav Narayan Temple Bank)	Small dam across the river constructed at Salinadi
	Preservation of intangible heritage	Revival, upgradation and management of Jatra route linking the monument with river, arrangement of physical structures for facilitating the Jatras (Changunarayan Chinnamasta Jatra; Rato Machindranath Jatra - Kotval daha; 12 year festival chariot festival; Tika bhairav jatra)	Number of Jatra route restored
		Revival and preservation of cultural trails	Number of cultural trails restored
		Identification, development, implementation of Master plan of cultural landscape to preserve the historic city plan- Tika bhairav to Lele and Chapagaon, Sankhu to Bajrayogini	Cultural landscape restored
River/Water Quality and Quantity Improvement	Management of Sewerage to prevent direct disposal into river	Construction of separate sewerage Treatment System including interceptor network in different location as per topography and load	Number of separate sewerage Treatment System including interceptor network constructed
	Management of Solid waste disposal directly into river system	Establishment of Control system with installation of CCTV along river corridor	Control system with installation of CCTV established
		Installation of soild waste collection netting across into river at 1km interval	Number of netting across into river for soild waste collection installed

Strategy	Sub Strategies	Action	Indicator
	Encourage organic farming	Promote/encourage urban organic farming through production based subsidy	Urban organic farming increased
		Discourage chemical fertilizer and chemical pesticide with alternatives	Organic fertilizer used
	Conservation and management of water sources	Construction of rain water storage/ harvesting ponds	Number of rain water storage/ harvesting ponds constructed
		Development of Water reservoir dam along rivers and water retaining ponds/reservoir	Number of Water reservoir dam along rivers and water retaining ponds/reservoir constructed
		Conservation of water recharge zone of existing water sources	water recharge zone of existing water sources conserved
		Revival and preservation of Historic/traditional ponds	Number of Historic/traditional pond rehabbed
		Revival and preservation of dhungedhara	Number of dhungedhara rehabbed
		Revival and preservation of Raj kulo (Kathmandu, Bhaktapur, and Lalitpur)	Length of Raj kulo rehabbed
		Support and participation of local communities in improving water use efficiency	Water recharge zone conserved
		Promote rainwater harvesting and reverse boring at institutional and household level	Increased number of household with rainwater harvesting and water recharge

7.3.1.3. Urban Zone

The strategies and actions for Urban zone prioritize river cleaning; green development with recreational facility along river corridor; implementation of Right of River Way to conserve river area; river training works with bioengineering; development of corridor transport system along rivers; management of Sewerage to prevent direct disposal into river through construction of interceptors and WWTPs; control of direct disposal of solid waste into river by strict law implementation; sustainable landuse management; and reclamation, rehabilitation and preservation of cultural heritages.

Table 7-17: Actions for Urban zone

Strategy	Sub Strategies	Action	Indicator
River conservation and Management	Strengthen River Cleaning Program	Periodic cleaning of rivers	Solid waste and sludge reduced in river
		Mass movement for cleaning campaign in collaboration with local government and community	Activities of cleaning campaign increased
		Promote corridor walkathon in each rivers	Corridor walkathon route and infrastructure developed

Strategy	Sub Strategies	Action	Indicator
	Management of Public Land along the River Corridor	Salix plantation along river corridor area	Length of Salix plantation increased
		Establish and maintain Child friendly park along River (Open Space & greenery management)	Number of Child friendly park constructed
		Establish and maintain Youth friendly park along River (with Gym equipment)	Number of Youth friendly park constructed
		Establish and maintain Old age friendly park along River (Open Space with Yoga facility)	Number of Old age friendly park constructed
		Verification and Inventory of illegally encroached land along river banks (P1)	Illegally encroached land along river banks recorded
		Relocation of verified squatters along the river bank Kuriyagaun, Sankhamul, Bansighhat, Thapathali, Balkhu, Pragati Tole, Chandani Tole, Sinamangal (Mahabir Galli), Jagriti Nagar, Gairigaun, Shanti Nagar, Dhirghyau Tole, Airport Gairigaun, Buddha Jyoti Marga, Jagriti Tole, Maoohara, Palpakot, Pathivara, Bishalnagar, Kalopul, Devi Nagar, Shanti Binayak, Anamnagar etc(P1)	Number of squatters resettled and managed
	Sustainable land use management	Construction of sediment trapping structures	Number of sediment trapping structures constructed
	Disaster mitigation	Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate	Length of River protected and number of Ghat structure increased
	Development of corridor transport system along rivers	Construction of pedestrian and environment friendly smart corridor road network (about 103 km) including road furniture and junction improvement along rivers beyond Proposed Waterway	New pedestrian and environment friendly river road corridor constructed No traffic congession at junction
		Upgrading of existing corridor road network (about 25 km) to pedestrian and environment friendly smart corridor road including road furniture and junction improvement	All existing river road corridor upgraded to pedestrian and environment friendly with high mobility
		Construction of Universal Smart pedestrian bridges at maximum 500m interval in Bagmati River (11), Bishnumati River (1), Hanumante River (4), Nakhu Khola (16),	Number of of Universal Smart pedestrian bridges constructed

Strategy	Sub Strategies	Action	Indicator
		Manahara Khola (13), Khodku Khola (3), Godawari Khola (1), Manamati Khola (1)	
		Improvement of Junctions of Bishnumati River Corridor Road at Nayabazaar, Gongabu, Baniyatar, Paropakar; Dhobi Khola Corridor Road at Bijulibazaar, Chabahil; Nakhu Khola Corridor Road at Nakhudole; Khodku Khola Corridor Road at Hattiban; Hanumanre River Corridor Road at Madhyapur Thimi	Mobility increased
		Installment of Traffic Sign, Signal, information Board along corridor road network	Mobility increased
Cultural/Civilization Rehabilitation	Reclaim, rehabilitate and conserve the cultural and heritage sites along river	Restoration of cultural monuments and sites including approach Trail	Number of cultural monuments and sites restored
		Reconstruction of lost monuments - Shankhamul	Lost monuments of Shankhamul restored
		Development of Ghat and Bhakari including metal chain using traditional construction technology beyond the proposed waterway and conserving the exisiting monuments and sites	Number of Ghat and Bhakari constructed
		Feasibility study and Development of traditional cremation site and necessary infrastructure - as per demand to minimize the pressure in Bhasmeshwar ghat, Pashupati khetra	Traditional cremation site constructed
		Pedestrian Bridge construction (Nakhu dovan) for ritual procession	Pedestrian Bridge consrtructed at Nakhu dovan
		Preservation of historic bridges (Jalbinayak gorge bridge, Sundari Ghat Bridge, Teku kalo pul, Kori tafu-Khokana, Koteshwor Mahadevsthan, kankeshwari bridge)	Historic bridges preserved and maintained
		Construction of small dam across the river for storage of water of river surface for ritual activities at Shankhamul Ghat area; Thapathali-Teku Dovan; Brahmayani temple ghat- Dhum Barahi temple ghat (Mangal Tirtha); Guheshwori - Pashupati; Shova Bhagwati temple - Teku dovan	Number of Small dam across the river constructed

Strategy	Sub Strategies	Action	Indicator
		Implementation of Pashupati Master Plan	Infrastructure developed within Pashupati area as per master plan
	Preservation of intangible heritage	Revival, upgradation and management of Jatra route linking the monument with river, arrangement of physical structures for facilitating the Jatras - Rato Machindranath Jatra - Nakhu dovan, , Kankeshwari Jatra, Bijeshwari 12 year jatra, Madhav narayan jatra, Hanuman ghat	Number of Jatra route restored
		Revival and preservation of cultural trails	Number of cultural trails restored
		Identification, development, implementation of master plan of cultural landscape to preserve the historic city plan - Shankhamul to Kumbeshwor area, Kankeshwari to Yatkha area, Dhum barahari to Bhaktapur darbar square, Pashupati to Siphal, Gokarneshwor temple to Gokarneshwar village, Balkumari to Tyagal Patan, Shobabhagwati to Swayambhu	Cultural landscape restored
River/Water Quality and Quantity Improvement	Management of Sewerage to prevent direct disposal into river	Construction of separate sewerage Treatment System including interceptor network in different location as per topography and load	Number of separate sewerage Treatment System including interceptor network constructed
		Construction of WWTP at Teku Dovan	Complete constructed WWTP at Teku Dovan
		Construction of WWTP at Kodku	Complete constructed WWTP at Kodku
		Construction of WWTP at Gokarna	Complete constructed WWTP at Gokarna
		Construction of WWTP at Humumanghat	Complete constructed WWTP at Humumanghat
	Management of Solid waste disposal directly into river system	Establishment of Control system with installation of CCTV along river corridor	Control system with installation of CCTV established
		Installation of soild waste collection netting across into river at 1km interval	Number of netting across into river for soild waste collection installed
	Conservation and management of water sources	Conservation of water recharge zone of existing water sources	Water recharge zone conserved
		Revival and preservation of Historic ponds including associated features like well, Jahru, shrines	Number of Historic/traditional pond rehabbed

Strategy	Sub Strategies	Action	Indicator
		Revival and preservation of Raj kulo (Kathmandu, Bhaktapur, and Lalitpur)	Length of Raj kulo rehabbed
		Revival and preservation of dhungedhara	Number of dhungedhara rehabbed
		Promote rainwater harvesting and reverse boring at institutional and household level	Increased number of household with rainwater harvesting and water recharge

7.3.1.4. Other General Action

Certain activities which are valid in all the zones are included as general activities. These activities are either common or associated with knowledge management that will help to build the capacity of HPCIDBC and other agencies and bolster the restoration and conservation of Bagmati River and its tributaries.

Table 7-18: General actions for strengthening implementation of action plan

Strategy	Sub Strategies	Action	Indicator
River conservation and Management	Sustainable land use management	Amendment of bylaws and endorsement	Amended bylaws and endorsed for preservation of RoR, management of building use, sewerage management, maintaining river water quality, rain water harvesting and sustainable land use practices within valley
		Promotion and support sustainable land management in valley	Sustainable land management project increased
	Management of Public Land along the River Corridor	Reclaim the encroached land along Rivers	Land encroached decreased
		Preparation of master Plan for Preserve and restore river course to minimize flood hazard impact	Master Plan for Preserve and restore river course to minimize flood hazard impact prepared
	Disaster mitigation	Conduct impact assessment of river corridors development (within RoR)	Impact assessment of river corridors development prepared
		Establishment of water gauge station	Number of water gauge station increased
		Installation of flood EWS based on citizen science based model for flood hazard in all study river	Number of flood EWS based on citizen science based model for flood hazard installed
		Detailed Study for implementation of proposed RoR	
Cultural/Civilization rehabilitation	Reclaim, Rehabilitate and conserve the cultural and	Detail documentation and publication of tangible and intangible heritage	Document of tangible and intangible heritage published
		Preparation of river front Urban design guidelines for Kathmandu valley	River front Urban design guideline prepared
		Training to produce skilled manpower for	Skilled human resource available

Strategy	Sub Strategies	Action	Indicator
	heritage sites along river	a) Production of traditional materials and tools	
		b) Traditional carvings and construction works	
River/Water Quality and quantity improvement	Management of Solid waste disposal directly into river system	Establishment of Control system for CCTV	Control system with installation of CCTV established
		Establishment of structure of Bagmati Police and development of mechanism for operation	Bagmati Police operated
		Study and coordinate for implementation of relocation of waste transfer station from river corridor area	Waste transfer station relocted from river corridor area
		Coordinate with municipalities for promotion of HH level waste management	Decreasing percentage of organic solid waste at landfill site
		Establishment of Vehicle washing center at entry point of KV especially for truck	Vehicle washing center established at entry point of KV
	Management of Sewerage to prevent direct disposal into river	Monitoring and implementation of septic tank at Residential Level	On site sanitation level improved
		Monitoring and implementation of waste water treatment in industries, hotel, hospital and Colony level	Waste water treatment in industries, hotel, hospital and Colony level improved
	Water source conservation to Increase ground water recharge and river discharge	Monitoring and implementation of water infiltration well/system in all institutions	Number of water infiltration well/system increased
		Monitoring and implementation of rain water harvesting system in all institutional buildings and promotion to residential buildings	Number of rain water harvesting system increased
		Mapping and reclaim encroached water sources area	Encroached water sources area preserved
		Detail documentation of Rajkulo with Kathmandu Valley	Detail documentation of Rajkulo prepared
	Strengthening river quality monitoring system	Establishment of real time monitoring system in all 19 tributaries of Bagmati river system	Real time monitoring system established
		Development of quick response mechanism for pollution management and implementation	Quick response mechanism for pollution management developed
Capacity building	Knowledge management	Enhance scientific research/ upgrade technical capacity/recognize the innovativeness of youth in related field of Bagmati Civilization and improvement	Number of scientific research increased in related field
		Development curricula on Bagmati Civilization for school level	Bagmati Civilization topic studied in school level

Strategy	Sub Strategies	Action	Indicator
		Provide research grants in related field of Bagmati Civilization and improvement for graduate and post graduate students	Number of research grants for graduate and post graduate students increased
		Establishment of digital database management system	Digital database management system established
		Support domestic technology development for preservation and conservation of natural cultural heritage of Bagmati	Improved doomestic technology and implemented
	Enhance community participation in BAP implementation	Establish and capacitate ward-level community organization along the river corridor	Strengthen the ward-level community organization along the river corridor
		Develop up-stream and downstream linkages	Interaction between up-stream and downstream increased
		Increase community participation and ownership in asset management and development activities	Community participation increased
	Institutional strengthening	Reduce waste generation through prevention, reduction, recycling, reuse in collaboration with local government	Decreasing percentage of organic solid waste at landfill site
		Training for capacity improvement for procurement, GIS, design & management of infrastructure	Skilled human resource for procurement, GIS, design & management of infrastructure increased
		Exposure visit (national/International) for knowledge sharing	Number of Exposure visit done
		Preparation of urban design guideline for each local government in the valley	Urban design guideline for each local government in the valley prepared
		Development and Operation of Assets Management System	Assets Management System operated
		Mid Term review of Bagmati action plan	Mid Term review report prepared
		Updating the Bagmati action Plan	Bagmati action Plan updated

7.4. INVESTMENT PLAN

The activities and actions are proposed under three broad sectors; River Conservation and Management, Cultural/Civilization Rehabilitation and River/Water Quality and Quantity Improvement. Certain activities which are valid in all the zones are included as general activities. For effective implementation, the activities/action and budget are grouped in short-term (0-5 years), first mid-term (6-10 year), second mid-term (11-15 year) and long-term (16-20 year) periods. The implementation of proposed activities require 147,580 million NPR in short term, 65,996 million NPR in first mid-term, 51,401 million NPR in second mid-term and 14,487 million NPR in long-term implementation period. The total tentative budget required for twenty year action plan is 279,605million NPR. Zone-wise implementation of proposed activities requires about 121,934 million NPR for Conservation Zone; 46,132 million NPR for Peri-Urban Zone; 110,421 million NPR for Urban Zone and 1,115 million NPR for general projects. Detailed budget summary is presented in Table **7-19**. The detail investment plan is attached in annex.

Table 7-19: Investment Plan for 20 years

S. N.	Activities/Plan	Periodical Target (Budget in 000)				Total (NRs.)
		0-5	5-10	10-15	15-20	
A	**Conservation Zone**					
	River conservation and Management	3,699,050.00	1,393,275.00	1,427,725.00	26,225.00	6,546,275.00
	Cultural/Civilization rehabilitation	130,000.00	32,500.00	22,500.00	22,500.00	207,500.00
	River/Water Quality and quantity improvement	79,648,000.00	21,523,000.00	14,010,000.00	-	115,181,000.00
	Sub Total	**83,477,050.00**	**22,948,775.00**	**15,460,225.00**	**48,725.00**	**121,934,775.00**
B	**Peri-Urban Zone**					
	River conservation and Management	10,310,000.00	11,091,000.00	8,930,000.00	3,080,000.00	33,411,000.00
	Cultural/Civilization rehabilitation	305,000.00	283,000.00	535,000.00	515,000.00	1,638,000.00
	River/Water Quality and quantity improvement	2,126,715.65	2,132,427.65	5,485,962.69	1,338,634.11	11,083,740.10
	Sub Total	**12,741,715.65**	**13,506,427.65**	**14,950,962.69**	**4,933,634.11**	**46,132,740.10**
C	**Urban Zone**					
	River conservation and Management	27,811,333.33	9,698,333.33	875,000.00	80,000.00	
	Cultural/Civilization rehabilitation	8,814,166.67	3,934,166.67	997,500.00	627,500.00	14,373,333.33
	River/Water Quality and quantity improvement	14,230,699.30	15,682,772.10	18,990,505.98	8,679,833.66	57,583,811.04
	Sub Total	**50,856,199.30**	**29,315,272.10**	**20,863,005.98**	**9,387,333.66**	**110,421,811.04**
D	**General**	585,889.47	255,336.84	157,336.84	117,336.84	1,115,900.00
	Sub Total	**585,889.47**	**255,336.84**	**157,336.84**	**117,336.84**	**1,115,900.00**
	Total	**147,660,854.42**	**66,025,811.59**	**51,431,530.51**	**14,487,029.62**	**279,605,226.14**

7.6.1. Programs/Projects for Short-Term

In the short-term, implementation of projects and programs require 83,477 million NPR in Conservation zone, 12,741 million NPR in Peri-Urban zone, 50,856 million NPR in Urban zone and 585 million NPR for general projects. Majority portion of short-term activities are focused with Conservation area in catchment improvement and conservation of water sources. The activities in Peri-Urban and Urban Zone are associated with green open space, road development, rehabilitation of monuments, and water treatment activities.

7.6.2. Programs/Projects for First Mid-Term

For the implementation of projects and programs within first mid-term period there requires 22,948 million NPR in Conservation zone, 13,506 million NPR in Peri-Urban zone, 29,315 million NPR in Urban zone and 255 million NPR for general projects. Large portion of first mid-term activities are focused with urban zone in corridor development, rehabilitation of monuments, and water treatment activities. The activities associated with Peri-urban are river cleaning, water treatment and enhancing water recharge while activities in Conservation zone are landuse management and catchment improvement.

7.6.3. Programs/Projects for Second Mid-Term

Implementation of projects and programs within second mid-term period requires about 15,460 million NPR in Conservation zone, 14,950 million NPR in Peri-Urban zone, 20,863 million NPR in Urban zone and 157 million NPR for general projects. Second mid-term activities centralize around activities in urban zone that will focus continuously in implementation of cleaning and water treatment related activities.

7.6.4. Programs/Projects for Long-Term

For long-term time interval, projects and programs implementation requires about 48 million NPR in Conservation zone, 4,933 million NPR in Peri-Urban zone, 9,387 million NPR in Urban zone and 117 million NPR for general projects. Long-term activities centralize around activities in Urban and Peri-Urban zone that will focus on maintaining cleaning and water treatment related activities.

CHAPTER-VIII

8. IMPLEMENTATION PLAN

8.1. IMPLEMENTATION STRATEGY AND MONITORING PLAN

The long-term stability of the efforts of Bagmati Action Plan can be ensured through planning and implementation but there is also a range of administrative, management and other supporting elements. For example, by ensuring long-term revenue streams to maintain or refresh capital works, by establishing appropriate institutional arrangements to ensure alignment with long-term development plans, and through regulatory arrangements that protect the gains made through actions and avoid undermining of those efforts through ecologically harmful practices within the river system.

Administrative, management and other supporting elements beyond the technical and practical aspects of developing and implementing the Bagmati Action Plan includes:

- Policies and laws to define the overarching objectives and principles for actions, as well as to provide a head of power for certain actions
- Institutional arrangements to establish the mandate and accountability for action plan, and to coordinate between different institutions
- Stakeholder engagement to ensure different views are considered as part of the planning process and to strengthen political support, at all levels, for action
- Funding to ensure that the financial resources are available to support implementation as well as to manage ongoing costs
- Science, monitoring and research to provide a basis for rational decision making, as well as to assess compliance and impact (through monitoring) and to support adaptive management
- Tools for giving effect to elements of the action plan's strategy, particularly through regulatory controls and other planning systems.

The implementation strategies for the Bagmati Action Plan are broadly categorized under the following headings:

8.1.1. Activities and Milestones

Study has provided number of activities to achieve goal in next twenty years. These activities are bounded with time frame and target indicator. It is expected that with minimum hurdle these activities will be completed smoothly, though there can appear problems which may hider speed of execution. It is expected that HPCIDBC will meet each target projected but in case of unforeseen obstacle study suggest to analyze reasons behinds; budget deficiency, political/social obstacle, legal conflict, and other, in periodic meeting, so that impact of such obstacle can be minimized in coming years.

8.1.2. Role and Responsibilities

There are different governmental, non-governmental and civil society organizations, and other stakeholders working in restoration, enhancement and management of Bagmati River and its tributaries. HPCIDBC is the institution with strong legislative power and the most capable

institution for planning, policy and decision-making and also for controlling and regulating activities in the Bagmati River and its tributaries. Ministry of Physical Infrastructure and Transport, Ministry of Forests and Environment, Ministry of Federal Affairs and General Administration, Department of Urban Development and Building Construction, Department of Land Management and Archive, Department of Archeology, Department of Water Induced Disaster Prevention, KVDA, KUKL, Department of Water Supply and Sewerage Management, Department of Water Resources and Irrigation, WECS, Shivapuri Nagarjun National Park, Pashupati Area Development Trust, Kathmandu Valley Water Supply Management Board, Melamchi Water Supply Board are among other government line agencies that are implementing many activities which help in protecting river ecosystem. Besides, the local governments of Kathmandu valley, User committees and community based organizations, NGOs and private sectors are also among the stakeholders working for the improvement of rivers in Kathmandu valley.

For the effective implementation of the Bagmati Action Plan:

- All these stakeholders should have strong coordination and collaboration and role of the each should be defined to avoid conflict and duplication of works and optimize the resources.
- All the stakeholders must be involved in an integrated and coordinated fashion both during the planning and implementation of activities.

Roles of different agencies working for improvement of rivers in the valley have to be specified clearly to avoid conflict and duplication of the work and optimizing the resources. Agencies identified as potential stakeholders and their roles for implementation of the action plan are presented below.

