CLIMATE RESILIENCE MODELING, PLANNING, AND DESIGNING for DEHRADUN and NAINITAL

Final Report Nainital

Climate Resilient Framework Plan and Concept Design

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Executive summary

This final report describes the results for Nainital under the Uttarakhand Integrated and Resilient Urban Development Project. The content is based on the outcomes of the design sessions by the stakeholders during the conceptualization workshops in June 2024 and the earlier results in the assessment report (November 2023). The two main deliverables in this final report are:

1. Climate Resilient Framework Plan.
2. Concept designs and prefeasibility assessment of priority adaptation measures.

A finalization workshop was conducted in October 2024 to review the deliverables and feedback from local stakeholders has been incorporated in this report. Specific feedback has been incorporated under “Pathways to master planning” and “Pathways to implementation” in chapters 2 & 3 respectively. Further, high-level suggestions have been incorporated under “opportunities and way forward” in Chapter 10.

Project objective and scope
The objective of the project is to support the Government of Uttarakhand in enhancing climate resilience in two cities: Dehradun and Nainital. The project is designed to contribute not only to address current problems but has the ambition to develop an approach that will enable the cities to sustainably achieve water-sensitive economic development and improve the quality of life for their people.

The work included a situation assessment, identification of adaptation measures, a strategy (framework plan) and a demonstration of how the measures and strategy can be incorporated in two selected locations (concept designs). For the adaptation measures the emphasis is on Nature-based Solutions (NbS). The elaboration for the two locations serves as a demonstration and is at a conceptual level.

Challenges and opportunities
In Nainital the focus is on landslides and water security. This includes both coping with the existing and progressing landslides, such as the one that occurred at Balia Nala, as well as including landslide susceptibility in the planning and design of future developments. This project does not aim to provide the solution for Balia Nala. The ambition is to bring together all involved departments and agencies to come to a common approach on how to deal with the issue of land slide susceptibility in urban development. There are relations with storm water, sewage and road drainage, irrigation, and construction of housing and infrastructure, such as roads and STPs.

Nature-based Solutions
Currently, grey infrastructure such as drains, culverts or constructed flood detention structures are the go-to solution to address water extremes. However, they follow a reactive approach that only address symptoms of a problem and not the cause. This is not a sustainable solution in the long term with the availability of space becoming more and more critical in urban areas while climate challenges are increasing rapidly. There is therefore a need to protect and enhance the functions of natural systems in the city to address issues at their cause.

In India the need to integrate Nature-based Solutions (NbS) in city planning is still growing. Although it builds on well-known approaches such as Ecosystem-based Adaptation and Water-Sensitive Planning. In urban areas, NbS are also associated with urban drainage, biodiversity improvement and greening of the urban environment. In cities such as Nainital, NbS should be considered first. In some cases, though, issues such as space availability might limit their implementation. In that kind of situation, hybrid solutions that include a mix of grey and green infrastructure may be more appropriate. Grey

measures should only be the last resort when other measures do not seem a feasible alternative from a technical or cost-effectiveness point of view.

Climate resilient framework plan
The Urban Framework Plan provides the basis for concept design. It is a strategy for a climate resilient Nainital, considering three planning scales: (a) macro level: Blue-Green network of Nainital, (b) meso level: resilient neighborhoods, and (c) micro level: small-scale interventions.
Based on the sketches by the participants in the conceptualization workshop in June 2024 the urban framework plan has been illustrated in a plan map. Main elements in the framework plan for a climate and water resilient Nainital are:

1. Urban development (restricted) based on landslide risk zoning, respect/ protect existing green pockets and expand green spaces.
2. Traffic/mobility: consider Park and Ride (P+R) locations outside the town and improve/ promote public transport.
3. Water circularity: reduce water demand and promote rainwater harvesting.

Concept design of measures in selected case study sites
To demonstrate the framework plan two concept designs were made with a pre-feasibility assessment of priority adaptation measures (NbS). For this two case study sites were selected: (1) Nainital Lake (west hills), and (2) Sri Krishnapur settlement (downstream of Nainital Lake). A tailored set of adaptation measures – NbS for mountainous areas – has been identified and elaborated, including costing. An example of an NbS combination is road drainage, gabions in stepped drain and soil nailing.

Lessons learnt
From working on the project simultaneously in Dehradun and Nainital, we can bundle the experiences and lessons learned from this period. Hopefully this will feed the dialogue and cooperation in developing, designing, and implementing measures to enhance climate resilience and water sensitivity. The lessons include:

1. Integrating ecosystem-based approach within urban planning. Both cities must consider developing a Water Management Strategy. The aim of the Water Management Strategy is to deliver a new approach and solutions (e.g. city as a sponge) in urban water management and spatial planning, to create a more water resilient Nainital. And can learn from other cities in India like Chandigarh, Chennai, Delhi, Kochi, Kolkata, Udaipur, where Water-Sensitive Planning (WSP) is already being practiced.
2. Mainstreaming climate change action. Climate change action should be driven by increased local monitoring, data collection and awareness building.
3. Designing community-inclusive solutions. The implementation of Nature-based Solutions within these sites requires the involvement and participation of local communities, landowners and beneficiaries.
4. Creating and increasing local ownership. For cities to become resilient to climate change and water extremes, a strong commitment and ownership from the local counterpart is required to ensure implementation. There is a need for a high-level official to act as a champion for the project with enough convening power to bring all relevant actors around the table.

Opportunities and the way forward
1. Find a city champion for the further planning, design and implementation of NbS interventions.
2. Promoting NbS in Nainital planning week. Engage city departments (engineers and planners) and high-level decision makers to develop neighborhood plans and measures.
3. Use the assessment and framework plan as input for zoning maps.
4. Use the framework plan and the concept designs as the departure point for further integrated planning and design of NbS interventions to increase climate resilience.
5. Involve from the start all relevant actors in further urban planning and design of interventions.
6. Prototyping NbS strategies for similar cities and towns in the mountains of India.

Recommendations

1. Although