Table 8-1: Working agencies and role & responsibilities

Agencies/ Institutions	Role and responsibilities
Municipalities	• Coordination with local stakeholders and political groups for implementation of action Plan • Review, Supervision & monitoring • Implementing efficiently the laws, bylaws and codes that could help directly or indirectly the river ecosystems in the valley • Manage the solid waste and waste water generating within local unit, which impact in the river environment through awareness campaigns and strengthening of waste management system • Discourage settlement development/expansion in upstream region of Bagmati River and its tributaries. • Regulate & monitoring the sand/stone/soil (quarry site) mining
Pashupati Area Development Trust	• Develop and implement the Master Plan of Pashupati area incorporating the Bagmati action Plan • Management of cremation waste and other generating waste within Pashupati area • Review, Supervision & monitoring • Coordination with stakeholders for implementation of Master Plan aligned with Bagmati action plan
KVDA	• Implementation of comprehensive master plan of KV aligned with Bagmati action plan • Review, Supervision & monitoring • Coordination with stakeholders for implementation of Master Plan aligned with Bagmati action plan

Agencies/ Institutions	Role and responsibilities
	• Development of riverfront spaces for recreational and other public activities, with disaster management aligned with Bagmati action plan
Kathmandu Upatyaka Khanepani Limited (KUKL)	• KUKL should follow the norms and regulations for using water from rivers and groundwater so that impact of use of such natural resources has minimum impact in the river ecosystem. • KUKL should also manage sewerage network and make sure the waste water discharge into the river should meet the national quality standard. • KUKL should develop, operate and maintain major waste water treatment systems in the valley
NGOs and private sector	• NGOs and private sector can play significant roles in activities such as awareness campaing, community based waste management, cleaning campaing, plantation, protection of river side cultural and heritage, management of parks and other public utilities along the river banks
Shivapuri National Park (SNP)	• SNP's role should be implementing activities identified by action plan inside SNP's area. These activities are the activities concerned to water discharge increment, protecting and maintaing biodiversity, managing waste produce by tourists and picnikers and settlements inside the national park, etc.
Local guthis and committees	• Regular maintenance, sustainable use and conservation of tangibal and intangitable heritage.

8.1.3. Promotion Strategy for Private Sector and Civil Society

Private sector had proved itself more efficient globally in management of project and effective service delivery. By involving private sector investment, it can improve operating efficiency through new technologies, innovation and transparency in organizational structures. Private sector investment guided by the motto of the profit making, so not all projects are suitable for public private partnership (PPP). There should exist specific conditions that entice private sector to deliver infrastructure assets and provision of services. But when private sector involve in execution of the project, historically it is found that efficiency and transparency procured. In other word it can be said that the benefits of involving the private sector in the delivery of infrastructure includes (i) efficient use of the resources, (ii) improved asset and service quality, (iii) improved public sector management, and (iv) overall improvement in public sector procurement. (ADB 2012). In the present state of government responsibility, role of private sector is inevitable for development activities in the society. To increase the role of PPP, investment activities have proposed as:

- PPP model can be implemented in development and operation of Sewerage treatment plant and multipurpose reservoir/storage project, or operational management contract method can be best suitable for this type with ownership to public sector. Private sector can be given incentives of tax exemption of 10% and benefit sharing of 80-20%.
- Open public spaces can be given on lease for 10-30 years to private sector to develop multipurpose parks etc. depending on the location.
- Small scale projects can be given to community level for development and operation

8.1.4. Budget

Tentative budget for activities implementation are proposed in the report, though actual investment only can be realize after real field scenario. As HPCIDBC has been working with unpredicted annual budget size, and similar activities also executed by other development partners (municipalities, NGOs, KUKL, KVDA, DWRI, DECS, Archeological department, etc.) in

such situation it can execute activities in partnership with sustainable budgets. In the long term all projects are handover to line agencies, it also can development partnership with stakeholder from implementation phase. However, international source of fund are unstable, but they also can contribute for the development of projects selected.

8.1.5. Monitoring and Reporting

Monitoring against defined and measurable objectives is critical for assessing the effectiveness of river restoration and conservation measures and for guiding adaptive management. Monitoring programs should validate (or disprove) the scientific assumptions that underpin the restoration and conservation strategy and should provide evidence about whether the projects have been successful. Monitoring should be built into the design of river restoration and conservation.

Projects at the start, and monitoring should begin at an appropriate time period before restoration and conservation actions begin. An appropriate scale of monitoring that will detect the impacts of actions over a relevant timeframe is required and should continue long after the actions have been completed.

The monitoring and evaluation plan should always refer to the overall objectives of the river restoration and conservation project or program, to specific strategies (including theories of change) and to details of specific measures that will be conducted. The key feature of any plan is the list of what is being monitored, how that monitoring is to take place, who is responsible for undertaking the monitoring and the frequency and time-scale over which monitoring should happen. Typically, a monitoring plan will provide a table of proposed locations, dates and methods of data collection.

The monitoring plan should consider the following:

- **Baseline Monitoring:** Characterizes the existing physical, ecological and socio-economic conditions for planning or future comparison
- **Activity Monitoring:** Determines if project was implemented as planned
- **Financial Monitoring:** Helps to assess cost-effectiveness and value for money and facilitates accountability
- **Impact Monitoring:** Determines if actions had desired effects on priority areas, river function, river health and catchment processes; and whether the hypothesized cause and effect relationship between action and response were correct
- **Surveillance Monitoring:** Determines changes in conditions over time, including changes not attributable to river rehabilitation

Regular monitoring is required from the concerned authorities and similarly feedbacks to the implementers. HPCIDBC must take the responsibility for overall monitoring. Besides, a participatory or joint monitoring system can be established where representatives from concerned stakeholders participate and monitor the programme. This report provides only the means of verification for the activities and actions proposed for Bagmati Action Plan. For effectiveness each implementing agencies have to prepare their own monitoring plans.

8.1.6. Strategy Review and Adaptation

Study has provided implementation strategies for next twenty years, if there will be minimal change in political, socio-economic and technological scenario within the country. Generally plan documents are reviewed at fiver year interval, but here due to multi-stakeholder participation, short term review can be conducted between two and three year. Technology has been creating remarkable differences in saving cost and time of project implementation globally, so latest verified technological adaptation are also suggested for each term plan review.

8.2. INSTITUTIONAL DEVELOPMENT PLAN

The plan identifies the needs for HPCIDBC to be responsible for monitoring activities taking place in and around the Bagmati River and its tributaries. However, strengthening of HPCIDBC

is important to achieve this priority. The plan recommends reforming the existing organizational structure of HPCIDBC to address the issues and activities highlighted in the plan.

8.2.1. Proposed Institutional Structure

HPCIDBC is an authorized organization for the implementation of activities for conservation and development along Bagmati and its tributaries for the preservation of Bagmati civilization. Institution has been working for the improvement of the river water quality and quantity and at the same time preservation of monuments & heritage along river banks since it was established. Due to existence of multiple development partners and line agencies, conflict of right between multiple stakeholder's hindered smooth implementation & operation of projects, though, there has been improvement in coordination between development partners in recent years.

Currently HPCIDBC is preparing action plan targeting vision for next twenty years. GIS inventory, improvement of river ecosystem, conservation of valley ecosystem, development of river banks, etc. by making strong coordination with its development partners and local and national line agencies are major objectives of plan. For the smooth operation of action plan, strong institutional setup is prerequisite. HPCIDBC has strong and full of expertise institutional setup, but for the smoother running of new action plan, some of subjective expert and section can be included in existing institutional frame.

- Coordination section can be added to minimize dispute of right between development stakeholders.
- Environment unit with Environmental Expert, Geological Expert and Landscape Planner can be added in institutional frame.
- GIS inventory system requires regular update, so either one GIS unit or GIS team in IT section can be added for the implementation of current action Plan.

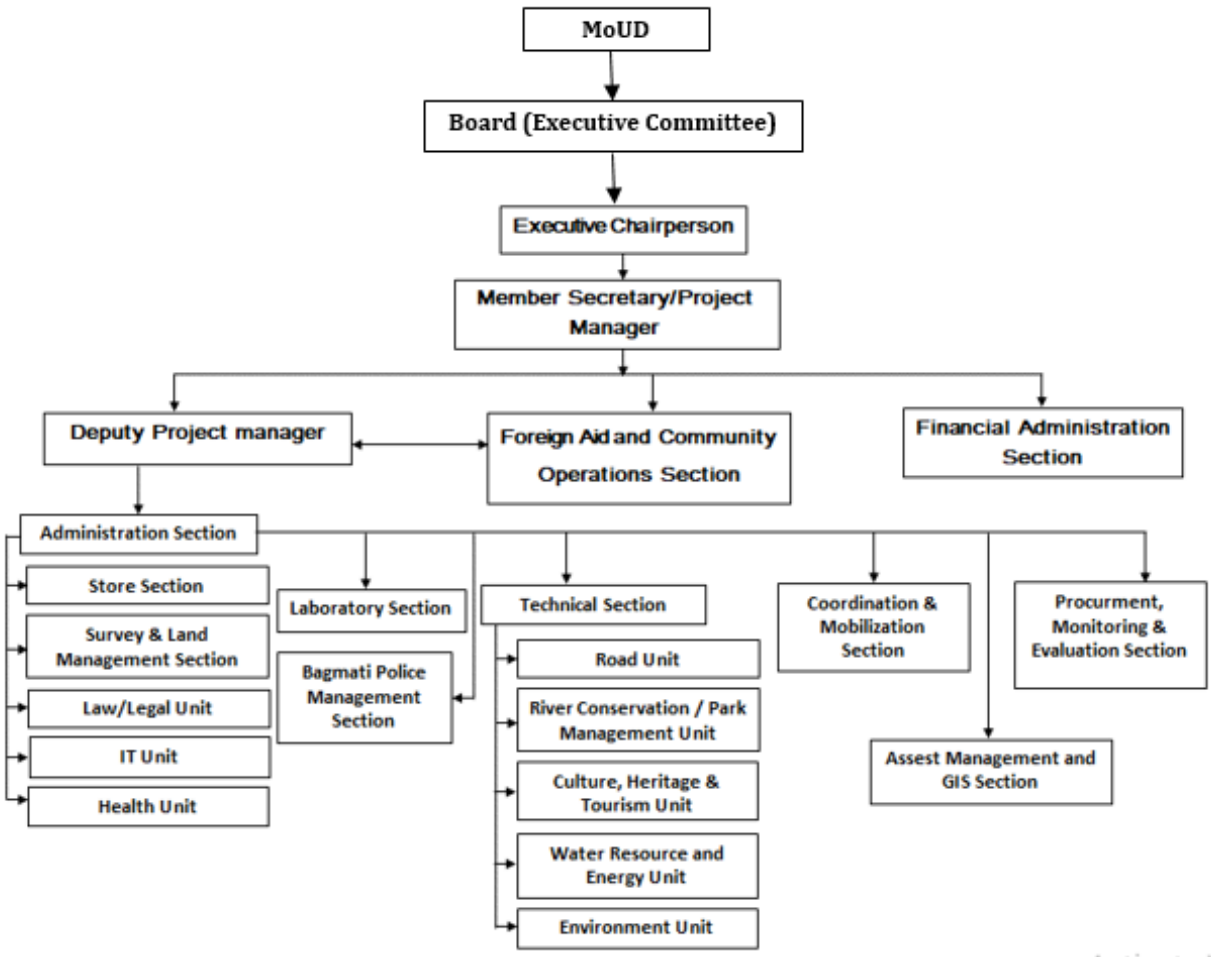


Figure 8-1: Proposed Institutional Structure

CHAPTER-IX

9. CONCLUSION AND RECOMENDATION

9.1. CONCLUSION

HPCIDBC has been working for the restoration of Bagmati civilization in the Kathmandu valley. Major objectives are to ensure cleanliness of Bagmati River and its tributaries, improving water discharge in rivers, and restoration of cultural and historical shrines/heritages in river banks of Kathmandu valley. During last three decades, prior 2009, HPCIDBC had been working for the improvement of environment in Bagmati river system, including construction, monitoring and supervision, in demand base system but Bagmati Action plan 2009-14, provided a structural working frame to the institution. After 2009 most of the river restoration activities are guided by the action plan. However, despite several interventions, the Bagmati River and its tributaries remain critically polluted and its space continues to be encroached upon for different purposes. Acknowledging the necessity for further interventions, this twenty-year action plan is prepared. This plan comprises GIS inventory of 19 rivers including Bagmati River in the valley, hydrological modeling of these rivers and actions for restoration and conservation of river ecosystem and cultural heritage.

This study prepared GIS inventory system for each of the 19 rivers from valley, which provide current information regarding land use, infrastructure development, tangible and intangible cultural heritages, green open spaces and water sources. Besides the inventory of the structures, existing scenario of study area in aspects of urban development scenario, environmental and disaster issues, aquatic biodiversity, natural hazard and socio-economic issues are analysed. Development of Physical amenities along Bagmati River Basin for conservation and encroachment of river land is undergoing under HPCIDBC which need sectoral and institutional integration.

This study also provides hydrological modeling with possible flood inundation area and proposes River Right of Way of each river for 50 years return period. Based on hydrological modeling, field survey and site visit, most of the Valley Rivers are found with insufficient width and depth for safe passage of 50 years return period flood. Construction of infrastructures and expansion of settlements in River Right of Way area are mainly responsible for shrinking river waterways. Soil erosion, gully erosion, and increasing land plotting and agriculture in sloppy land are responsible for rise in river beds. Solid waste dumping, direct discharge of sewer and industrial effluents and use of chemical fertilizers and pesticides in agriculture are found responsible factors for water pollution which is enhanced by depletion of water discharge caused by catchment degradation. Increasing population, expanding settlements, exploitation of ground water, increasing commercial/industrial activities and decreasing water conservation systems are degrading water quality and quantity in rivers of Kathmandu valley. Changing population/ethnic composition, decreasing cultural beliefs/values, and increasing longings for monetary assets are found major responsible influences for degradation and encroachment of physical and intangible heritage associated with rivers. Increase in population, expansion of

settlements along rivers increases development need of the area which are found influencing heritages and river ecosystem negatively within the valley.

The land cover change in KV revel the rapid urbanization with 4.56% annual increment in built up during last decade which is about four times higher than that of the period from 2000 to 2010. From the trend of population growth, the population of KV is projected 4.66 million and 5.89 million for year 2032 and 2042.

The new zonation concept has been developed on the basis of watershed ecology and urban growth scenario of Kathmandu Valley: i) Conservation Zone, ii) Peri-Urban Zone, and iii) Urban Zone. Conservation Zone is forest area surrounding the valley while the Urban Zone includes the urban core area of valley within the boundary of ORR. The area between the Conservation Zone and Urban Zone is defined as Peri-Urban Zone. Based upon requirement of each zone, action plan has been proposed. The activities and actions are proposed under three broad sectors; River Conservation and Management, Cultural/Civilization Rehabilitation, River/Water Quality and Quantity Improvement and Capacity building. Certain activities which are valid in all the zones are included as general activities. For effective implementation, the activities/action and budget are grouped in short-term (0-5 years), first mid-term (6-10 year), second mid-term (11-15 year) and long-term (16-20 year) periods. The total tentative budget required for twenty year action plan is 276,605 million NPR. Zone-wise implementation of proposed activities requires about 121,934 million NPR for Conservation Zone; 46,132 million NPR for Peri-Urban Zone; 110,421 million NPR for Urban Zone and 1,115 million NPR for general projects.

The Bagmati Action Plan 2022-2042 is prepared for restoration and conservation of Bagmati River system in integrated and coordinated approach. The successful implementation of the Action Plan not only brings the river back to life but also enhances the overall urban environment of the Kathmandu valley. Besides planning and implementation, a range of administrative, management and other supporting elements should also be considered to ensure stability of the efforts of Bagmati Action Plan. These are policies and laws; institutional arrangements; stakeholder engagement; science, monitoring and research; and tools for giving effect to elements of the action plan's strategy through regulatory controls and other planning systems.

Regular monitoring is very essential from the concerned authorities to identify how effectively and efficiently the proposed activities are implemented. Short term review can be conducted at every five-year interval for creating remarkable differences in saving cost and time of project implementation. HPCIDBC is an authorized organization for implementation of the proposed activities for conservation and development along Bagmati and its tributaries for preservation of Bagmati civilization on the basis of prepared action plan. For the smooth operation fo action plan, strong institutional setup is prerequisite. HPCIDBC has strong and full of expertise institutional setup, but for smoother running of new action plan, some of subjective expert and sections such as environment unit with Environmental Expert, Geological Expert and Landscape Planner, GIS Unit with GIS Expert, IT Expert needs to be added in institutional arrangement.

9.2. RECOMMENDATION

Based on the inventory, stakeholder consultations, hydrological modeling and various analysis during the planning process following recommendations are made for successful implementation of Bagmati Action Plan 2022-2042 and support the goals and vision for restoration of Bagmati River and its tributaries:

i) Restoration of RoRW, periodic cleaning of river bed, provision of river training structures, retaining wall and flood embankments are effective measures for flood mitigation in the areas.

ii) Adoption of disaster mitigation measures; bio engineering, gully control, sediment trapping, siltation management are necessary steps to manage rivers and watershed.

iii) Management of Informal settlements along the river corridor for conservation of riparian land.
iv) Amendment of bylaws and endorse for sewerage management, maintaining river water quality, rain water harvesting and sustainable land use practices within valley.
v) Preservation of tangible and intangible cultural heritage through Reclaim, Renovation and Reconstruction.
vi) Development of sewerage system; interceptor, WWTP, DEWATS along rivers in the valley and implement sewerage and waste water treatment plant in institution/housing of the valley.
vii) Develop infrastructure and promote activities for water conservation/harvesting and ground water recharge in the valley.
viii) Promote ecotourism to increase ownership over resources by the people from valley.
ix) Involve the community and ward offices for periodic river cleaning, cultural and recreational activities to be encouraged in urban zone.
x) Develop information system to provide current status of assets associated with rivers such as infrastructure, heritages, land availability, water discharge and quality, and catchment area.
xi) Land subdivision (plotting) and settlement development to be discouraged in the conservation zone.
xii) Afforestation programme to be launched with the involvement of community.
xiii) Urban agriculture, terrace farming and urban forestry to be encouraged in peri-urban zone.
xiv) Management of solid waste at the household and community level to be emphasized. Reduce, reuse and recycle (3R) concept to be applied in solidwaste management
xv) To promote private sector and civil society;
- PPP model can be implemented in development and operation of Sewerage treatment plant and multipurpose reservoir/storage project, or operational management contract method can be best suitable for this type with ownership to public sector. Private sector can be given incentives of tax exemption of 10% and benefit sharing of 80-20%.
- Open public spaces can be given on lease for 10-30 years to private sector to develop multipurpose parks etc. depending on the location.
- Small scale projects can be given to community level for development and operation.

xvi) Coordination and collaboration among governmental, non-governmental and civil society organizations, and other stakeholders working in restoration, enhancement and management of Bagmati River and its tributaries. Role of the each should be defined to avoid conflict and duplication of works and optimize the resources. All the stakeholders must be involved in an integrated and coordinated fashion both during the planning and implementation of activities.
xvii) HPCIDBC must take the responsibility for overall monitoring. A participatory or joint monitoring system can also be established where representatives from concerned stakeholders participate and monitor the programs. For effectiveness each implementing agencies have to prepare their own monitoring plans.
xviii) Efforts should be made to strengthen HPCIDBC in terms of technical capacity, financial resources and legal back up. For institutional strengthening this action plan proposes the inclusion of Coordination section to minimize dispute of right between development stakeholders; Environment unit with environmental expert, geological expert and landscape planner and GIS unit or GIS team in IT section in current organizational structure of HPCIDBC.
xix) The government should ensure adequate resources to ensure effective implementation of action plan in reaching goals and ultimately the vision.

REFERENCES

Ancient Monument Preservation (Fifth Amendment) Act, 2052 (1996), 1 (1996).

Brosius, C., & Michaels, A. (2020). Vernacular heritage as urban place-making. Activities and positions in the reconstruction of monuments after the gorkha earthquake in Nepal, 2015–2020: The case of patan. *Sustainability (Switzerland)*, *12*(20), 1–23. https://doi.org/10.3390/su12208720

Dhungel, Apekshya (2017), Introduction to Kathmandu Valley (History, Geography, Culture and Religion)

GoN/NTNC. (2009). *Bagmati Action Plan (2009–2014)*.

Khatakho R.; Gautam, D.; Aryal, K.R.; Pandey, V.P.; Rupakhety, R.; Lamichhane, S.; Liu, Y.-C.; Abdouli, K.; Talchabhadel, R.; Thapa, B.R.; et al. (2021). Multi-Hazard Risk Assessment of Kathmandu Valley, Nepal. Sustainability 2021, 13, 5369.

KVDA. (2016). Vision 2035 and Beyond : 20 Years Strategic Development Master Plan (2015-2035) for Kathmandu Valley. In *Kathmandu Valley Development Authority, Ministry of Urban Development*.

Local Self-Governance Act, 2055, Pub. L. No. Act number 5 of the year 2056 (1999) AN, 2055 1 (1999). https://www.lawcommission.gov.np/np/

MoUD. (2017). National Urban Development Strategy. In *Ministry of Urban Development*.

NPC. (2019). *The Fifteenth Plan (2076/77-2080-81)*.

Peng, J. D. (2018). Impact of Urbanization on Public Health in Kathmandu Valley, Nepal- A Review. *Juniper Online Journal of Public Health*, *3*(4). https://doi.org/10.19080/jojph.2018.03.555617

Pokhrel, S. (2019). Green space suitability evaluation for urban resilience: an analysis of kathmandu metropolitan city, nepal. *Environmental Research Communications*, *1*(10). https://doi.org/10.1088/2515-7620/ab4565

Rijal, S., Rimal, B., Acharya, R. P., & Stork, N. E. (2021). Land use/land cover change and ecosystem services in the Bagmati River Basin, Nepal. *Environmental Monitoring and Assessment*, *193*(10). https://doi.org/10.1007/s10661-021-09441-z

Sharma, Y (2010). Land Sharing Experience in Kathmandu, Case of Sankhamul Squatter Settlement,

Smolka, M (2002), Regularizing Urban Land Tenure: The solution which is part of the problem, and the problem that is part of the solution

Solid Waste Management Act, 2068, Pub. L. No. Act no. 4 of 2068 B.S, 2068 (2011). www.lawcommission.gov.np%0ASolid

The Environment Protection Act, 2019 (2076), Ministry of Environment and Forests, Government of Nepal (2019).

The Forests Act, 2019 (2076), Pub. L. No. Act No. 12 of the year 2019 (2076), 1 (2019).

Disaster Risk Reduction and Management Act, 2074, Pub. L. No. Act No.45 of the year

2074(2017) Preamble:, Ministry of Home Affair, GoN (2017).

The Guthi Corporation Act , 2033 (1976), Pub. L. No. 2033.7.4 (20 October 1976), 2033 1 (1976). www.lawcommission.gov.np

UN Habitat (2003), The Challenge of Slums: Global Report on Human Settlements, UN Habitat.

Wang, S. W., Gebru, B. M., Lamchin, M., Kayastha, R. B., & Lee, W. K. (2020). Land use and land cover change detection and prediction in the kathmandu district of nepal using remote sensing and GIS. *Sustainability (Switzerland)*, *12*(9). https://doi.org/10.3390/su12093925

Wang, W., Wu, T., Li, Y., Xie, S., Han, B., Zheng, H., & Ouyang, Z. (2020). Urbanization impacts on natural habitat and ecosystem services in the Guangdong-Hong Kong-Macao "Megacity." Sustainability (Switzerland), 12(16). https://doi.org/10.3390/su12166675

Annex I: Methodology for Soil Erosion and Landslide Hazard Mapping

A. Methodology for Estimation of Soil Erosion

Several empirical models have been developed for estimating soil erosion in watersheds; among these, the most used during the past 30 years is the Universal Soil Loss Equation (USLE). Its revised version, i.e., Revised Universal Soil Loss Equation (RUSLE), has been employed in this study. The RUSLE is an empirical model for the prediction of the long-term average annual rate of soil erosion (expressed in tons/ha/yr), by combining several factors having a bearing on the erosion rate, namely; rainfall erosivity, soil erodibility, steepness and length of the slope (topography), vegetation cover and conservation support practices. The input parameters were generated in the GIS platform in various thematic maps used in equation (1) (Renard et al., 1997).

$$A = R * K * L S * C * P$$

Where,

A: computed annual soil loss per unit area [ton/ha/year]

R: Rainfall erosivity factor, an erosion index for the given storm period in [MJ mm·ha−1·hr−1·year−1]

K: Soil erodibility factor

LS: Topographic factors

C: Cover-management factor-ratio of soil loss P: Support practice factor-ratio of soil loss with a support practice contour tillage, strip cropping, terracing to soil loss with row tillage parallel to the slope.

Rainfall erosivity factor (R): The rainfall-runoff erosive factor, *R*, is calculated from the following relationship (Morgan, 1984):

$$R = 79 + 0.363p$$

Where, p is the average annual rainfall, mm. The annual rainfall was obtained from the WorldClim database that provided 1 km spatial resolution climatic data (Fick and Hijmans, 2017).

Soil erodibility factor (K): The soil erodibility factor K is a measure of erodibility for a standard condition. Since soil erodibility factor K represents soil's susceptibility to erosion and the amount and rate due to runoff effect. Soil data of study area for both Nepal and China were obtained from the Soil and Terrain Database (SOTER), compiled and prepared by World Food Organization (FAO). Similarly, K factors were initially extracted from the monograph published by the US Department of Agriculture (USDA, 2000) with necessary modification referring to the past studies on similar mountain regions (Gardner and Gerrard, 2003; Maqsoom et al., 2020; Veeranarayana, Raju and Wuletaw, 2019).

Characteristics and K factors of soil types

Soil types	Sub units	Characteristics	K (tons ha h ha−1 MJ−1mm−1)	Justification
Combisols	Eutric Combisols	Eutric Cambisols are developed in medium and fine-textured materials derived from a wide range of rocks, mostly in colluvial.	0.25	These soils are present on steep slopes are best kept under forest
	Gleyic cambisoils	The Gleyic Cambisols of alluvial plains are highly productive 'paddy soils'	0.25	These soils are present on flat to gentle slopes

Soil types	Sub units	Characteristics	K (tons ha h ha−1 MJ−1mm−1)	Justification
	Chromic Cambisols	Soils are developed in medium and fine-textured materials with Triassic and Cretaceous limestones are investigated	0.5	These soil though less fertile, are used for (mixed) arable farming and as grazing and forest land
Luvisiols	Chromic luvisoils	Characterized by a dark coloured sandy clay loam texture and moderately well drained	0.3	

Topographic Factors (LS)

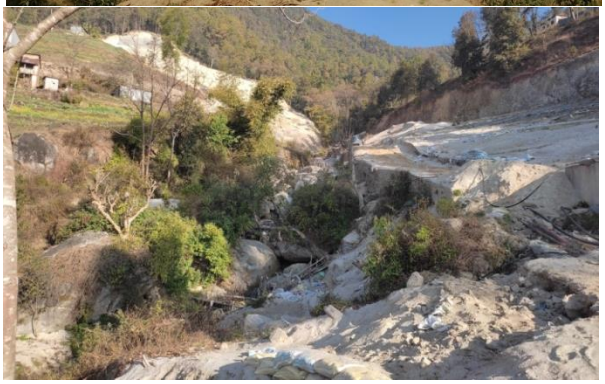
The topographical factor constitutes two factors named slope length (L) and slope steepness (S). Slope length (L) is the effect of slope length on erosion. The slope length is a function of flow accumulation that is defined as the distance from the point of origin of overland flow to the point where either the slope decreases to the extent that deposition begins or runoff water enters a well-defined channel. Slope steepness (S) represents the effect of slope steepness on erosion (Smith and Wischmeier, 1957). The effects of slope steepness have a greater impact on soil loss than slope length. Steeper the slope, the greater is the erosion.

Land Cover

The land cover factor, C, affects the erosion rate through vegetation cover, cropping, and management practices. C factor for the different land cover classes is assigned according to Koirala, et al., 2019.

Expanding plotting (land development) in the hillslope is causing the high to severe erosion through removing the vegetation and disturbing the compactness of the soil. These areas have been incorporated in land cover as barren land while evaluating the erosion potentiality.






Support Management

Support management factor accounts for control practices that reduce the erosion potential of runoff by their influence on drainage patterns, runoff concentration, runoff velocity, and hydraulic

forces exerted by the runoff on the soil surface (Renard et al., 1991). The river banks within the ring road are well protected through the corridor development and other protection infrastructures. Such embankments are also found in gentle to moderate valley slope within proposed outer ring road area. However, agriculture on the hill slope is less managed and erosion in the form of sheet, rill and gullies are very common.

B. Methodology for Landslide Hazard Mapping

Landslide Inventory

The inventory of landslides is the entry point for evaluating the hazard which will be done by using high-resolution multi-temporal images (2001-2022) provided by Google Earth. The 3D view and the history slicer (allowing to shift to images from different dates) combined with the relief exaggeration will be used to interpret landslides and their type. The morphological signatures representing various landslides and erosional features will be identified with shape, size, texture, color, topographic location, and vegetation characteristics revealed in an image vis-a-vis expert judgment.

The topographic maps also be used to identify the probable creep sites or subsistence sites through contour crenulation patterns showing hummock or irregular topography in conjunction with satellite imagery. These features are typical of slow mass movement, landslides scarps, lobate-shaped flow deposits, flow scars and bulges, and vegetation patterns. The interpretation of lithological and geological structures shown in the map vis-a-vis the topographic map aids in interpreting the potential landslide area.

Generation of Landslide Contributing Parameters

There are several factors contribute on landslide occurrence directly as well as indirectly. For instances, factors can be broadly categorized into four domains: i) Topographic domain (Aspect, Elevation, Relief range, Slope gradient, Solar illumination and Topographic position index), ii) Hydrological domain (Annual rainfall, and Topographic wetness index), iii) Anthropogenic domain (Land-use/ Land-cover, Road networks and NDVI), and iv) Geological domain (Lithology and Structures).

Among them, some factors are more crucial and have high impact on landslide triggering. Since, the role of different parameters is not uniform; the weightage was calculated using the Landslide index method.

Proposed Landslide susceptibility mapping parameters and their justification

Theme / Domain	Parameters/ Variables	Data types and sources	Descriptions & Justifications
Topographical	Slope Aspect	Digital Elevation Model (DEM): https://search.asf.alaska.edu/; Survey Department/GoN	Aspect played a dominant role in controlling the spatial distributions of the landslides. For instance, north facing slope in Nepal effect on landslide due to their shadier, colder, and more humid conditions. In contrast, the east–south-facing slopes are very prone to landslides because they are affected by intense wetting and drying cycles.
	Ground Elevation		Elevation influences to landslide are often displayed as an indirect relationship or by means of other factors. The weathering factor that plays an important role in land sliding is closely related with elevation. Another important aspect relating relief and landslide hazard is that construction activities like roads are preferentially built along the same relief.
	Slope gradient		Slopes in combination with the slope material cohesion, angle of repose and moisture conditions normally determine slope stability conditions. It is a very important parameter in the slope stability analysis, and it is frequently used in preparing landslide susceptibility maps (Ercanoglu, 2005; Chalkias, Ferentinou, & Polykretis, 2014; Budimir et al., 2015).
	Relief range		Elevation-relief ratio is defined as mean elevation minus minimum elevation divided by relief. This variable can capture the overall morphology of an area which is also good descriptors of landslide terrain (Carrara et al., 1991, 1995; Lee and Min, 2001).
	Topographical position index		The TPI is calculated as the difference between the cell elevation and the mean elevation of neighboring cells, is calculated using Jenness et al. (2011).
	Solar illuminations		Solar illuminations combine sun angle (slope dependence) and its direction (aspect dependence) influences on moisture and thereby vegetation (Pawluszek & Borkowski, 2016).
Hydrological	Topographic wetness index	DEM	Topographic wetness index (TWI) is a complex geo-hydrological calculation which can capture the hydro-morphological response.

Theme / Domain	Parameters/ Variables	Data types and sources	Descriptions & Justifications
	Annual average rainfall	Department of Hydrology and Meteorology/GoN of Nepal	Landslides do not occur until field capacity is exceeded, a certain amount of rain must fall to initially wet the regolith such that a future rainfall may produce a positive pore pressure to trigger landslides (Campbell, 1975; Crozier, 1999). Dahal and Hasegawa (2008) concludes that when daily rainfall amount exceeds 144 mm, there is always risk of landslides in Himalayan slopes.
Anthropogenic domain	Normalized difference vegetation index (NDVI)	Image analysis of Landsat 8	It reflects the quality of forest. The areas with lesser vegetation or devoid of any vegetation give a negative value or a value close to zero whereas a value close to positive one represents luxurious vegetation.
	Land use/ Land cover	Topographic Survey and Land Use Management Division (TSLUMD)/GoN	Land use/Land cover help to accrue knowledge on information necessary for landslide susceptibility modeling in a specific area or region.
	Road distance	Department of rad (DoR)/ Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR); field observation and update	Increased erosion rates from road building have been well documented and considered as one of the most critical human impacts in the Himalaya (McAdoo.. et.al, 2018; Rieux, et.,al, 2019).
Geology	Geological formation	Department of Mines and Geology/GoN, field observation and update	Different lithological units have different landslide susceptibility values, it is very important to consider the individual unit contributions for susceptibility mapping. For this reason, it is essential to group the lithological properties properly.
	Structures		Geological structure is structural discontinuities such as folds, faults, joints, orientation and inclination of bedrocks, which influence in shaping the landscape (Chorley et al. 1984). Many of these are related to tectonic movement, which trigger landslides in the Himalayas (Burbank 2003).

Landslide Hazard Mapping

Landslide hazard is represented by susceptibility, which is the likelihood of a potential damaging landslide and erosion occurring within the province. The weight of evidence (WoE) method was applied. This method is considering both the presence of a certain landslide causative factor class and the absence of remaining classes, which will be used for determining a clearly spatial correlation between a landslide occurrence and the causative factors (Regmi et al., 2010).

The inventory landslide was cross tabulated on factor classes and weights were calculated using the statistical procedures containing both prior probabilities and posterior probabilities. Prior probability measures the likelihood that a terrain factor contains the landslides(L) before taking classes of terrain factor (F) into account, and its estimation is based on the landslide density (S) for the study area.

$$P_{Prior} = P(L) = \frac{pixel(landslides)}{Pixel(Total)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{i}$$

P(L) = Probability of having a landslide,

Pixel (landslide) =Number of pixels with landslides in the map

Pixel (total) Total number of pixels in the map

Posterior probability is to be measured according to the S density for each class of the F. It is a modification of an earlier estimate of probability, which can be expressed as:

$$P(S|F) = \frac{P(S \cap F)}{P(F)} = \frac{Grids(S \cap F)}{Grids(F)} \ldots\ldots\ldots\ldots\text{ii}$$

$P(S|F) =$ the posterior probability of occurrence of landslides in each class of F

Considering this concept, the weight of a class of factors, i.e., multiple class factor map based on the presence or absence of the landslides (L) within the area (Bonham-Carter G. 1994) will be calculated in log linear form.

$$\text{Wi+} = \ln\left(\frac{P\{F|S\}}{P\{F|\bar{S}\}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\text{iii}$$

$$\text{Wi-} = \ln\left(\frac{P\{\bar{F}|S\}}{P\{\bar{F}|\bar{S}\}}\right) \ldots\ldots\ldots\ldots\ldots\ldots\text{iv}$$

Where, P is the probability and ln is the natural log F is the presence of class of factor, and $\bar{F}$ is the absence of a class of factor for landslides occurrence, L is the presence, and $\bar{L}$ is the absence of the landslides.

Wi+ is used for those pixels of a class in a multi-class factor map (F) to indicate the importance of the presence of the factor for the occurrence of landslides (S). If Wi+ is positive, the presence of the factor is favorable for the occurrence of landslides, and if Wi+ is negative, it is not favorable. Similarly, Wi- is those for grids of a factor class to indicate the importance of the absence of factors. If Wi- is positive, the absence of the factor is favorable for the occurrence of landslides, and if Wi- is negative, it is not favorable. The final weight is then calculated as:

$$\text{W} = W_i^+ + [\sum_{j=i}^{n} W_j^-] - W_i^- \text{---------v}$$

After computation of weight of each parameter based on WoE, landslide susceptibility index (LSI) will be calculated through summing of indexes of all parametric classes.

Annex II: Population Growth Trend and Projection

Population Growth Trend and Projected Population and Density for 20 years (till 2042)

Local Bodies	Area (ha)	Population Growth Rate	Adopted Population Growth Rate	Year 2032		Year 2042	
				Projected Population	Density (ppha)	Projected Population	Density (ppha)
Kathmandu Metropolitan City	4,945	-1.42%	0.93%	936,427	189	1,027,251	208
Lalitpur Metropolitan City	3,612	0.51%	0.93%	331,984	92	364,183	101
Bhaktapur Municipality	689	-0.36%	0.93%	87,307	127	95,774	139
Kritipur Municipality	1,476	2.23%	2.23%	104,225	71	129,931	88
Madhyapur Thimi Municipality	1,147	3.75%	3.75%	179,782	157	259,715	226
Gokarneshwor Municipality	5,850	3.48%	3.48%	220,380	38	310,397	53
Budhanilkantha Municipality	3,480	5.23%	4.00%	276,621	79	409,467	118
Kageshwari Manohara Municipality	2,738	8.27%	4.00%	205,251	75	303,821	111
Trakeshwar Municipality	5,495	6.40%	4.00%	233,240	42	345,252	63
Tokha Municipality	1,711	3.20%	3.20%	192,017	112	263,194	154
Nagarjun Municipality	2,985	2.00%	4.00%	177,818	60	263,214	88
Chandragiri Municipality	4,392	4.86%	4.00%	210,794	48	312,027	71
Dakshinkali Municipality	4,268	0.96%	0.96%	29,721	7	32,715	8
Shankharapur Municipality	6,021	1.84%	1.84%	37,180	6	44,628	7
Changunarayan Municipality	6,298	4.80%	4.00%	136,414	22	201,926	32
Suryabinayak Municipality	4,245	5.80%	4.00%	212,400	50	314,404	74
Godawari Municipality	9,611	2.57%	2.57%	133,477	14	172,073	18
Mahalaxmi Municipality	2,651	6.68%	4.00%	182,749	69	270,513	102
Konjyosom Rural Municipality	4,416	-0.71%	0.93%	10,011	2	10,982	2
Bagmati Rural Municipality	11,149	-1.52%	0.93%	12,396	1	13,598	1
Total	**87,179**	1.90%	**2.58%**	**3,910,193**	**45**	**5,145,065**	**59**

Annex III: Water Quality Analysis

Water Quality Analysis of Bagmati River and its Tributaries

The river water quality for 2077 B.S is evaluated based on data, acquired from HPCIDBC website (*https://bagmati.gov.np/np/download-types/bagmati-river-water-quality-test-report/*). A composite pollution was prepared through involvement of officials of Department of Environment under Ministry of Forest and Environment, which is also authorized institution for pollution management in Nepal. For this, multi-criteria method called Analytical Hierarchy Process (AHP) (Saaty 1980) was used to calculate the weight of the individual variable with an objective of obtaining visually clear with less odor water in Bagmati river system.

AHP evaluates variables by comparing them pairwise according to the importance of a variable over others in determining turbidity and odor of the river. Input values for comparison are based on expert judgments, whereas the output comes from systematic mathematical calculation. The comparisons are made using a scale of judgments that represents how much one element (variable) has an intensity of importance over another with respect to a given attribute. Here, four intensity types of importance: equal, slight, moderate, high and very high denoted by the ordinal values 1, 2, 3, 4 and 5, respectively, were used as scale of judgment. By normalizing the pairwise matrix, the weight value for each variable was determined (Erden and Coşkun 2010). A consistency ratio is calculated using the following method to verify the degree of credibility of the relative weights.

$$CR = CI/RI \ldots\ldots\ldots\ldots \text{ equation 1.}$$

Where,

(RI) is the random consistency index for n (Variables) =16, RI= Random index value

The consistency index (CI) is determined using the following equation

$$CI = (\lambda max - n)/n\text{-}1 \ldots\ldots\ldots \text{equation 2.}$$

Where,

λmax is the maximum value of the eigenvector, and (n) is the criteria number. If the value of consistency rate is above (0.10), then there are inconsistencies in the evaluation process, but if the value is less than (0.10) indicates consistency in the evaluation process.

Comparative matrix for water quality analysis

	Turbidity (NTU)	TSS mg/l	TDS mg/l	DO mg/l	BOD mg/l	COD mg/l	Total phosphate mg/l
Turbidity (NTU)	1	1	4	2	1	1	3
TSS mg/l	1	1	2	1	0.5	0.5	3
TDS mg/l	0.25	0.5	1	1	0.25	0.25	1
DO, mg/l	0.5	1	1	1	0.2	0.2	0.5
BOD, mg/l	1	2	4	5	1	2	4
COD, mg/l	1	2	4	5	0.5	1	3
Total phosphate mg/l	0.3	0.3	1	2	0.25	0.3	1
	5.1	7.8	17	17	3.7	5.3	15.5

Normalized matrix and weight for water quality analysis

	Turbidity (NTU)	TSS mg/l	TDS mg/l	DO mg/l	BOD mg/l	COD mg/l	Total phosphate mg/l	Weigh t
Turbidity (NTU)	0.20	0.13	0.24	0.12	0.27	0.19	0.19	**0.19**
TSS mg/l	0.20	0.13	0.12	0.06	0.14	0.09	0.19	**0.13**
TDS mg/l	0.05	0.06	0.06	0.06	0.07	0.05	0.06	**0.06**
DO (mg/l)	0.10	0.13	0.06	0.06	0.05	0.04	0.03	**0.07**
BOD (mg/l)	0.20	0.26	0.24	0.29	0.27	0.38	0.26	**0.27**
COD (mg/l)	0.20	0.26	0.24	0.29	0.14	0.19	0.19	**0.21**
Total phosphate (mg/l)	0.07	0.04	0.06	0.12	0.07	0.06	0.06	**0.07**

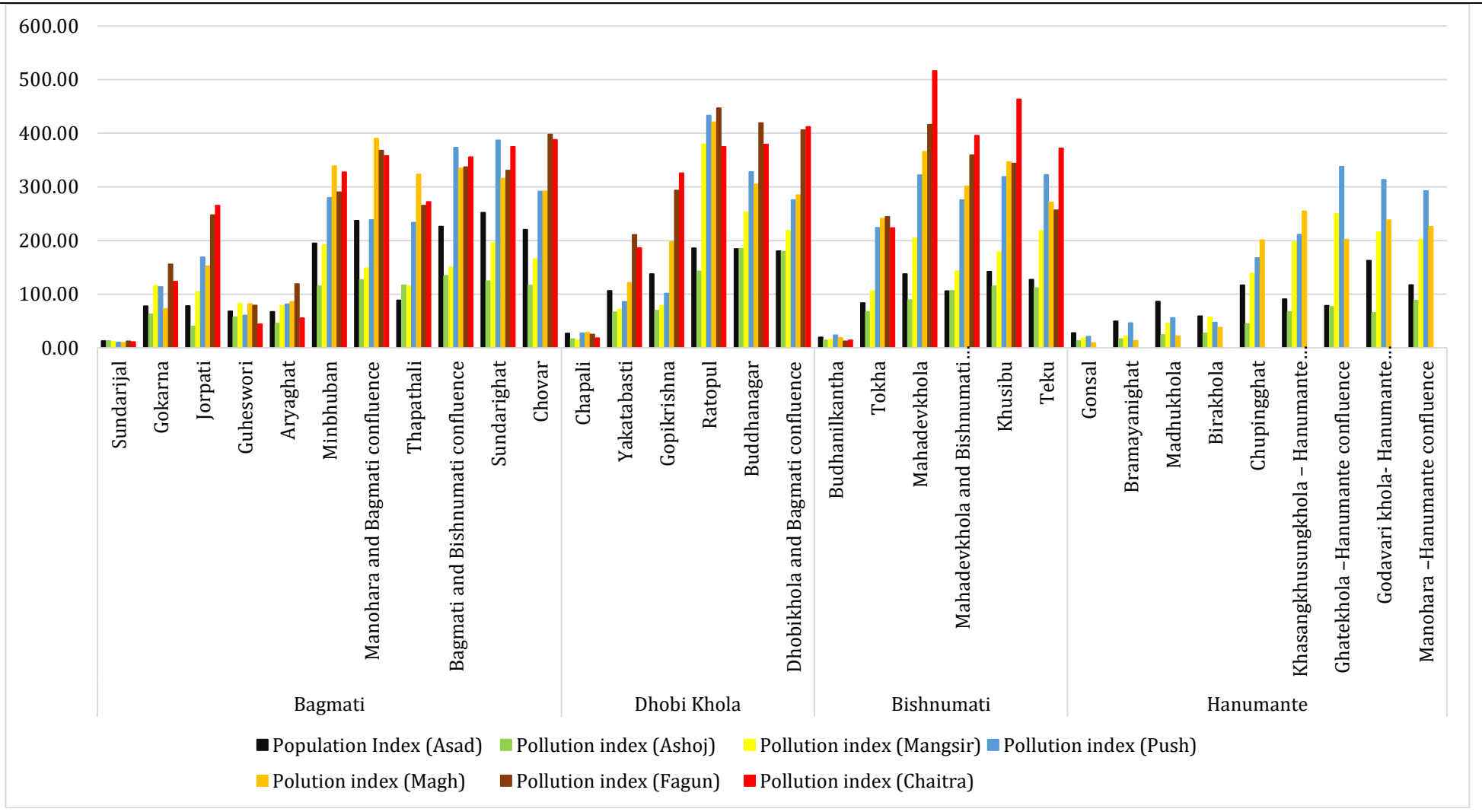
Eigen value-7.32; Ci-0.05; R-1.33; CR-0.04

Finally, a composite pollution index was produced through summing of the product of weight and pollution value of each variable;

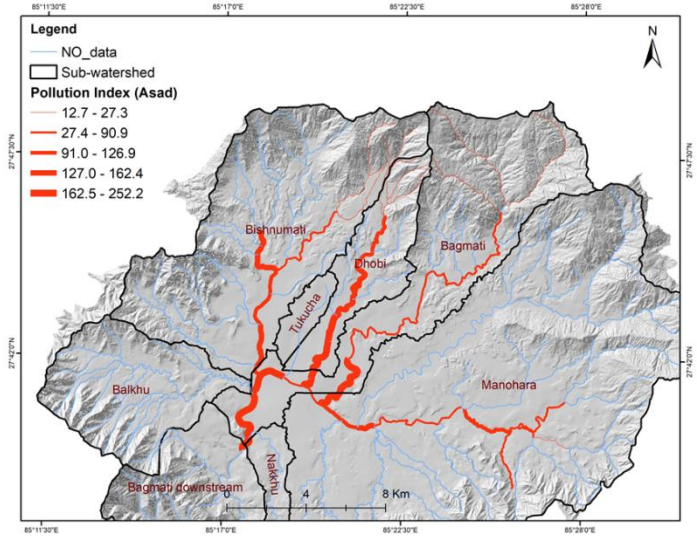
$$\text{Pollution index} = \Sigma ViWi \ldots\ldots\ldots \text{equation 3.}$$

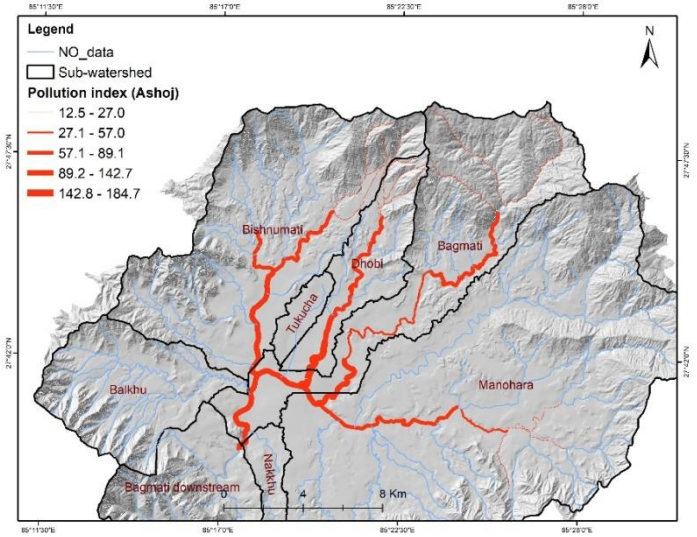
Where,

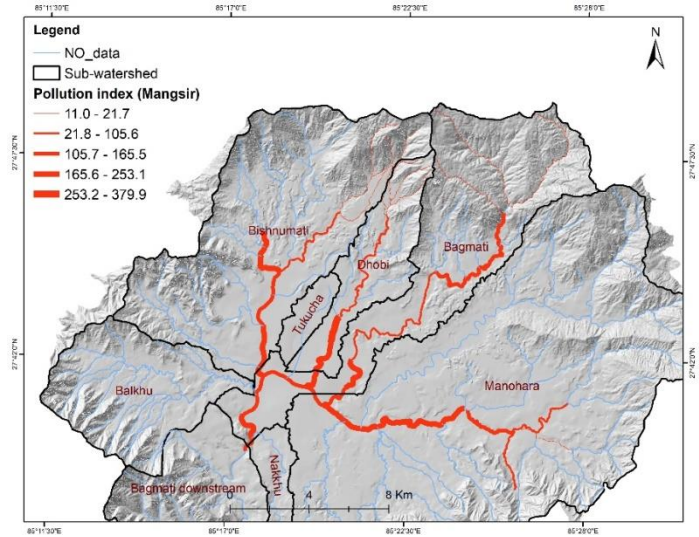
Vi = Pollution value of variables and Wi = Weight of each variable

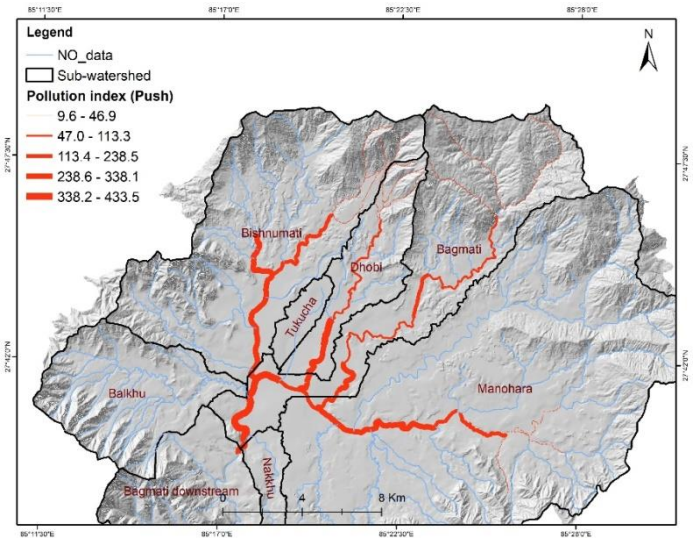


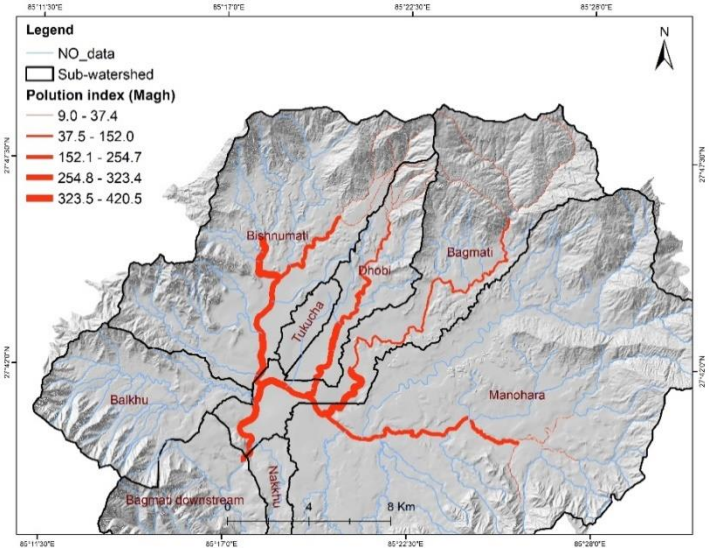
Monthly Water Pollution Index

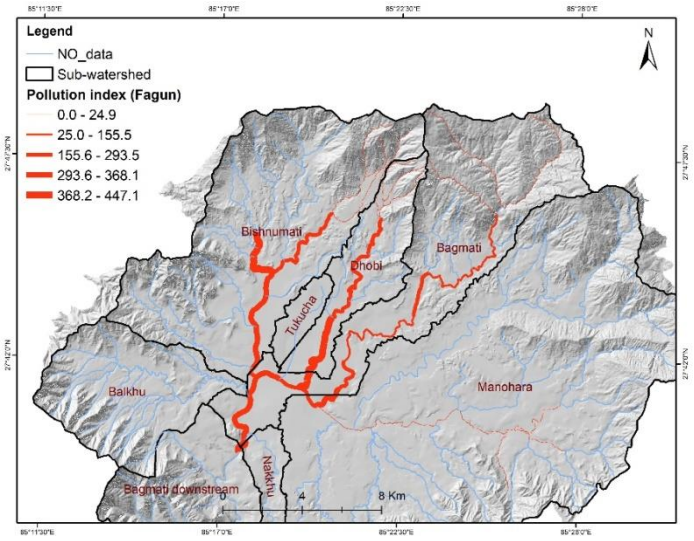

Legend
NO_data
Sub-watershed
Pollution Index (Asad)
12.7 - 27.3
27.4 - 90.9
91.0 - 126.9
127.0 - 162.4
162.5 - 252.2
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakkhu
Bagmati downstream
0
4
8 Km

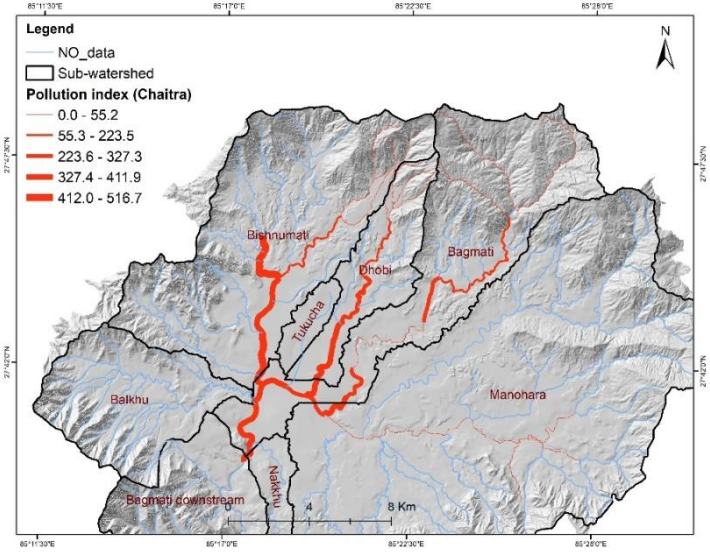

Legend
NO_data
Sub-watershed
Pollution index (Ashoj)
12.5 - 27.0
27.1 - 57.0
57.1 - 89.1
89.2 - 142.7
142.8 - 184.7
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakkhu
Bagmati downstream
0
4
8 Km


Legend
NO_data
Sub-watershed
Pollution index (Mangsir)
11.0 - 21.7
21.8 - 105.6
105.7 - 165.5
165.6 - 253.1
253.2 - 379.9
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakkhu
Bagmati downstream
0
4
8 Km


Legend
NO_data
Sub-watershed
Pollution index (Push)
9.6 - 46.9
47.0 - 113.3
113.4 - 238.5
238.6 - 338.1
338.2 - 433.5
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakkhu
Bagmati downstream
0
4
8 Km


Legend
NO_data
Sub-watershed
Polution index (Magh)
9.0 - 37.4
37.5 - 152.0
152.1 - 254.7
254.8 - 323.4
323.5 - 420.5
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakhu
Bagmati downstream
0
4
8 Km


Legend
NO_data
Sub-watershed
Pollution index (Fagun)
0.0 - 24.9
25.0 - 155.5
155.6 - 293.5
293.6 - 368.1
368.2 - 447.1
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakhu
Bagmati downstream
0
4
8 Km


Legend
NO_data
Sub-watershed
Pollution index (Chaitra)
0.0 - 55.2
55.3 - 223.5
223.6 - 327.3
327.4 - 411.9
412.0 - 516.7
N
Bishnumati
Dhobi
Bagmati
Tukucha
Balkhu
Manohara
Nakhu
Bagmati downstream
0
4
8 Km

Annex IV: Total Sewerage Generation and Land Requirement for Sewerage Treatment Plant

The estimation of land requirement for sewerage treatment plant is made on the basis of the following:

Design Water Quality

Item	Influent	Effluent	Removal rate (%)
BOD (mg/l)	300	30	0.9
SS (mg/l)	300	60	0.8

Design Assumptions

Grit chamber	Surface loading, $m^3/m^2/day$	2160
Oxidation ditch	Hydraulic detention time, hr	15
Sedimentation basin	Surface loading, $m^3/m^2/day$	15
Sand filtration tank	Filtration rate, $m^3/m^2/day$	200
Disinfection tank	Retention time, min	15
Sludge thickening tank	Dry solid load, $kgDS/m^2/day$	30
Sludge digestion tank	Sludge retention time, day	14
Sludge moisture		97%

Population forecast and total sewerage generation in year 2042

Local Bodies	Population forecast Design Population of 2042	Total domestic sewage quantity (lit/day)	Non domestic sewage quantity (10%) (lit/day)	Infiltration rate (10%) (lit/day)	Total sewerage flow (lit/day)	Existing WWTP serving discharge (lit/day)	Net Inflow after deduction (lit/day)
Kathmandu Metropolitan City	1,176,994.00	112,991,424.00	11,299,142.40	11,299,142.40	135,589,708.80	16,400,000.00	119,189,708.80
Lalitpur Metropolitan City	417,270.00	40,057,920.00	4,005,792.00	4,005,792.00	48,069,504.00	16,500,000.00	31,569,504.00
Bhaktapur Municipality	109,735.00	10,534,560.00	1,053,456.00	1,053,456.00	12,641,472.00	2,500,000.00	10,141,472.00
Kritipur Municipality	148,871.00	14,291,616.00	1,429,161.60	1,429,161.60	17,149,939.20		17,149,939.20
Madhyapur Thimi Municipality	297,574.00	28,567,104.00	2,856,710.40	2,856,710.40	34,280,524.80		34,280,524.80
Gokarneshwor Municipality	355,644.00	34,141,824.00	3,414,182.40	3,414,182.40	40,970,188.80		40,970,188.80
Budhanilkantha Municipality	469,155.00	45,038,880.00	4,503,888.00	4,503,888.00	54,046,656.00		54,046,656.00

Local Bodies	Population forecast Design Population of 2042	Total domestic sewage quantity (lit/day)	Non domestic sewage quantity (10%) (lit/day)	Infiltration rate (10%) (lit/day)	Total sewerage flow (lit/day)	Existing WWTP serving discharge (lit/day)	Net Inflow after deduction (lit/day)
Kageshwari Manohara Municipality	348,109.00	33,418,464.00	3,341,846.40	3,341,846.40	40,102,156.80		40,102,156.80
Trakeshwar Municipality	395,580.00	37,975,680.00	3,797,568.00	3,797,568.00	45,570,816.00		45,570,816.00
Tokha Municipality	301,560.00	28,949,760.00	2,894,976.00	2,894,976.00	34,739,712.00		34,739,712.00
Nagarjun Municipality	301,583.00	28,951,968.00	2,895,196.80	2,895,196.80	34,742,361.60		34,742,361.60
Chandragiri Municipality	357,511.00	34,321,056.00	3,432,105.60	3,432,105.60	41,185,267.20		41,185,267.20
Dakshinkali Municipality	37,484.00	3,598,464.00	359,846.40	359,846.40	4,318,156.80		4,318,156.80
Shankharapur Municipality	51,133.00	4,908,768.00	490,876.80	490,876.80	5,890,521.60		5,890,521.60
Changunarayan Municipality	231,361.00	22,210,656.00	2,221,065.60	2,221,065.60	26,652,787.20		26,652,787.20
Suryabinayak Municipality	360,235.00	34,582,560.00	3,458,256.00	3,458,256.00	41,499,072.00		41,499,072.00
Godawari Municipality	197,156.00	18,926,976.00	1,892,697.60	1,892,697.60	22,712,371.20		22,712,371.20
Mahalaxmi Municipality	309,946.00	29,754,816.00	2,975,481.60	2,975,481.60	35,705,779.20		35,705,779.20
Konjyosom Rural Municipality	12,583.00	1,207,968.00	120,796.80	120,796.80	1,449,561.60		1,449,561.60
Bagmati Rural Municipality	15,581.00	1,495,776.00	149,577.60	149,577.60	1,794,931.20		1,794,931.20
Total	**5,895,065.00**	**565,926,240.00**	**56,592,624.00**	**56,592,624.00**	**679,111,488.00**	**35,400,000.00**	**643,711,488.00**

Land requirement for sewerage treatment plant in year 2042

Location	Daily average flow, (m^3/day)	Peak factor	Peak flow (m^3/day)	Land requirements (m^2)											
				Grit chamber	Oxidation ditch	Sedimentation basin	Sand filtration tank	Disinfection tank	Sludge thickening tank	Sludge digestion tank	Sludge dewatering	Total area (m^2)	Area for office, lab, road, parking, maintenance (2.0 x total area) (m^2)	Total area required (m^2)	Total area required (ha)
Kathmandu Metro City	101,939.3	3	305817.9	141.6	21237.4	6796.0	509.7	1061.9	815.5	475.1	7759.3	38796.4	77592.8	116389.0	11.6
Lalitpur Metro City	25,453.9	3	76361.6	35.4	5302.9	1696.9	127.3	265.1	203.6	159.3	1947.6	9738.1	19476.3	29214.0	2.9
Bhaktapur Municipality	8,533.2	3	25599.5	11.9	1777.7	568.9	42.7	88.9	68.3	279.4	709.4	3547.1	7094.2	10641.0	1.1
Kritipur Municipality	14,968.1	3	44904.2	20.8	3118.3	997.9	74.8	155.9	119.7	558.5	1261.5	6307.5	12615.0	18922.0	1.9
Madhyapur Thimi Municipality	29,919.2	3	89757.5	41.6	6233.2	1994.6	149.6	311.7	239.4	667.5	2409.4	12046.8	24093.5	36140.0	3.6
Gokarneshwor Municipality	35,757.7	3	107273.2	49.7	7449.5	2383.8	178.8	372.5	286.1	880.5	2900.2	14501.1	29002.2	43503.0	4.4
Budhanilkantha Municipality	47,170.6	3	141511.8	65.5	9827.2	3144.7	235.9	491.4	377.4	653.3	3698.8	18494.2	36988.4	55483.0	5.5
Kageshwari Manohara Municipality	35,000.2	3	105000.5	48.6	7291.7	2333.3	175.0	364.6	280.0	742.4	2808.9	14044.6	28089.2	42134.0	4.2
Trakeshwar Municipality	39,773.0	3	119319.1	55.2	8286.0	2651.5	198.9	414.3	318.2	566.0	3122.5	15612.7	31225.4	46838.0	4.7
Tokha Municipality	30,319.9	3	90959.8	42.1	6316.7	2021.3	151.6	315.8	242.6	566.0	2414.0	12070.1	24140.3	36210.0	3.6
Nagarjun Municipality	30,322.3	3	90966.8	42.1	6317.1	2021.5	151.6	315.9	242.6	671.0	2440.4	12202.2	24404.4	36607.0	3.7
Chandragiri Municipality	35,945.5	3	107836.5	49.9	7488.6	2396.4	179.7	374.4	287.6	70.4	2711.8	13558.8	27117.5	40676.0	4.1
Dakshinkali Municipality	3,768.8	3	11306.3	5.2	785.2	251.3	18.8	39.3	30.2	96.0	306.5	1532.3	3064.7	4597.0	0.5
Shankharapur Municipality	5,141.1	3	15423.4	7.1	1071.1	342.7	25.7	53.6	41.1	434.2	493.9	2469.5	4938.9	7408.0	0.7
Changunarayan Municipality	23,261.9	3	69785.6	32.3	4846.2	1550.8	116.3	242.3	186.1	676.1	1912.5	9562.7	19125.3	28688.0	2.9

Location	Daily average flow, (m^3/day)	Peak factor	Peak flow (m^3/day)	Land requirements (m^2)											
				Grit chamber	Oxidation ditch	Sedimentation basin	Sand filtration tank	Disinfection tank	Sludge thickening tank	Sludge digestion tank	Sludge dewatering	Total area (m^2)	Area for office, lab, road, parking, maintenance (2.0 x total area) (m^2)	Total area required (m^2)	Total area required (ha)
Suryabinayak Municipality	36,219.3	3	108658.0	50.3	7545.7	2414.6	181.1	377.3	289.8	370.0	2807.2	14036.0	28072.0	42108.0	4.2
Godawari Municipality	19,822.8	3	59468.4	27.5	4129.8	1321.5	99.1	206.5	158.6	581.7	1631.2	8155.9	16311.7	24468.0	2.4
Mahalaxmi Municipality	31,163.1	3	93489.3	43.3	6492.3	2077.5	155.8	324.6	249.3	23.6	2341.6	11708.1	23416.2	35124.0	3.5
Konjyosom RM	1,265.1	3	3795.4	1.8	263.6	84.3	6.3	13.2	10.1	29.2	102.1	510.7	1021.3	1532.0	0.2
Bagmati R M	1,566.5	3	4699.5	2.2	326.4	104.4	7.8	16.3	12.5	10403.1	2718.2	13591.0	27182.0	40773.0	4.1
Total	**557,311.5**													**697,455.000**	

Annex V: Salient Features of the Potential Sites for Water Retaining Ponds/Reservoir

S.N	Longitude	Latitude	Municipality	Location/ Stream	Proposed Dam Height (m)	Proposed Dam Crest Length (m.)	Covering Area (ha)	Reservoir Capacity (m3)	Topographical characteristics	Existing land use/land cover	Rock/Soil characteristics	Remarks
A. Potential Sites for Water Retaining Reservoirs												
1	85.269593284 70	27.709985533 10	Nagarjun-6	Sitapaila	10.0	30.0	0.33	6284.81	The elevation of the place ranges from 1309 to 1317 m and average slope is 3.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Thick sedimentary deposits mainly sandy clay soil of Lukundol Formation	
2	85.436582700 70	27.766199774 30	Kageshwori Manahara-1	Mahankal	20.0	60.0	1.30	78048.74	The elevation of place ranges from 1700 to 1720 m and average slope is 11.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderately weathered Gneiss with thick soil cover	
3	85.493975178 90	27.749198294 10	Shankharapur-3	Jaharsing Pauwa-1	6.0	25.0	0.22	4569.90	The elevation of river centre line ranges from 1788 to 1794 m and average slope is 5 %. The slope of Adjacent hills is flat to gentle	Forest	Moderately weathered Gneiss and thick residual soil	
4	85.495393072 10	27.740133946 20	Shankharapur-3 & 5	Ahalchaur	18.0	70.0	2.57	150721.70	The elevation of the palce ranges from 1748 to 1764 m and average slope is 5-10 %. The slope of Adjacent hills is flat to gentle	Forest & Weland	Moderately weathered Gneiss and thick residual soil	
5	85.492101253 80	27.743042910 50	Shankharapur-3 & 5	Ahalchaur-2	30.0	90.0	7.39	558834.51	The elevation of river centre line ranges from 1720 to 1742 m and average slope is 11.5 %. The slope of Adjacent hills is gentle to moderate	Abandoned cultivated land, Wetland & Forest	Moderately weathered Gneiss and thick residual soil	Drinking water supply and private land (need to be confirmed)

S.N	Longitude	Latitude	Municipality	Location/ Stream	Proposed Dam Height (m)	Proposed Dam Crest Length (m.)	Covering Area (ha)	Reservoir Capacity (m3)	Topographical characteristics	Existing land use/land cover	Rock/Soil characteristics	Remarks
6	85.48983688010	27.74606191900	Shankharapur-3	Jaharsing Pauwa-2	15.0	40.0	0.65	31473.07	The elevation of river centre line ranges from 1710 to 1722 m and average slope is 1-5 %. The slope of Adjacent hills is gentle to moderate	Abandoned cultivated land & forest	Moderately weathered Gneiss and thick residual soil	
7	85.24866384470	27.73406889900	Nagarjun-3, 6 & 8	Manamati	50.0	160.0	3.44	569961.80	The elevation of river centre line ranges from 1450 to 1480 m and average slope is 7%. The slope of Adjacent hills is moderate to steep	Occupied land/Cultivation and some houses	Fractured and jointed limestone and slate with thin soil cover	Priviate land shall be acqusited and reservior lies on National park
8	85.26218050960	27.70757172040	Nagarjun-7	Manamati (Kimsi)	12.0	50.0	0.70	18870.53	The elevation of the place ranges from 1312 to 1326 m and average slope is 5.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Thick sedimentary deposits mainly sandy clay soil of Lukundol Formation	
9	85.41035339350	27.61569623420	Mahalakshmi-9	Lankuri Bhanjyang	30.0	60.0	0.84	137145.77	The elevation of place ranges from 1926 to 1958 m and average slope is 5-8 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderately weathered metasandstone covered by thick soil layer	
10	85.39303217920	27.60447237720	Godawari-2 & 3	Godawari	40.0	200.0	8.58	101132.31	The elevation of river centre line ranges from 1590 to 1640 m and average slope is 12.5 %. The slope of Adjacent hills is gentle to moderate	Grazing land and forest	Moderately weathered limestone covered by thick soil layer	Reservior enlarment through excavation & artifical waterfall at inlet
11	85.27985696940	27.60413245340	Dakshinkali-7	Kopugaun	10.0	70.0	1.08	34136.89	The elevation of the place ranges from 1350 to 1370 m and average slope is 7 %. The slope of Adjacent	Forest	Sedimentary deposits comprising fine sand and silty	

S.N	Longitude	Latitude	Municipality	Location/ Stream	Proposed Dam Height (m)	Proposed Dam Crest Length (m.)	Covering Area (ha)	Reservoir Capacity (m3)	Topographical characteristics	Existing land use/land cover	Rock/Soil characteristics	Remarks
									hills is gentle to moderate		sand with gravel	
12	85.24948014310	27.63730286390	Dakshinkali-5 & 9	Sundol Khola	50.0	120.0	4.71	862675.81	The elevation of river centre line ranges from 1920 to 1966 m and average slope is 13.9 %. The slope of Adjacent hills is gentle to moderate	Forest & Wetland	Moderate to highly weathered slates covered with thin soil layer	
13	85.25407197090	27.63833921510	Dakshinkali-5	Panim Khola	20.0	70.0	1.16	33782.88	The elevation of river centre line ranges from 1775 to 1805m and average slope is 12.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderate to highly weathered slates covered with thin soil layer	
14	85.40729188600	27.62209927990	Mahalakshmi-9	Lubhu Khola-1	40.0	90.0	1.94	100993.32	The elevation of river centre line ranges from 1700 to 1740 m and average slope is 10.7 %. The slope of Adjacent hills is moderate to steep	Forest	Moderately weathered metasandstone covered by thick soil layer	
15	85.46230077480	27.79695414880	Gokarneshwor-1	Nagmati upstream-2	30.0	80.0	2.46	179987.59	The elevation of river centre line ranges from 1994 to 2016 m and average slope is 12.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderately weathered Gneiss and thick residual soil	
16	85.46738752090	27.79665084880	Gokarneshwor-1	Nagmati upstream-1	20.0	80.0	1.47	55000.00	The elevation of river centre line ranges from 2028 to 2040 m and average slope is 9.5 %. The slope of Adjacent hills is flat to gentle	Wetland & forest	Moderately weathered Gneiss and thick residual soil	Shivapuri Nagarjun NP
B. Potential Sites for River Water Dam and Reservoirs												

S.N	Longitude	Latitude	Municipality	Location/ Stream	Proposed Dam Height (m)	Proposed Dam Crest Length (m.)	Covering Area (ha)	Reservoir Capacity (m3)	Topographical characteristics	Existing land use/land cover	Rock/Soil characteristics	Remarks
17	85.33139781550	27.80342161190	Tokha-1	Bhandare Khahare	24.0	40.0	0.55	43298.00	The elevation of river centre line ranges from 1522 to 1552 m and average slope is 8.4 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderately weathered Gneiss and thick residual soil	Shivapuri Nagarjun NP
18	85.49229473310	27.70725052220	Changunarayan-6 & 7	Muhanpokhari (Option-1)	50.0	130.0	6.80	807911.18	The elevation of river centre line ranges from 1535 to 1578 m and average slope is 13.4 %. The slope of Adjacent hills is moderate to steep	Forest	Moderate to highly weathered schist and fractured quartzite with thick soil cover	
19	85.504962595580	27.72495474100	Shankharapur-5 & Changunarayan-6	Kattike Khola	50.0	60.0	1.26	192463.51	The elevation of river centre line ranges from 1516 to 1531 m and average slope is 14.6 %. The slope of Adjacent hills is moderate to steep	Forest	Moderately weathered Gneiss and thick residual soil	Series of siltation dams are required in the upstream
20	85.42372875450	27.78193958100	Gokarneshwor-1	Bagmati (Option-1)	65.0	150.0	13.05	2546604.83	The elevation of river centre line ranges from 1630 to 1690 m and average slope is 14 %. Adjacent hillslope is moderate to steep.	Forest	Moderately weathered Gneiss and thick residual soil	Shivapuri Nagarjune National Park
21	85.42339945900	27.78273400110	Gokarineshwor-1	Bagmati (Option-2)	80.0	200.0	24.01	5485592.30	TThe elevation of river centre line ranges from 1630 to 1690 m and average slope is 14 %. Adjacent hillslope is moderate to steep.	Forest	Moderately weathered Gneiss and thick residual soil	Shivapuri Nagarjune National Park
22	85.49259802400	27.70727462710	Changunarayan-6 & 7	Muhanpokhari (Option-2)	60.0	170.0	10.93	1682836.11	The elevation of river centre line ranges from 1994 to 2016 m and average slope is 12.5 %. The slope of Adjacent hills is gentle to moderate	Forest	Moderate to highly weathered schist and fractured quartzite with thick soil cover	

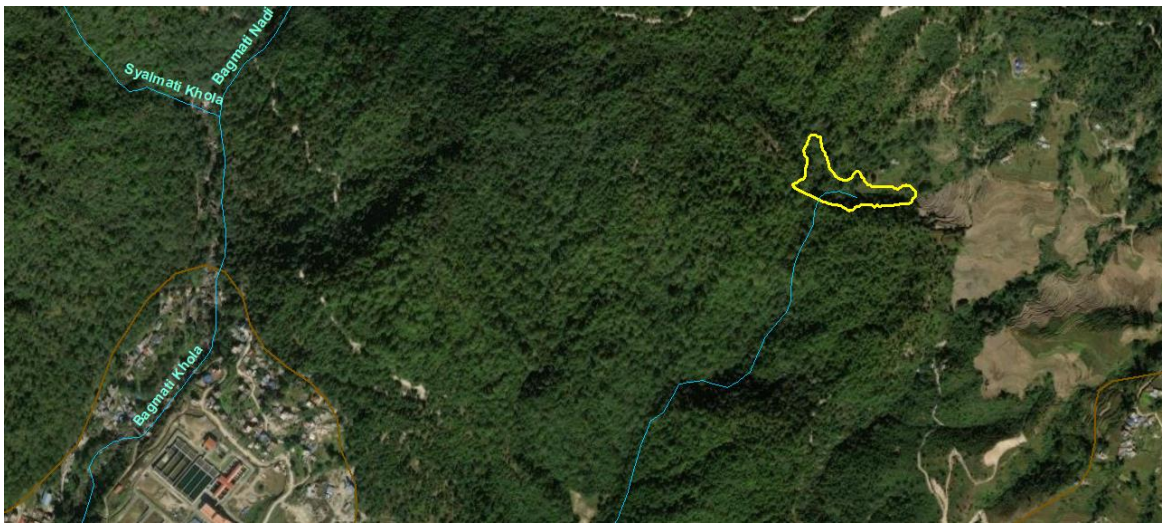
S.N	Longitude	Latitude	Municipality	Location/ Stream	Proposed Dam Height (m)	Proposed Dam Crest Length (m.)	Covering Area (ha)	Reservoir Capacity (m3)	Topographical characteristics	Existing land use/land cover	Rock/Soil characteristics	Remarks
23	85.295877689990	27.54679339890	Godawari-6	Burugachuli Khola	50.0	140.0	3.64	537134.00	The elevation of river centre line ranges from 1841 to 1871 m and average slope is 15 %. The slope of Adjacent hills is moderate to steep	Forest	Moderately weathered metasandstone covered by thick soil layer	
24	85.27810215270	27.61206413100	Dakshinkali-3, 6 &7	Shesnarayan Khola	20.0	60.0	0.78	65706.54	The elevation of the place ranges from 1420 to 1444 m and average slope is 10%. The slope of Adjacent hills is gentle to moderate	Forest	Sedimentary deposits comprising fine sand and silty sand with gravel	
25	85.36430672330	27.76508841950	Budhanilkantha-2 & 8	Dhobi khola	25.0	70.0	3.62	238452.35	The elevation of river centre line ranges from 1350 to 1370 m and average slope is 8.4 %. The slope of Adjacent hills is gentle to moderate	Park and private land	Sedimentary deposits comprising sandy gravel, peaty clay	Existing park will be inundated partially & some issues of private land

Potential sites for water retaining reservoirs

There are 16 potential sites identified from the field for the water retaining reservoirs. A brief description of these potential sites is presented here.

1. Mahankal

The potential site of Mahankal lies in Ward no. 1 of Kageshwori Manahara Municipality. It is proposed at the top of a small tributary, named Mahankal Khola that feeds the Bagmati River to the northeast of Sundarijal. At present, the proposed site is covered by sparse forest and grassland. It covers about 1.29 ha of area and can hold approximately 78048 m3 of water after construction of 20m high dam. The vicinity of the proposed reservoir site shows presence of moderately weathered gneiss bedrock showing stable sloping terrain.



Potential site for water retaining reservoir at Mahankal

2. Jaharsing Pauwa (2 sites)

There are two potential sites for medium-sized water retaining reservoir at near to Jaharsing Pauwa. They lie in Ward no. 3 of Shankharapur Municipality. One of the proposed sites is elongated and small depression gully adjacent to an entrance gate built on Jaharsing Pauwa-Sankhu road. There are some sparse trees of rhododendron and mixed species. It covers about 0.22 ha and can hold 4570 m3 water after construction of only 6m high dam. It will also be an attractive center for tourism.

The second proposed site lies at about 2 km from previous site towards Sankhu along the road. There is a depression surrounded by moderately weathered bedrocks covered by sparse forest. There is potentiality of constructing a water retaining reservoir covering an area of about 0.65 ha that can hold about 31473 m3 water after construction of 15m high dam. Both of the sites lie in gneiss bedrock and residual soil and seem geologically stable.

Potential sites for water retaining reservoir near Jaharsing Pauwa

A depression below the road from Jaharsing Pauwa - Sankhu, identified as a potential site for water retaining reservoir

3. Ahalchaur (2 sites)

There is a small streamlet flowing through the boarder between Ward no. 3 and Ward no. 5 of Shankarapur Municipality, which feeds the Shali Nadi. There are two potential sites for large-sized water retaining reservoir along that stream. Both of these sites show relatively flat and swampy land. Thus, there is possibility of two reservoirs in a series in an effective way. The first site covers about 2.57 ha and can hold 150721 m3 water after construction of only 18m high dam. It is surrounded by rhododendron and pine forest. The reservoir will also be an attractive center for tourism.

The second proposed site lies at immediate downstream of the first site. There is a wide swampy depression surrounded by moderately weathered gneiss bedrocks covered by sparse forest. There is potentiality of constructing a water retaining reservoir covering an area of about 7.39 ha that can hold about 558834 m3 water after construction of 30m high dam. Both of the sites lie in gneiss bedrock and residual soil and seem geologically stable.

Potential sites for construction of water retaining structures in Ahalchaur

Flat and swampy land surrounded by forest in Ahalchaur, a potential site for water retaining reservoir

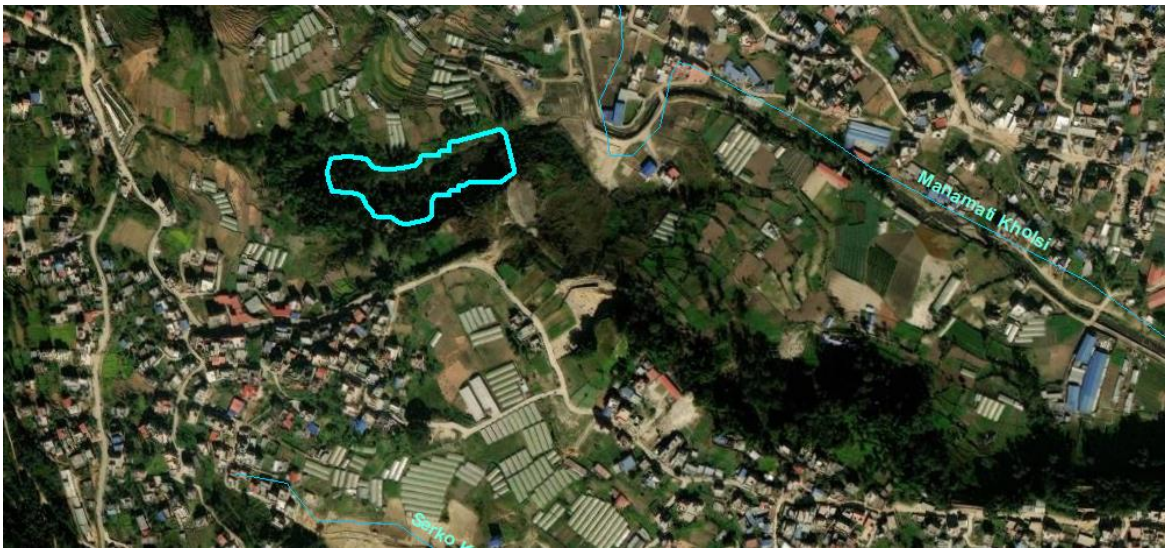
4. Manamati Kholsi, Ramkot

There is a potential site for water retaining reservoir in Ramkot, which lies in boarder among Ward no. 3, Ward no. 6, and Ward no. 8 of Nagarjun Municipality. There is deep valley walled by very steep rocky terrain on both banks and sloping hills in the upstream side. The surrounding area is covered by forest but the valley is occupied by local residents. There is quarry of limestone aggregates in the proposed site at present. Due to presence of limestone and slate, the site is geologically stable. The proposed reservoir covers about 3.43 ha and can hold about 569962 m3 water after construction of 50m high dam.

Potential site for the water retaining reservoir at Ramkot along the Manmati Kholsi

5. Manamati Kholsi, Kimsi

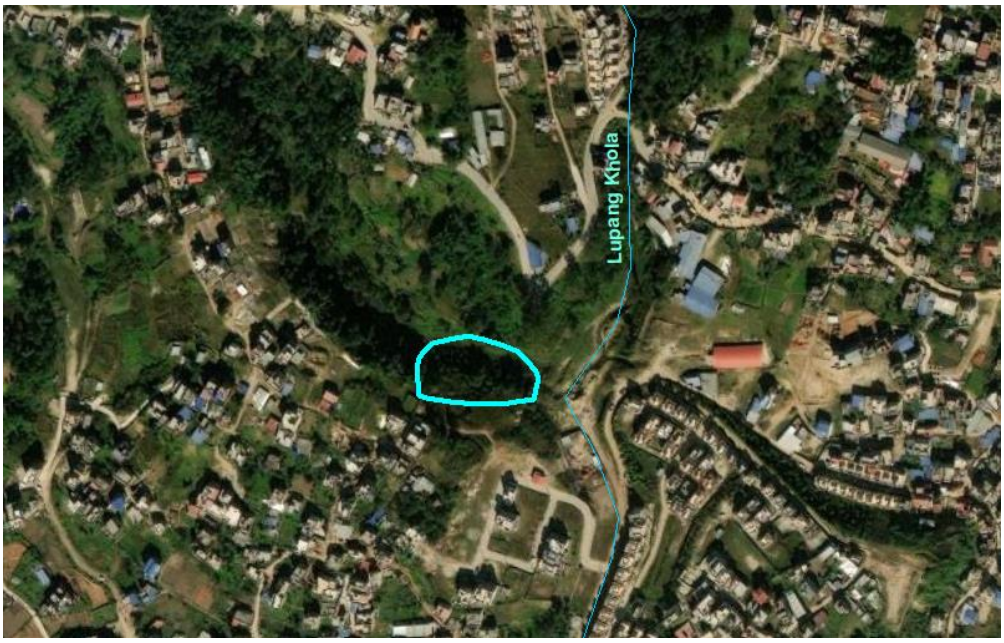
There is a potential site for water retaining reservoir in a small depressed gully flowing through west of Sitapaila. It lies near to Hasantar, Ward no. 7 of Nagarjun Municipality. The proposed site is situated in sandy clay deposits of Lukundol Formation belonging to Kathmandu Valley sedimentary deposits. It covers about 0.7 ha of an area and can hold 18870 m3 of water after construction of 12m high dam. There is local forest cover in the site at present.



Potential site for water retaining reservoir near to Hasantar, Kimsi

6. Sitapaila

A potential site for water retaining reservoir has been identified behind the Civil Housing of Sitapaila. It lies in the Ward no. 6 of Nagarjun Municipality. There is a confluence of two small streamlets and have made a deep depression valley. The proposed site shows sandy clay deposits of Lukundol Formation of Lacustrine valley sedimentary deposits. There is possibility of constructing a reservoir of about 0.33 ha and it can hold 6284 m3 of water after construction of 10 m. high dam. There are sparse trees in the valley and surrounded by dense residence. It can be developed as a recreation center.



Potential site for water retaining reservoir near to Civil Homes, Sitapaila

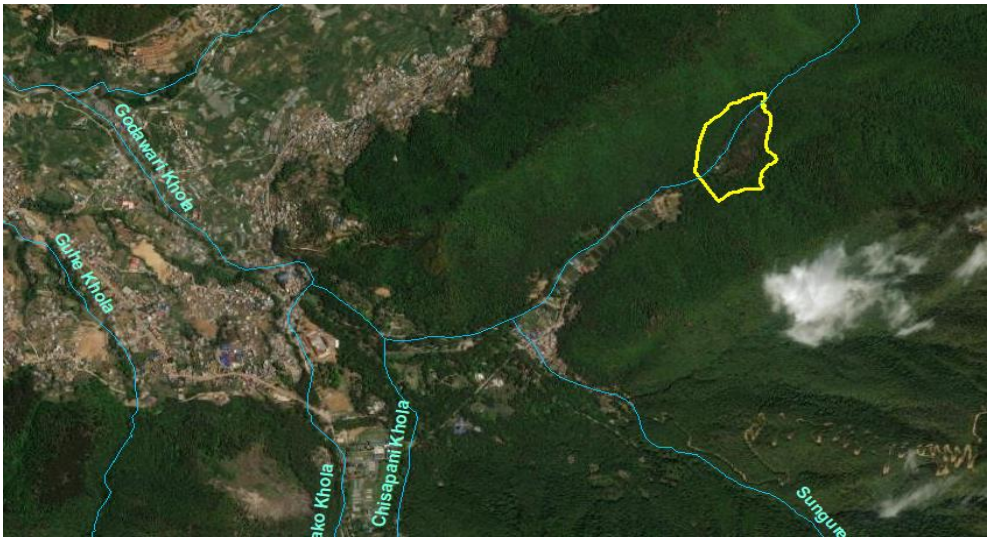
7. Lakuri Bhanjyang

There is a small streamlet that meets the Lubhu Khola near to Lakuri Bhanjyang. A potential site for the water retaining reservoir has been identified in that streamlet, where it makes a depression valley. The proposed site lies in Ward no. 9 of Mahalakshmi Municipality. There is forest and grassland in the proposed site, which is very close to a residential area. Moderately weathered metasandstone is found in the vicinity of the proposed site that is covered by thick soil cover. The proposed reservoir covers about 0.84 ha and it can hold 137145 m3 after construction of 30 m high dam.

Potential site for water retaining reservoir near to Lakuri Bhanjyang and Lubhu Khola

8. Godawari

A potential site for the water retaining reservoir has been identified in the head of Godawari Khola, which lies at the border of Ward no. 2 and Ward no. 3 of Godawari Municipality. At present, the identified site covers forest and grass land and lies far from the residential area. The terrain is composed of moderately weathered limestone covered by thick soil. The proposed reservoir covers about 8.58 ha of area and it can hold about 101132 m3 water after construction of 40 m. high dam.



Potential site for water retaining reservoir in the Godawari Khola

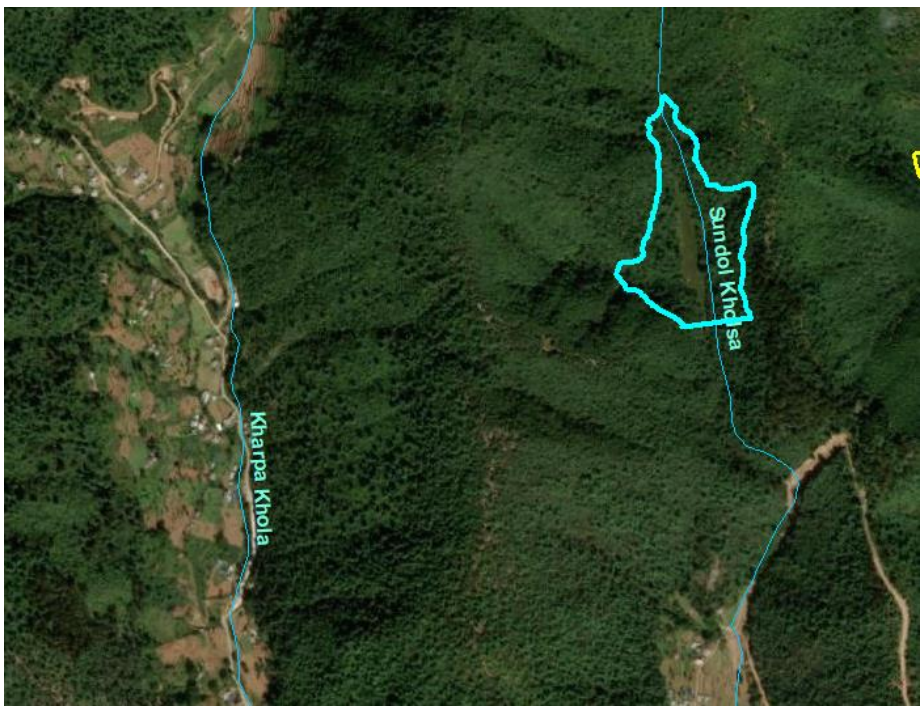
9. Kopugaun

There is a potential site for water retaining reservoir near to Kopugaun village. It lies in Ward no. 7 of Dakhsninkali Municipality. There are two small streamlet flow from hillock and meet at a point, where the terrain is suitable to develop a reservoir. The proposed site comprises sedimentary deposits mainly dominant of fine sand and silty sand with rare gravels belonging to Kobgaun Formation. The site has been covered by sparse forest and grassland. It covers about 1.08 ha of an area that can hold about 34136 m3 after construction of 10 m. high dam.

Potential sit for water retaining reservoir near to Kopugaun village in Dakshinkali-7

10. Sundol Khola

The identified potential site lies in the border between Ward no. 5 and Ward no. 9 of Dakshinkali Municipality. There is a depressed valley formed by the Sundol Khola, which can be developed as a water retaining reservoir. The valley is bare and swampy land and surrounded by dense forest. Moderately weathered slate bedrocks are exposed in the vicinity of the proposed site. There is geologically stable terrain around the proposed site. There is possibility of constructing a large reservoir of a surface area of about 4.7 ha, when a dam of 50m height is constructed. The reservoir can hold 862675 m3 water as its maximum capacity.



Potential sit for water retaining reservoir in Sundol Khola in the border of Dakshinkali-5 and Ward no. 9

11. Panim Khola

The potential site for water retaining reservoir lies in the Ward no. 5 of Dakshinkali Municipality. There is a depressed valley formed by the Panim Khola, which can be developed as a water retaining reservoir. The valley is bare and swampy land and surrounded by dense forest. Moderately weathered slate bedrocks are exposed in the vicinity of the proposed site. There is geologically stable terrain around the proposed site. There is possibility of constructing a medium-sized reservoir of a surface area of about 1.2 ha, when a dam of 20m height is constructed. The reservoir can hold 33782 m3 water as its maximum capacity.

Potential site for water retaining reservoir in Panim Khola, Dakshinkali Municipality Ward no. 5

12. Lubhu Khola

There is a potential site for water retaining reservoir near to Lubhu village. It lies in Ward no. 9 of Mahalakshmi Municipality. There is a small streamlet flowing from southeastern hills and meet the Lubhu Khola. The proposed reservoir site is situated at head of the stream. The proposed site comprises moderately weathered metasandstones with thick soil layer on surface belonging to Tistung Formation. The site has been covered by dense forest. After construction of 40 m high dam, the reservoir will cover an area of about 1.94 ha and can hold about 100993 m3 of water.

Potential site for water retaining reservoir in Lubhu Khola, Mahalakshmi Municipality Ward no. 9

13. Nagmati Upstream (2 sites)

There are two potential sites for water retaining reservoir at near to Chisapani within Shivapuri National Park. They lie in Ward no. 1 of Gokarneshwor Municipality. One of the proposed sites is small elongated depression gully adjacent to a road from Sundarijal to Chisapani. A small streamlet flows from east to west to meet Nagmati Khola. These sites are proposed along that small streamlet. There are some sparse trees of rhododendron and mixed forest species.

The first site will cover an area of about 1.47 ha after construction of 20 m high dam. It can hold 55000 m3 water. The second proposed site lies at about 200 m downstream from the previous site. There is a depression surrounded by moderately weathered bedrocks covered by sparse forest. There is potentiality of constructing a water retaining reservoir covering an area of about 2.46 ha that can hold about 179987 m3 water after construction of 30m high dam. Both of the sites lie in gneiss bedrock and residual soil and seem geologically stable.

Potential sites for water retaining reservoir in Nagmati Khola, Gokarneshwor Municipality Ward no. 1

Potential sites for reservoir dams along rivers

There are 8 potential sites identified from the field for the reservoir dams along rivers. A summary brief description of these potential sites is presented here.

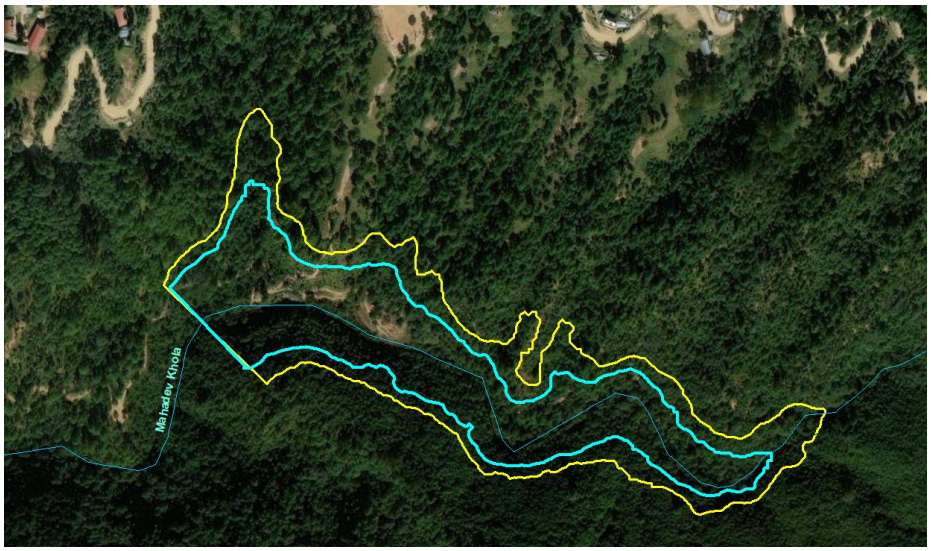
1. Bhandare Khahare

The Bhandare Khahare origins in Shivapuri National Park and flows towards south as a tributary of Sangla Khola, which finally feeds the Bishnumati River. The stream is perineal and flows making narrow valley with steep banks. A potential site for the construction of dam has been identified near to Jhor of Tokha -1. A 40 m long dam of height 24 m can block the stream water to form a river dammed reservoir. The reservoir will spread within an area of 0.55 ha having capacity of 43298 m3.

Potential site for construction of river dammed reservoir in Bhandare Khahare, Tokha-1

2. Muhanpokhari

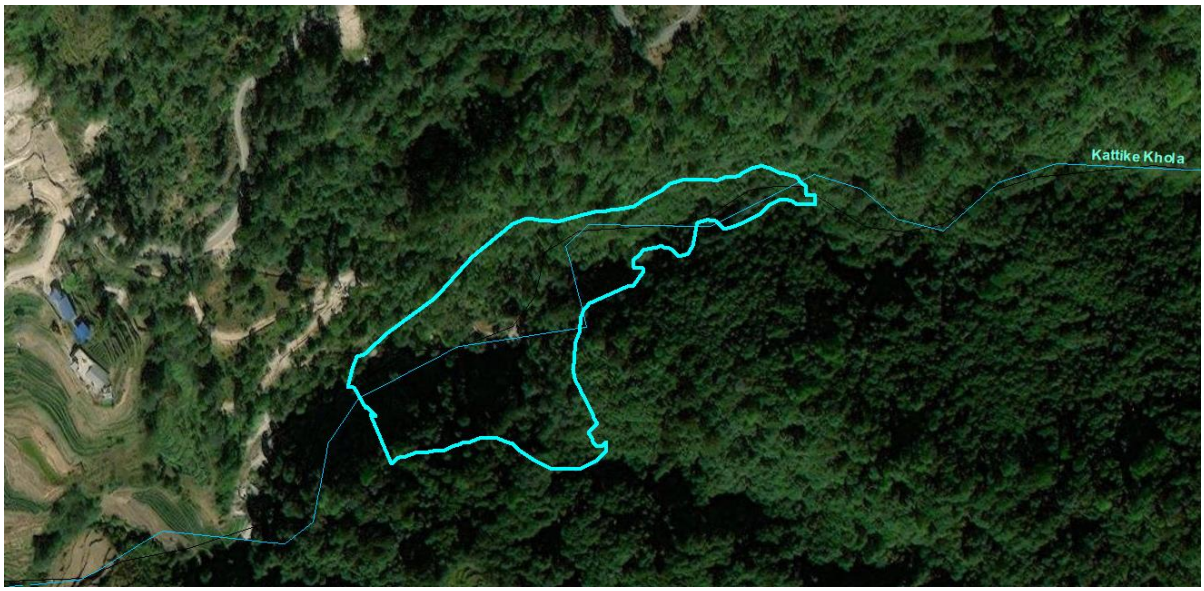
The Muhanpokhari is one of the drinking water sources for Bhanktapur, which taps water from the Mahadev Khola, a tributary of Hanumante Khola. There is existing intake structure for drinking water in the Mahadev Khola that taps water as run-of-river form. If this stream is dammed to make a reservoir, it will contribute significantly to the residents of Bhaktapur. The stream is perineal and comprises forest in its upper catchment. A potential site has been identified for construction of dam to get a reservoir in Mahadev Khola at about 1 km upstream from the present intake location at Muhanpokhari. The proposed site lies in Ward no. 6 and Ward no. 7 of Changunarayan Municipality. The height of dam determines the capacity of reservoir. So, there are two options of raising dam height. In first option, a 50m high dam will give a large reservoir with an aerial expansion of about 6.8 ha and capacity will be 807911 m3. In the second option, the 60m high dam will make about two-times larger reservoir with an area of 10.93 ha. In that case, the reservoir can hold about 1682836 m3.



Potential site for construction of river dammed reservoir in Muhanpokhari, Mahadev Khola showing two alternatives

3. Kattike Khola

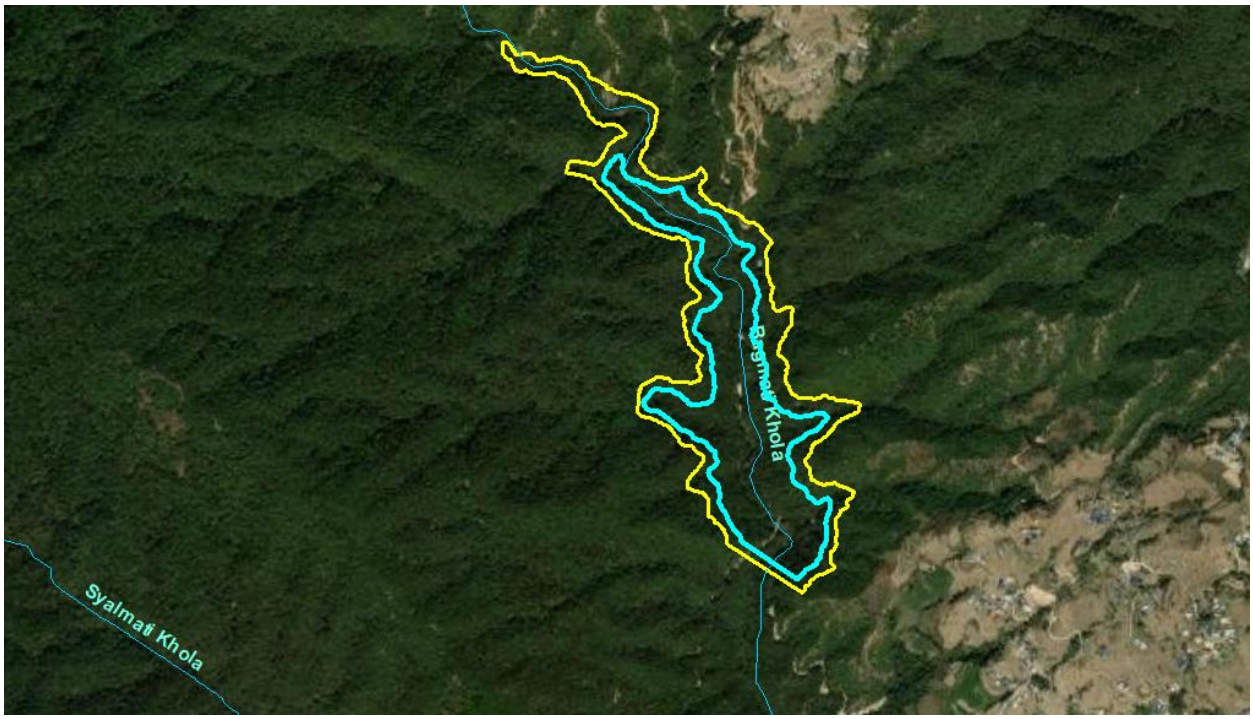
The Kattike Khola is one of the tributaries of Manahara Khola that flows being border between Ward no. 6 of Changunarayan Municipality and Ward no. 5 of Shankharapur Municipality. The stream is perineal and comprises forest in its upper catchment. A potential site has been identified for construction of dam to get a reservoir in Kattike Khola. The height of dam determines the capacity of reservoir. A 50m high dam will give a medium-sized reservoir with an aerial expansion of about 1.26 ha and capacity will be 192463 m3.



Potential site for construction of river dammed reservoir in Kattike Khola

4. Bagmati River

The upstream channel of Bagmati River flows through a narrow course but having a wide valley before meeting with Nagmati Khola. If this stream channel is dammed to make a reservoir, it will contribute significantly to the residents of Bhaktapur. The stream is perineal and comprises forest in its upper catchment. A potential site has been identified for construction of dam to get a reservoir in Bagmati River within Shivapuri National Park. The proposed site lies in Ward no. 1 of Gokarneshwor Municipality. The height of dam determines the capacity of reservoir. So, there are two options of raising dam height. In first option, a 65m high dam will give a large reservoir with an aerial expansion of about 13.05 ha and capacity will be 2546604 m3. In the second option, the 80m high dam will make about two-times larger reservoir with an area of 24.01 ha. In that case, the reservoir can hold about 5485592 m3.



Potential site for construction of river dammed reservoir in Bagmati Nadi showing two alternatives

5. Burungchuli Khola

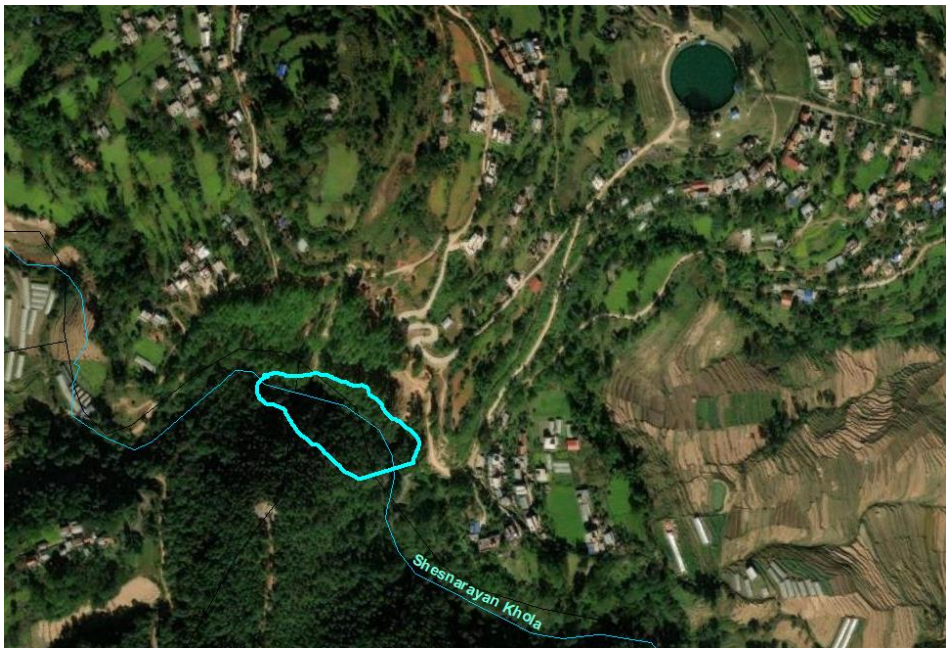
The Burungchuli Khola is one of the tributaries of Nakkhu Khola that flows through south to north in Ward no. 6 of Godawari Municipality, Lalitpur. The stream is perineal and comprises forest in its upper catchment. A potential site has been identified for construction of dam to get a reservoir in Burungchuli Khola. The height of dam determines the capacity of reservoir. A 50m high dam will give a medium-sized reservoir with an aerial expansion of about 3.64 ha and capacity will be 537134 m3.

Potential site for construction of river dammed reservoir in Burungchuli Khola, Godawari-6

6. Sheshnarayan Khola

The Sheshnarayan Khola is one of the tributaries of Bagmati River that flows through west to east near to Pharping. It lies in the boundary of three wards 3, 6, and 7 of Dakshinkali Municipality, Kathmandu. The stream is perineal and comprises forest in its upper catchment. A potential site has been identified for construction of dam to get a reservoir in Sheshnarayan Khola. The height

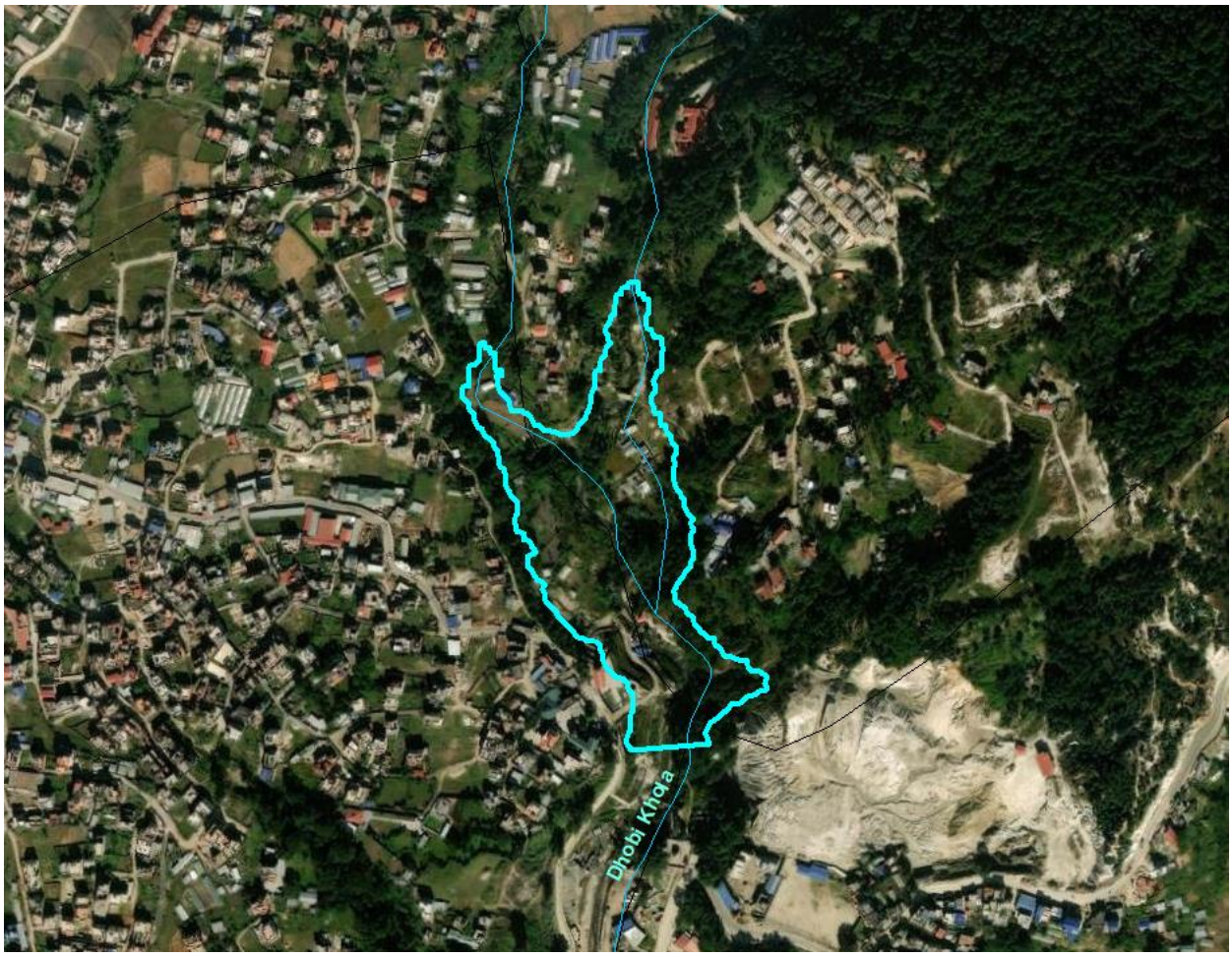
of dam determines the capacity of reservoir. A 20m high dam will give a small reservoir with an aerial expansion of about 0.78 ha and capacity will be 65706 m3.



Potential site for construction of river dammed reservoir in Sheshnarayan Khola, Pharping

7. Dhobi Khola

The Dhobi Khola that flows from north to south through Budhanilkantha. There are dense residential areas along both bank of the stream. It is being highly polluted too. A potential site for construction of river damming reservoir has been identified in Dhobi Khola. It lies in the boundary of Ward no. 2 and Ward no. 8 of Budhanilakantha Municipality. The height of dam determines the capacity of reservoir. A 25m high dam will give a medium-sized reservoir with an aerial expansion of about 3.62 ha and capacity will be 238452 m3.



Potential site for construction of river dammed reservoir in Dhobi Khola

Annex VI: Investment Plan

General Action

S. N.	Sector		Activities/Action	Total Budget (in 000)	Periodical Target (in 000)																			Budget and source		
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
1	River conservation and Management	Sustainable land use management	**Amendment of bylaws and endorsement**	8,000		2,000				2,000					2,000					2,000					Municipality	HPCIDBC	
			Promotion and support sustainable land management in valley	100,000	30,000					30,000					40,000										Municipality	HPCIDBC	
		Management of Public Land along the River Corridor	**Reclaim the encroached land along Rivers**	5,000		2,500	2,500																	Municipality	HPCIDBC, MoLMCPA	
			Preparation of master Plan for Preserve and restore river course to minimize flood hazard impact	20,000	10,000	10,000																			HPCIDBC, DWIDP	
		Implementation of RoR to conserve river area	**Detailed Study for implementation of proposed RoR**	100,000	25,000.00	25,000.00	25,000.00	25,000.00																	HPCIDBC	
		Disaster mitigation	**Conduct impact assessment of river corridors development (within RoR)**	10,000		2,500				2,500					2,500					2,500				Municipality	HPCIDBC, DHM	
			Establishment of water gauge station	10,500	5,250	5,250																		Municipality	HPCIDBC, DHM	
			Installation of flood EWS based on citizen science based model for flood hazard in all study river	50,400	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	2,520	Municipality	HPCIDBC	
2	Cultural/Civilization rehabilitation	Reclaim, Rehabilitate and conserve the cultural and heritage sites along river	**Detail documentation and publication of tangible and intangible heritage**	45,000	22,500	22,500																		Municipality	HPCIDBC	Donar agencies
			Preparation of river front Urban design guidelines for Kathmandu valley	40,000	20,000	20,000																		Municipality	HPCIDBC, DUDBC	
			Training to produce skilled manpower for																					Municipality	HPCIDBC, MCTCA	
			a) Production of traditional materials and tools	60,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000			
			b) Traditional carvings and construction works	60,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000			
3	River/Water Quality and quantity improvement	Management of Solid waste disposal directly into river system	**Establishment of Control system for CCTV**	10,000	4,000					2,000					2,000					2,000					HPCIDBC	
			Establishment of structure of Bagmati Police and development of mechanism for operation	3,000		3,000																			HPCIDBC	
			Study and coordinate for implementation of relocation of waste transfer station from river corridor area	5,000		2,500	2,500																	Municipality	HPCIDBC	
			Coordinate with municipalities for promotion of HH level waste management	100,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000										Municipality	HPCIDBC	
			Establishment of Vehicle washing center at entry point of KV especially for truck	45,000		45,000																			DoTM	
		Management of Sewerage to prevent direct disposal into river	**Monitoring and implementation of septic tank at Residential Level**	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	Municipality	HPCIDBC	
			Monitoring and implementation of waste water treatment in industries, hotel, hospital and Colony level	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	Municipality	HPCIDBC	
		Water source conservation to Increase ground water recharge and river discharge	**Monitoring and implementation of water infiltration well/system in all institutions**	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	Municipality	HPCIDBC	
			Monitoring and implementation of rain water harvesting system in all institutional buildings and promotion to residential buildings	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	Municipality	HPCIDBC	
			Mapping and reclaim encroached water sources area	10,000	2,000	2,000	2,000	2,000	2,000															Municipality	HPCIDBC	
			Detail documentation of Rajkulo with Kathmandu Valley	30,000	10,000	10,000	10,000																	Municipality	HPCIDBC	Donar agencies
		Strengthening river quality monitoring system	**Establishment of real time monitoring system in all 19 tributaries of Bagmati river system and implementation**	80,000	10,000	10,000	10,000	10,000	10,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000		HPCIDBC	Donar agencies
			Development of quick response mechanism for pollution management and implementation	30,000	12,000	947	947	947	947	947	947	947	947	947	947	947	947	947	947	947	947	947	947		HPCIDBC	Donar agencies
4	Capacity building	Knowledge management	**Enhance scientific research/ upgrade technical capacity/recognize the innovativeness of youth**	50,000	10,000					20,000				20,000											HPCIDBC	
			Development curricula on Bagmati Civilization for school level	4,000	2,000					1,000				1,000										Municipality	HPCIDBC	
			Provide research grants for graduate and post graduate students	20,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000.00	1,000.00	1,000.00	1,000.00		HPCIDBC	
			Support domestic technology development for preservation and conservation of natural cultural heritage of Bagmati	20,000	10,000					10,000														Municipality	HPCIDBC	
		Enhance community participation in BAP implementation	**Establish and capacitate ward-level community organization along the river corridor**	20,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	Municipality	HPCIDBC	
			Develop up-stream and downstream linkages	20,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	Municipality	HPCIDBC	
			Increase community participation and ownership in asset management and development activities	20,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	Municipality	HPCIDBC	
		Institutional strengthening	**Reduce waste generation through prevention, reduction, recycling, reuse in collaboration with local government**	10,000	5,000					5,000														Municipality	HPCIDBC	
			Training for capacity improvement for procurement, GIS, design & management of infrastructure	10,000	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500.00	500.00	500.00	500.00		HPCIDBC	
			Exposure visit (national/International) for knowledge sharing	20,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000.00	1,000.00	1,000.00	1,000.00		HPCIDBC	
			Preparation of urban design guideline for each local government in the valley	2,000	1,000					1,000														Municipality	HPCIDBC, DUDBC	
			Development and Operation of Assets Management System	24,000	5,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		HPCIDBC	Donar agencies
			Mid Term review of Bagmati action plan	4,000			1,000						1,000					1,000				1,000				HPCIDBC	
			Updating the Bagmati action Plan	30,000						10,000					10,000					10,000						HPCIDBC	
			Total	**1,115,900**	**209,770**	**190,217**	**80,967**	**64,967**	**39,967**	**113,467**	**29,967**	**29,967**	**30,967**	**50,967**	**76,467**	**19,967**	**19,967**	**20,967**	**19,967**	**36,467**	**19,967**	**20,967**	**19,967**	**19,967**			

Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in	Total Budget, NRs. (in 000)	Periodical Target (in 000)																			Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
1	**River conservation and Management**	Strengthen River Cleaning Program	**Periodic cleaning of rivers**	20	Year	10,000	200,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	Municipality	HPCIDBC	
			Mass movement for cleaning campaign in collaboration with local government and community	20	Year	2,000	40,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	Municipality	HPCIDBC	
			Promote corridor walkathan in each rivers	20	Year	2,000	40,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	Municipality	HPCIDBC	
		Management of Public Land along the River Corridor	**Salix plantation along river corridor area**	10	Year	10,000	100,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000											Municipality	HPCIDBC	
			Establish and maintain Child friendly park Along River (Open Space & greenery management)	1	LS	200,000	200,000	8,000	8,000	8,000	8,000	8,000																Municipality	HPCIDBC	
			Establish and maintain Youth friendly park Along River (with Gym eqquippment)	1	Ls	300,000	300,000	8,000	8,000	8,000	8,000	8,000																Municipality	HPCIDBC	
			Establish and maintain Old age friendly park Along River (Open Space with Yoga facility)	1	Ls	200,000	200,000	40,000	40,000	40,000	40,000	40,000																Municipality	HPCIDBC	
			Verification and Inventory of illegally encroached land along river banks (P1)	1	Ls	10,000	10,000	10,000																				Municipality	HPCIDBC	
			Relocation of verified squatters along the river bank Kuriyagaun, Sankhamul, Bansighhat, Thapathali, Balkhu, Pragati Tole, Chandani Tole, Sinamangal (Mahabir Galli), Jagriti Nagar, Gairigaun, Shanti Nagar, Dhirghyau Tole, Airport Gairigaun, Buddha Jyoti Marga, Jagriti Tole, Maoohara, Palpakot, Pathivara, Bishalnagar, Kalopul, Devi Nagar, Shanti Binayak, Anamnagar etc(P1)	1	Ls	1,650,000	1,650,000		2,500,000	4,500,000	4,500,000	4,500,000																Municipality	HPCIDBC	
		Sustainable land use management	**Construction of sediment trapping structures**																									Municipality	HPCIDBC	
			a) Bagmati River	1	nos.	5,000	5,000	5,000																						
			b) Balkhu Khola	1	nos.	5,000	5,000		5,000																					
		Disaster mitigation	**Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate**	94	km	80,000	7,520,000		752,000	752,000	752,000	752,000	752,000	752,000	752,000	752,000	752,000	752,000											Municipality	HPCIDBC/ MoEWRI	
		Development of corridor transport system along rivers	**Construction of pedestrian and environment friendly smart corridor road network (about 108 km) including road furniture and junction improvement along rivers beyond Proposed Waterway**																									Municipality	HPCIDBC, DoR	
			a) Road Corridor along Bagmati River (Both Side - 14km)	14	km	120,000	1,680,000		240,000	240,000	240,000	240,000	240,000	240,000	240,000															
			b) Road Corridor along Bishnumati River (Both Side-5km)	5	km	80,000	400,000				200,000	200,000																	
			c) Road Corridor along Hanumante River (Both Side-12km)	12	km	80,000	960,000		120,000	120,000	120,000	120,000	120,000	120,000	120,000	120,000													
			d) Road Corridor along Nakhu Khola (Both Side-4km)	4	km	80,000	320,000					80,000	80,000	80,000	80,000														
			e) Road Corridor along Balkhu Khola (Both Side-12km)	12	km	80,000	960,000				160,000	160,000	160,000	160,000	160,000	160,000													
			f) Road Corridor along Khodku Khola (Both Side-16km)	16	km	80,000	1,280,000		213,333	213,333	213,333	213,333	213,333	213,333	213,333	213,333													
			g) Road Corridor along Manahara River (Both Side-18km)	18	km	80,000	1,440,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000													
			h) Road Corridor along Godawari Khola (Both Side-12km)	12	km	80,000	960,000			160,000	160,000	160,000	160,000	160,000	160,000														
			i) Road Corridor along Manamati Khola (Both Side-5km)	5	km	80,000	400,000						200,000	200,000															
			j) Road Corridor along Suryamati Khola (Both Side-10km) including three motorable bridges (nearby hanuman chowk, border of ward-2 & 3 and nearby Jaldevi temple)	10	km	84,800	848,000	300,000	300,000	248,000																			
			Upgrading of existing corridor road network (about 25 km) to pedestrian and environment friendly smart corridor road including road furniture and junction improvement																									Municipality	HPCIDBC, DoR	
			a) Road Corridor along Bagmati River (10km)	10	km	80,000	800,000		160,000	160,000	160,000	160,000	160,000																	
			b) Road Corridor along Bishnumati River (9km)	9	km	60,000	540,000			180,000	180,000	180,000																	
			c) Road Corridor along Hanumante River (12km)	12	km	60,000	720,000		90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000													
			d) Road Corridor along Nakhu Khola (13km)	13	km	60,000	780,000		120,000	120,000	120,000	120,000	120,000	180,000															
			e) Road Corridor along Balkhu Khola (2km)	2	km	60,000	120,000					120,000																	
			f) Road Corridor along Khodku Khola (4km)	4	km	60,000	240,000				120,000	120,000																	

Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in	Total Budget, NRs. (in 000)	Periodical Target (in 000)																		Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
			g) Road Corridor along Manahara River (6km)	6	km	60,000	360,000				120,000	120,000	120,000																	
			h) Road Corridor along Mahadev Khola (3km)	3	km	60,000	180,000					90,000	90,000																	
			j) Road Corridor along Baucha Khola (2km)	2	km	60,000	120,000				120,000																			
			k) Road Corridor along Godawari Khola (2km)	2	km	60,000	120,000					120,000																		
			l) Road Corridor along Manamati Khola (2km)	2	km	60,000	120,000						120,000																	
			Construction of Universal Smart pedestrian bridges at maximum 500m interval in Bagmati River (11), Bishnumati River (1), Hanumante River (4), Nakhu Khola (16), Manahara Khola (13), Khodku Khola (3), Godawari Khola (1), Manamati Khola (1)	50	Nos.	10,000	500,000		3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	Municipality	HPCIDBC, DoR	
			Improvement of Junctions of Bishnumati River Corridor Road at Nayabazaar, Gongabu, Baniyatar, Paropakar; Dhobi Khola Corridor Road at Bijulibazaar, Chabahil; Nakhu Khola Corridor Road at Nakhudole; Khodku Khola Corridor Road at Hattiban; Hanumanre River Corridor Road at Madhyapur Thimi	9	Nos.	20,000	180,000			20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000										Municipality	HPCIDBC, DoR	
			Installment of Traffic Sign, Signal, information Board along corridor road network	162	km	1,000	162,000	10,000	20,000	20,000	20,000	20,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000									Municipality	HPCIDBC, DoR	
			Sub Total				**24,460,000**	**575,000**	**4,773,333**	**7,076,333**	**7,548,333**	**7,838,333**	**2,852,333**	**2,422,333**	**2,042,333**	**1,562,333**	**819,000**	**799,000**	**27,000**	**17,000**	**16,000**	**16,000**	**16,000**	**16,000**	**16,000**	**16,000**			
2	**Cultural/ Civilization rehabilitation**	Reclaim, Rehabilitate and conserve the cultural and heritage sites along river	**Restoration of cultural monuments and sites including approach Trail**																							Municipality	HPCIDBC, DoA	Donar agencies
			a. Bagmati river -Shankhamul (P1), Kalmochan (remaining), Teen dewal (remaining), Tripureshwor mahadev (remaining) (P2), Pachali bhairav-Pachali ghat (P1), Chitamani Tirtha (P1)	6	Place	400,000	2,400,000	200,000	250,000	250,000	250,000	250,000	200,000	200,000	200,000	200,000	200,000	200,000												
			b. Vishnumati river - Sobha bhagwati, Bijeshwari, Indrayani, Kankeshwar, Mhepi (P2)	5	Place	10,000	50,000						15,000	15,000	20,000																
			c. Nakhu river - Vishnudevi, Mahalaxmi(P3)	2	Place	20,000	40,000											20,000	20,000											
			d. Hanumante river - Brahmayani temple (P1), Hanuman ghat (P1), Chupinghat (P2), Ram mandir (P1), Dhum barahi temple (P2)	5	Place	7,000	35,000				10,000	10,000	10,000	5,000																
			e. Manohara river - Balkumari (P3)	1	Place	60,000	60,000													30,000	30,000									
			Reconstruction of lost monuments - Shankhamul (P2)	1	Place	30,000	30,000						15,000	15,000													Municipality	HPCIDBC, DoA	Donar agencies
			Development of Ghat and Bhakari including metal chain using traditional construction technology beyond the proposed waterway and conserving the exisiting monuments and sites																							Municipality	HPCIDBC, DoA	Donar agencies
			a) Vishnumati stretch from Teku Dovan to Shoba bhagwati (4km) (P1)	4	km	20,000	80,000		20,000	20,000	20,000	20,000																	
			b) Southern edge of the Ram mandir temple along Hanumante Khola, Bhaktapur (P2)	1	Place	20,000	20,000						20,000																
			c) Manohara dovan (P3)	1	Place	20,000	20,000											20,000											
			d) all study river at interval of 100m	40	km	20,000	800,000	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33	53,333.33													
			Feasibility study and Development of traditional cremation site and necessary infrastructure - as per demand to minimize the pressure in Bhasmeshwar ghat, Pashupati khetra (2 no.s)	2	nos.	50,000	100,000				50,000						50,000											Municipality	HPCIDBC, DoA	Donar agencies
			Pedestrian Bridge construction (Nakhu dovan) for ritual procession	1	no.	10,000	10,000					10,000																Municipality	HPCIDBC	
			Preservation of historic bridges (Jalbinayak gorge bridge, Sundari ghat bridge, Teku kalo pul, Kori tafu-Khokana, Koteshwor Mahadevsthan, kankeshwari bridge)	6	nos.	6,000	36,000					60,000	60,000	60,000	60,000	60,000	60,000											Municipality	HPCIDBC	

Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in	Total Budget, NRs. (in 000)	Periodical Target (in 000)																			Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
			Construction of small dam across the river for storage of water of river surface for ritual activities at Shankhamul Ghat area; Thapathali-Teku Dovan; Brahmayani temple ghat-Dhum Barahi temple ghat (Mangal Tirtha); Guheshwori - Pashupati; Shova Bhagwati temple - Teku dovan	5	stretch	10,000																						Municipality	HPCIDBC	
			Implementation of Pashupati Master Plan (P1)	1	Pck	8,000,000	8,000,000		1,600,000	1,600,000	1,600,000	1,600,000	1,600,000																HPCIDBC, PADT, MoCTCA	Community
		Preservation of intangible heritage	**Revival, upgradation and management of Jatra route linking the monument with river, arrangement of physical structures for faciliating the Jatras - Rato Machindranath Jatra - Nakhu dovan, (P1), Kankeshwari Jatra, Bijeshwari 12 year jatra, Madhav narayan jatra, Hanuman ghat (P1)**	5	nos.	25,000	125,000		25,000	25,000	25,000	25,000	25,000															Municipality	HPCIDBC	
			Revival and preservation of cultural trails	1	pck	60,000	60,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	Municipality	HPCIDBC	
			Identification, development, implementation of master plan of cultural landscape to preserve the historic city plan - Shankhamul to Kumbeshwor area (P1), Kankeshwari to Yatkha area (P1), Dhum barahari to Bhaktapur darbar square (P2), Pashupati to Siphal (P1), Gokarneshwor temple to Gokarneshwar village, Balkumari to Tyagal Patan, Shobabhagwati to Swayambhu (P2)	7	nos.	350,000	8,000,000	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	122,500	Municipality	HPCIDBC	Donar agencies
			Sub Total				**19,866,000**	**378,833**	**2,073,833**	**2,073,833**	**2,133,833**	**2,153,833**	**2,123,833**	**473,833**	**458,833**	**438,833**	**438,833**	**415,500**	**145,500**	**155,500**	**155,500**	**125,500**	**125,500**	**125,500**	**125,500**	**125,500**	**125,500**			
3	**River/Water Quality and quantity improvement**	Management of Sewerage to prevent direct disposal into river	**Construction of separate sewerage Treatment System including interceptor network in following location**																								Municipality	HPCIDBC	Donar agencies
			a) Budhanilkhantha Municipality-9	1	nos.	2,432,100	2,432,100		810,699.84	810,699.84	810,699.84																		
			b) Budhanilkhantha Municipality-6	1	nos.	2,432,100	2,432,100					810,699.84	810,699.84	810,699.84															
			c) Chandragiri Municipality-15	1	nos.	3,706,674	3,706,674								1,853,337.02	1,853,337.02													
			d) Changunarayan Municipality-02	1	nos.	2,398,751	2,398,751										1,199,375.42	1,199,375.42											
			e) Godawari Municipality-12	1	nos.	1,022,057	1,022,057												340,685.57	340,685.57	340,685.57								
			f) Godawari Municipality-14	1	nos.	1,022,057	1,022,057															340,685.57	340,685.57	340,685.57					
			g) Kageshwori Manahora Municipality-09	1	nos.	3,609,194	3,609,194												1,203,064.70	1,203,064.70	1,203,064.70								
			h) Kathmandu Metropolitan City-16	1	nos.	5,363,537	5,363,537				1,340,884.22	1,340,884.22	1,340,884.22	1,340,884.22															
			i) Kathmandu Metropolitan City-11/12	1	nos.	5,363,537	5,363,537								1,340,884.22	1,340,884.22	1,340,884.22	1,340,884.22											
			j) Madhyapur Thimi Municipality-01	1	nos.	3,085,247	3,085,247				1,028,415.74	1,028,415.74	1,028,415.74																
			k) Mahalaxmi Municipality-02	1	nos.	3,213,520	3,213,520												1,071,173.38	1,071,173.38	1,071,173.38								
			l) Mahalaxmi Municipality-05	1	nos.	3,213,520	3,213,520															1,071,173.38	1,071,173.38	1,071,173.38					
			m) Nagarjun Municipality-09	1	nos.	3,126,813	3,126,813															1,042,270.85	1,042,270.85	1,042,270.85					
			n)Suryabinayak Municipality-02	1	nos.	1,867,458	1,867,458										622,486.08	622,486.08	622,486.08										
			o) Tarakeshwor Municipality-04	1	nos.	4,101,373	4,101,373													1,367,124.48	1,367,124.48	1,367,124.48							
			p) Tokha Municipality -09	1	nos.	3,126,574	3,126,574																1,042,191.36	1,042,191.36	1,042,191.36				
			Construction of WWTP at Teku Dovan	1	nos.	3,000,000	3,000,000	1,000,000	1,000,000	1,000,000																		Municipality	HPCIDBC	Donar agencies
			Construction of WWTP at Kodku	1	nos.	1,575,000	1,575,000	525,000	525,000	525,000																		Municipality	KUKL	Donar agencies
			Construction of WWTP at Gokarna	1	nos.	680,000	680,000	340,000	340,000																			Municipality	KUKL	Donar agencies
			Construction of WWTP at Humumanghat	1	nos.	270,000	270,000	216,000	54,000																			Municipality	KUKL	Donar agencies
		Management of Solid waste disposal directly into river system	**Establishment of Control system with installation of CCTV along river corridor**																								Municipality	HPCIDBC	
			a) Bagmati River	500	nos.	10	5,000		5,000																				
			b) Bishnumati River	230	nos.	10	2,300		2,300																				
			c) Dhobi Khola	240	nos.	10	2,400		2,400																				
			d) Manahara River	280	nos.	10	2,800			2,800																			
			e) Hanumante Khola	280	nos.	10	2,800			2,800																			
			f) Nakhu Khola	200	nos.	10	2,000			2,000																			
			h) Balkhu Khola	180	nos.	10	1,800				1,800																		
			i) Godawari Khola	180	nos.	10	1,800				1,800																		
			j) Manamati Khola	80	nos.	10	800				800																		
			k) Khodku Khola	220	nos.	10	2,200				2,200																		
			l) Mahadev Khola	40	nos.	10	400				400																		
			Installation of soild waste collection netting across into river at 1km interval	1	LS	260,000	260,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	Municipality	HPCIDBC	
		Conservation and management of water sources	**Conservation of water recharge zone of existing water sources**	1	LS	50000	50000		5000	5000	5000	5000	5000	5000	5000	5000	5000	5000										Municipality	HPCIDBC	
			Revival and preservation of Historic ponds including associated features like well, Jahru, shrines																								Municipality	HPCIDBC, DoA	Donar agencies

Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in	Total Budget, NRs. (in 000)	Periodical Target (in 000)																		Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
			a) Ikhapukhu, Kamal pokhari, Khyecha pokhari, Kirtipur bhi pukhu - mabhi pukhu - Lava pukhu - De pukhu - Gwa pukhu, Gahana pokhari, Nag pokhari, Kamaladi pokhari, Pachali bhairav pokhari, Rajrajeshwari pokhari, Lampokhari - chabahil, Puwa pokhari - handigaon, Nag pokhari - civil mall, Kamal pokhari - Chaya complex within Kathmandu district	18	nos.	100,000	1,800,000		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000				
			b) Nag daha, Manda pukhu north and south , Pina pukhu, dathu pukhu - thecho, Hyangu nyah pukhu, Fongashi - thecho, Fongashi, Kvey lachi pukhu, ujah pukhu, sauja pukhu - Sunakothi , Saptapatal pokhari, Nhu pukhu, Prayag pukhu, Na pukhu, Palesva pukhu - pulchowk, Balkumari pukhu, Guita pukhu, Mal pokhari, Harisiddhi pokhari, Godavari kunda, Badegoan buddha pokhari, Thaiba pokhari within Lalitpur district	22	nos.	100,000	2,200,000	10,000	10,000	10,000	10,000	20,000	20,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000				
			c) Kamal binayak pukhu (raj kulo disruption), Tekhacho pukhu, Bekhal pukhu, Chyamasingh pukhu, Byasi pukhu, Sunga pukhu - thimi, Bal kumari square pukhu - thimi, Dondal pukhu - thimi, Bode palesva pukhu, Nagadesh pukhu within Bhaktapur District	10	nos.	100,000	1,000,000		10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000													
			Revival and preservation of Raj kulo (Kathmandu, Bhaktapur, and Lalitpur) (P1)	1	Pck	1,500,000	1,500,000		75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	90,000	90,000	90,000	90,000	90,000	75,000	75,000	75,000	75,000	75,000	Municipality	HPCIDBC, DoA	Donar agencies
			Revival and preservation of dhungedhara																							Municipality	HPCIDBC, DoA	Donar agencies
			a) Sundhara, Ko hiti, Maru hiti, Tha hiti, Narayan hiti, swara hiti - durbarmarg, Kimdol hiti, Swayambhu hiti, Tangal Gairidhara, Lazimpat hiti, Bhatbhateni hiti, Dhum barahi hiti, Handigaon hiti, Handigaon Pach dhara, Naxal Bhagwati hiti, Boudha Mahankal, Chabahil hiti, Chabahil Ganesh hiti, Jaya bageshwari hiti, Bhuwaneshwari hiti - pashupati, battisputali hiti, Koteshwor Mahadevsthan hiti, Dallu hiti, Yanga hiti, Paknajol hiti, Kapur dhara, Bhimsenthan hiti - propakar, Lagan hiti, Dhobi dhara within Kathmandu District	30	nos.	10,000	300,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000				
			b) Tapa hiti, Thapa hiti, Guita hiti, Chyasal hiti, Misa hiti, Konti hiti, Swara hiti, Alko hiti, Tyagal hiti, Tangal hiti, Saugal hiti, Sincha hiti, Na tole hiti, Nag bahal hiti, Badegaon hiti, Jawalakhel hiti, Sundhara hiti, Dhobighat within Lalitpur District	17	nos.	10,000	170,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000							
			c) Chyasalin mandap hiti, Pulan hiti, Sundhara hiti, sala ganesh hiti, Baku hiti - Hanumanghat, Bhimdyo hiti, Dhauwa hiti - indrayani pith, Brahmayani pith hiti, Dhum barahi pith hiti, khauma hiti, Nasamana tol hiti, Ga hiti -taumadhi, Byasi gate hiti, hiti at Nagadesh, Hiti at Bode, HIti at Thimi within Bhaktapur District	17	nos.	10,000	170,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000							
Sub Total							**62,083,811**	**2,139,000**	**2,897,400**	**2,501,300**	**3,345,000**	**3,348,000**	**3,348,000**	**2,309,584**	**3,352,221**	**3,352,221**	**3,320,746**	**3,335,746**	**3,395,410**	**4,140,048**	**4,140,048**	**3,979,254**	**3,639,321**	**3,639,321**	**1,165,191**	**123,000**	**113,000**			
Total							**106,409,811**	**3,092,833**	**9,744,567**	**11,651,467**	**13,027,166**	**13,340,166**	**8,324,166**	**5,205,751**	**5,853,388**	**5,353,388**	**4,578,579**	**4,550,246**	**3,567,910**	**4,312,548**	**4,311,548**	**4,120,754**	**3,780,821**	**3,780,821**	**1,306,691**	**264,500**	**254,500**			

Peri Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in 000)	Total Budget, NRs. (in 000)	Periodical Target (in 000)																			Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
1	River conservation and Management	Strengthen River Cleaning Program	**Periodic cleaning of rivers**	20	years	10,000.00	200,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	Municipality	HPCIDBC	
			Mass movement for cleaning campaign in collaboration with local government and community	20	years	2,000.00	40,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	Municipality	HPCIDBC	
			Promote corridor walkathan in each rivers	20	years	2,000.00	40,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	Municipality	HPCIDBC	
		Management of Public Land along the River Corridor	**Verification and Inventory of illegally encroached land along river banks (P1)**	1	Ls	10,000	10,000	10,000																				Municipality	HPCIDBC	
			Relocation of verified squatters of squatter settlement - Khandpakha, Palpakot, Narayanthan, Maijubahal, Khadgabhadrakali, Mandikhatar, Ramhiti along the river bank (P1)	1	Ls	1,650,000	1,650,000		750,000	1,250,000	1,250,000	1,250,000																Municipality	HPCIDBC	
			Establish and maintain Child friendly park along River (Open Space & greenery management)	1	LS	200,000	200,000	40,000	40,000	40,000	40,000	40,000																Municipality	HPCIDBC	
			Establish and maintain Youth friendly park along River (with Gym eqquippment)	1	Ls	300,000	300,000	60,000	60,000	60,000	60,000	60,000																Municipality	HPCIDBC	
			Establish and maintain Old age friendly park along River (Open Space with Yoga facility)	1	Ls	200,000	200,000	40,000	40,000	40,000	40,000	40,000																Municipality	HPCIDBC	
			Salix plantation along river corridor area	10	Year	10,000.00	100,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00	10,000.00											Municipality	HPCIDBC	
		Sustainable landuse management	**Construction of sediment trapping structures**																									Municipality	HPCIDBC, DoFSC	
			a) Bagmati River	1	nos.	5,000	5,000	5,000																						
			b) Bagmati downstream River	1	nos.	5,000	5,000					5,000																		
			c) Bishnumati River	2	nos.	5,000	10,000	10,000																						
			d) Hanumante Khola	2	nos.	5,000	10,000	10,000																						
			e) Manohara River	2	nos.	5,000	10,000				10,000																			
			f) Nakkhu Khola	1	nos.	5,000	5,000							5,000																
			Promote alternative practices to surface water irrigation	1	LS	20,000	20,000		5,000	5,000	5,000	5,000																Municipality	HPCIDBC, DoI	
		Disaster mitigation	**Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate**	150	km	80,000	12,000,000		1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000	1,200,000										Municipality	HPCIDBC/ MoEWRI	
		Development of corridor transport system along rivers	**Construction of pedestrian and environment friendly smart corridor road network (about 151 km) including road furniture and junction improvement along rivers beyond Proposed Waterway**																									Municipality	HPCIDBC, DoR	
			a) Road Corridor along Bagmati River (Both Side - 33km)	33	km	120,000.00	3,960,000										360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000	360,000			
			b) Road Corridor along Bishnumati River (Both Side-5km)	5	km	80,000.00	400,000						200,000	200,000																
			c) Road Corridor along Hanumante River (Both Side-10km)	10	km	80,000.00	800,000										160,000	160,000	160,000	160,000	160,000									
			d) Road Corridor along Nakhu Khola (Both Side-14km)	14	km	80,000.00	1,120,000									160,000	160,000	160,000	160,000	160,000	160,000	160,000								
			e) Road Corridor along Balkhu Khola (Both Side-14km)	14	km	80,000.00	1,120,000										160,000	160,000	160,000	160,000	160,000	160,000	160,000							
			f) Road Corridor along Khodku Khola (Both Side-9km)	9	km	80,000.00	720,000										120,000	120,000	120,000	120,000	120,000	120,000								
			g) Road Corridor along Manahara River (Both Side-22km)	22	km	80,000.00	1,760,000										160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000			
			h) Road Corridor along Mahadev Khola (Both Side-8km)	8	km	80,000.00	640,000								160,000	160,000	160,000	160,000												
			i) Road Corridor along Dhobi Khola (Both Side-3km)	3	km	80,000.00	240,000										120,000	120,000												
			j) Road Corridor along Sangla Khola (Both Side-10km)	10	km	80,000.00	800,000										160,000	160,000	160,000	160,000	160,000									
			k) Road Corridor along Godawari Khola (Both Side-10km)	10	km	80,000.00	800,000									160,000	160,000	160,000	160,000	160,000										
			l) Road Corridor along Manamati Khola (Both Side-13km)	13	km	80,000.00	1,040,000								160,000	160,000	160,000	160,000	160,000	240,000										
			Upgrading of existing corridor road network (about 25 km) to pedestrian and environment friendly smart corridor road including road furniture and junction improvement																									Municipality	HPCIDBC, DoR	
			a) Road Corridor along Bagmati River (8.45km)	8.45	km	80,000.00	676,000							159,434	159,434	159,434	197,698													
			b) Road Corridor along Bishnumati River (2.54km)	2.54	km	60,000.00	152,400						152,400																	
			c) Road Corridor along Hanumante River (3.5km)	3.5	km	60,000.00	210,000										120,000	90,000												
			d) Road Corridor along Balkhu Khola (3km)	3	km	60,000.00	180,000						90,000	90,000																

Peri Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in 000)	Total Budget, NRs. (in 000)	Periodical Target (in 000)																	Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
			e) Road Corridor along Mahadev Khola (4.22km)	4.22	km	60,000.00	253,200							120,000	133,200															
			f) Road Corridor along Godawari Khola (2.24km)	2.24	km	60,000.00	134,400						134,400																
			g) Road Corridor along Manamati Khola (1km)	1	km	60,000.00	60,000							60,000															
			Construction of Universal Smart pedestrian bridges at maximum 500m interval in Bagmati River (27), Bishnumati River (1), Hanumante River (1), Nakhu Khola (8), Balkhu Khola (3), Manahara Khola (15), Khodku Khola (2), Mahadev Khola (1), Godawari Khola (2), Manamati Khola (3), Sangle Khola (3), Suryamati Khola (3)	69	nos.	10,000.00	690,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	50,000	50,000	50,000	50,000	50,000	50,000	Municipality	HPCIDBC, DoR	
Sub Total							**30,561,000**	**199,000**	**2,149,000**	**2,649,000**	**2,659,000**	**2,654,000**	**1,830,800**	**1,888,434**	**1,866,634**	**2,053,434**	**3,451,698**	**3,214,000**	**1,644,000**	**1,724,000**	**1,324,000**	**1,024,000**	**744,000**	**584,000**	**584,000**	**584,000**	**584,000**			
2	**Cultural/ Civilization rehabilitation**	Reclaim, Rehabilitate and conserve the cultural and heritage sites along river	**Restoration of cultural monuments and sites including approach trail**																								Municipality	HPCIDBC, DoA	Donar agencies
			a) Bagmati river - Chobaha, Jal binayak (P2)	1	Place	40,000.00	40,000.00						8,000.00	8,000.00	8,000.00	8,000.00	8,000.00												
			b) Vishnumati river - Manamaiju (P2)	1	Place	20,000.00	20,000.00						6,000.00	6,000.00	6,000.00														
			c) Nakhu river - Tika bhairav (P1)	1	Place	40,000.00	40,000.00		20,000.00	20,000.00																			
			d) Manahara river - Salinadi, Changu narayan temple (P1)	1	Place	60,000.00	60,000.00		30,000.00	15,000.00	15,000.00																		
			Development of Ghat and Bhakari including metal chain using traditional construction technology beyond the proposed waterway with conserving the exisiting monuments and sites																								Municipality	HPCIDBC, DoA	Donar agencies
			a) Nakhu tika bhairav temple area (P1), confluence of Bagmati and Nakhu river (P3)	2	Place	20,000.00	40,000.00			20,000.00			20,000.00																
			b) all study river at interval of 100m	30	km	20,000	600,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00	30,000.00			
			Construction of small dam across the river for storage of water of river surface for ritual activities at Salinadi (Madhav Narayan Temple Bank)	1	stretch	10,000.00	10,000.00																				Municipality	HPCIDBC, DoI	
		Preservation of intangible heritage	**Revival, upgradation and management of Jatra route linking the monument with river, arrangement of physical structures for faciliating the Jatras (Changunarayan Chinnamasta Jatra (P1); Rato Machindranath Jatra - Kotval daha (P2); 12 year festival chariot festival (P3); Tika bhairav jatra (P2))**	4	nos.	25,000.00	100,000.00		20,000.00				20,000.00		20,000.00			20,000.00										Municipality	HPCIDBC	
			Revival and preservation of cultural trails	1	pck	60,000.00	60,000.00	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	Municipality	HPCIDBC	
			Identification, development, implementation of Master plan of cultural landscape to preserve the historic city plan - Tika bhairav to Lele(P4) and Chapagaon,Sankhu to Bajrayogini (P3)	2	nos.	350,000.00	700,000.00										70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000	Municipality	HPCIDBC	
Sub Total							**1,670,000**	**33,000**	**103,000**	**88,000**	**48,000**	**33,000**	**87,000**	**47,000**	**67,000**	**41,000**	**41,000**	**123,000**	**103,000**	**103,000**	**103,000**	**103,000**	**103,000**	**103,000**	**103,000**	**103,000**	**103,000**			
3	**River/Water Quality and quantity improvement**	Management of Sewerage to prevent direct disposal into river	**Construction of separate sewerage Treatment System including interceptor network in following location**																								Municipality	HPCIDBC	
			a) Dakshinkali Municipality-03	1	nos.	388,634	388,634																		129,544.70	129,544.70	129,544.70			
			b) Shankharapur Municipality-09	1	nos.	530,147	530,147					176,715.65	176,715.65	176,715.65															
			c) Lalitpur Metropolitan City-22	1	nos.	2,841,255	2,841,255										947,085.12	947,085.12	947,085.12										
			d) Kirtipur Municipality-6	1	nos.	771,747	771,747								385,873.63	385,873.63													
			e) Kirtipur Municipality-4	1	nos.	771,747	771,747										257,249.09	257,249.09											
			f) Suryabinayak Municipality-05	1	nos.	1,867,458	1,867,458													622,486.08	622,486.08	622,486.08							
		Management of Solid waste disposal directly into river system	**Establishment of Control system with installation of CCTV along river corridor**																								Municipality	HPCIDBC	
			a) Bagmati River	420	nos.	10	4,200		4,200																				
			b) Bishnumati River	80	nos.	10	800		800																				
			c) Dhobi Khola	60	nos.	10	600		600																				
			d) Manahara River	220	nos.	10	2,200			2,200																			
			e) Hanumante Khola	140	nos.	10	1,400			1,400																			
			f) Nakhu Khola	200	nos.	10	2,000			2,000																			
			h) Balkhu Khola	160	nos.	10	1,600				1,600																		
			i) Godawari Khola	180	nos.	10	1,800				1,800																		
			j) Manamati Khola	120	nos.	10	1,200				1,200																		
			k) Khodku Khola	150	nos.	10	1,500				1,500																		
			l) Mahadev Khola	120	nos.	10	1,200				1,200																		
			Installation of soild waste collection netting across into river at 1km interval	1	Ls	260,000	260,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	Municipality	HPCIDBC	
		Encourage organic farming	**Promote/encourage urban organic farming through production based subsidy (Location/Area)**	1	LS	50,000	50,000		10,000		10,000		10,000	10,000	10,000													Municipality	HPCIDBC, DoA	

Peri Urban Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in 000)	Total Budget, NRs. (in 000)	Periodical Target (in 000)																		Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
			Discourage chemical fertilizer and chemical pesticide with alternatives	1	LS	5,000	5,000	1,000	1,000	1,000			1,000	1,000															Municipality	HPCIDBC, DoA	
		Conservation and management of water sources	**Construction of rain water storage/ harvesting ponds**	8	Nos.	3000	24000	12000					12000															Municipality	HPCIDBC, KUKL	
			Development of Water reservoir dam along rivers and water retaining ponds/reservoir (3 nos.)	1	LS	1250000	1250000	250000	250000	250000	250000	250000																Municipality	HPCIDBC, DoED, DoI	Donar agencies
			Conservation of water recharge zone of existing water sources	1	LS	50000	50000		5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000										Municipality	HPCIDBC, DoFSC	
			Revival and preservation of Historic/traditional ponds																									Municipality	HPCIDBC, DoA	Donar agencies
			a) Tau daha, Kritipur (P1)	1	nos.	20,000.00	20,000.00																							
			b) Saraswati Kund (P4), Lele Kunda, Pyangaon Fongasi Pokhari, Pauli Pukhu - Bulu (P4) , Ta Pukhu - Bhansar tol - Chapagaon (P4), Bhaorav pukhu - chapagaon, Bajrabarahi Pokhari (P1), Kamal Pokhari - Singenyah Pukhu -Jhyalipati (P2) within Lalitpur District	9	nos.	100,000.00	900,000.00	100,000.00	100,000.00				100,000.00	100,000.00									100,000.00	100,000.00	100,000.00	100,000.00	100,000.00			
			Revival and preservation of dhungedhara																									Municipality	HPCIDBC, DoA	Donar agencies
			a) Dhungedhara at Sankhu historic settlement (P1), Tokha lachi hiti (P3), Manamaiju hiti (P2), Baise dhara - balaju (P1) within Kathmandu district	4	nos.	10,000.00	40,000.00		10,000.00	10,000.00					10,000.00									10,000.00							
			b) Chapagaon hiti (P1), Harisiddhi hiti dhalko, siddhipur hiti, Lubhu hiti, (P2) Godavari nau dhara (P1),Hitiphusa - Dholahiti - Sunakothi (P1) within Lalitpur district	6	nos.	10,000.00	60,000.00			10,000.00	10,000.00	10,000.00	10,000.00	10,000.00																
			c) Hiti at changunarayan area (P1), Hiti at Suryabinayak area (P1) within Bhaktapur district	2	nos.	10,000.00	20,000.00		10,000.00	10,000.00																				
			Revival and preservation of Raj kulo (Kathmandu, Bhaktapur, and Lalitpur)	1	Pck	1,500,000.00	1,500,000.00		75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	90,000.00	90,000.00	90,000.00	90,000.00	90,000.00	75,000.00	75,000.00	75,000.00	75,000.00	75,000.00	Municipality	HPCIDBC, DoA, DoI	Donar agencies
			Support and participation of local communities in improving water use efficiency	1	LS	2500	2500		1500				1000															Municipality	HPCIDBC, DoFSC	
Sub Total							**11,370,989**	**376,000**	**481,100**	**379,600**	**370,300**	**519,716**	**303,716**	**390,716**	**598,874**	**488,874**	**350,249**	**1,312,334**	**1,050,085**	**1,672,571**	**725,486**	**725,486**	**198,000**	**188,000**	**317,545**	**317,545**	**317,545**			
Total							**43,601,989**	**608,000**	**2,733,100**	**3,116,600**	**3,077,300**	**3,206,716**	**2,221,516**	**2,326,150**	**2,532,508**	**2,583,308**	**3,842,947**	**4,649,334**	**2,797,085**	**3,499,571**	**2,152,486**	**1,852,486**	**1,045,000**	**875,000**	**1,004,545**	**1,004,545**	**1,004,545**			

Conservation Zone

S. N.	Sector	Activities	Action	Qty	Unit	Unit Rate, NRs. (in 000)	Total Budget, NRs. (in 000)	Periodical Target (in 000)										Periodical Target (in 000)										Budget and source		
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Local	Central	Others
1	River conservation and Management	Promote Ecotourism	**Study and development of Cycling/Hiking trail along the foot hill of the valley**	258	km	10,000	2,580,000	860,000	860,000	860,000																		Municipality	HPCIDBC, SNNP	
			Establishment of waste management services along treking/cycling routes	1	Ls	6,000	6,000	1,500				1,500					1,500					1,500						Municipality	HPCIDBC	
		Conservation of the land use to recharge water source	**Relocation of existing settlement of SNNP area - Mulkharka Settlement (187 HH)(P3), Thulo/Sano Chilaune (70 HH)(P1), Okhreni (167 HH)(P2) and Kunegaun (45 HH)(P1)**	1	Ls	3,500,000	3,500,000		140,000	200,000	260,000	250,000	100,000	250,000	350,000	400,000	150,000	150,000	350,000	400,000	300,000	200,000						Municipality	HPCIDBC	
			Identify and study the existing settlement within Conservation Zone area and prepare the development modality of identified settlements. (P1)	1	nos	5,000	5,000	5,000																				Municipality	HPCIDBC	
		Disaster mitigation	**Construction of river training structure with bioengineering (salix and other plantation) or Ghat structure along river corridor area as per appropirate**	18	km	80,000		16,000	16,000	16,000	16,000	16,000																Municipality	HPCIDBC/ MoEWRI	
		Sustainable landuse management	**Construction of check dams for Gully control in following river**																									Municipality	HPCIDBC, DoFSC	
			a) Bagmati River	77	nos.	100	7,700	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385	385			
			b) Bagmati downstream River	220	nos.	100	22,000	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100			
			c) Balkhu Khola	68	nos.	100	6,800	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340			
			d) Bishnumati River	165	nos.	100	16,500	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825	825			
			e) Dhobi Khola	22	nos.	100	2,200	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110			
			f) Godawari Khola	32	nos.	100	3,200	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160	160			
			g) Hanumante Khola	161	nos.	100	16,100	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805	805			
			h) Kodku Khola	19	nos.	100	1,900	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95			
			i) Manohara River	156	nos.	100	15,600	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780	780			
			J) Nakkhu Khola	109	nos.	100	10,900	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545	545			
			Construction of sediment trapping structures																									Municipality	HPCIDBC, DoFSC	
			a) Bagmati River	1	nos.	5,000	5,000		5,000																					
			b) Bagmati downstream River	3	nos.	5,000	15,000						5,000		5,000		5,000													
			c) Dhobi Khola	1	nos.	5,000	5,000			5,000																				
			d) Hanumante Khola	2	nos.	5,000	10,000		5,000				5,000																	
			e) Manohara River	2	nos.	5,000	10,000				5,000				5,000														
			f) Nakkhu Khola	2	nos.	5,000	10,000							5,000			5,000												
			Terrace improvement and promote multiyear crop cultivation	1	Ls	2,000.00	2,000	500					500					500					500					Municipality	HPCIDBC, DoFSC	
			a)Bishnumati Watershed	2,325	ha	15	34,875	20,925					13,950																	
			b) Balkhu Watershed	600	ha	15	9,000	5,400					3,600																	
			c) Dhobi Watershed	150	ha	15	2,250	1,350					900																	
			d) Hanumante Watershed	2,260	ha	15	33,900	20,340					13,560																	
			e) Nakkhu Watershed	1,935	ha	15	29,025	17,415					11,610																	
			f) Bagmati downstream Watershed	3,700	ha	15	55,500	33,300					22,200																	
			g) Bagmati Watershed	490	ha	15	7,350	4,410					2,940																	
			h) Kodku Watershed	190	ha	15	2,850	1,710					1,140																	
			i) Manohara Watershed	1,000	ha	15	15,000	9,000					6,000																	
			j) Godawari Watershed	775	ha	15	11,625	6,975					4,650																	
			Replacement of pine with broad leave forest 321Ha; Godawari-75 Ha, Hanumante-210 Ha , Nakkhu-23 Ha, Bagmati downstream-13 Ha	1	Ls	14,000	14,000		6,000	6,000	2,000																	Municipality	HPCIDBC, DoFSC	
			Sub Total				**6,466,275**	**1,008,970**	**1,037,145**	**1,092,145**	**288,145**	**272,645**	**196,195**	**260,145**	**365,145**	**405,145**	**166,645**	**155,645**	**355,145**	**405,145**	**305,145**	**206,645**	**5,645**	**5,145**	**5,145**	**5,145**	**5,145**			
2	Cultural/ Civilization rehabilitation	Reclaim, Rehabilitate and conserve the cultural and heritage sites along river	**Restoration of cultural monuments and sites including approach trail - Tarkeshwar Mahadev (P3), Bajrayogini (P1), Bagdwar (P2), Vishnu dwar (P4) and Mahadev Pokhari (P2)**	5	place	10,000	50,000		10,000				10,000					10,000					10,000					Municipality	HPCIDBC, DoA	Donar agencies
			Revival and preservation of Historic Manichud daha, Shankharapur including associated features	1	place	10,000	10,000						5,000	5,000													Municipality	HPCIDBC	Donar agencies
		Preservation of intangible heritage	**Revival and preservation of cultural trails (Sundarijal to Bagdwar (P1), Kotval daha trail (P1), Sankhu to Bajrayogini to Manichud daha (P1), Mahadev Pokhari - Nagarkot trail (P2) and Tarkeshwar Mahadev trail (P3)**	5	nos.	10,000	50,000	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	Municipality	HPCIDBC, DoA	Donar agencies
			Sub Total				**110,000**	**2,500**	**12,500**	**2,500**	**2,500**	**2,500**	**17,500**	**7,500**	**2,500**	**2,500**	**2,500**	**12,500**	**2,500**	**2,500**	**2,500**	**2,500**	**12,500**	**2,500**	**2,500**	**2,500**	**2,500**			
3	River/Water Quality and quantity improvement	Encourage organic farming	**Promote/encourage urban organic farming through production based subsidy**	1	LS	50,000	50,000	10,000	10,000	10,000	10,000	10,000																Municipality	HPCIDBC, DoA	
			Discourage chemical fertilizer and chemical pesticide with alternatives	1	LS	1,500	1,500	1,000	500																	Municipality	HPCIDBC, DoA	
		Water source conservation to Increase ground water recharge and river discharge	**Construction of rain water storage/ harvesting ponds**	198	nos.	3,000	594,000		60,000	60,000	60,000	60,000	60,000	60,000	60,000												Municipality	HPCIDBC, KUKL	
			Implementation of Nagmati Multipurpose dam Project	1	nos.	9,420,000	9,420,000		1,884,000	1,884,000	1,884,000	1,884,000	1,884,000														Municipality	HPCIDBC	Donar agencies
			Development of Water reservoir dam and water retaining ponds/reservoir (21 nos.)	1	Ls	47,500,000	47,500,000	4,000,000	4,000,000	4,000,000	4,000,000	4,500,000	4,000,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	2,000,000						Municipality	HPCIDBC, DoED, DoI	Donar agencies
			Salix plantation along river banks and dhap areas	1	LS	200,000	200,000	5,000					5,000					10,000									Municipality	HPCIDBC, DoFSC	
			Conservation and management of existing water sources	1	LS	2,000	2,000	2,000																			Municipality	HPCIDBC, DoFSC	
			Sub Total				**57,767,500**	**4,018,000**	**5,954,500**	**5,954,000**	**5,954,000**	**6,454,000**	**5,949,000**	**3,060,000**	**3,060,000**	**3,000,000**	**3,000,000**	**3,010,000**	**3,000,000**	**3,000,000**	**2,000,000**	-	-	-	-	-	-			
			Total				**64,343,775**	**5,029,470**	**7,004,145**	**7,048,645**	**6,244,645**	**6,729,145**	**6,162,695**	**3,327,645**	**3,427,645**	**3,407,645**	**3,169,145**	**3,178,145**	**3,357,645**	**3,407,645**	**2,307,645**	**209,145**	**18,145**	**7,645**	**7,645**	**7,645**	**7,645**			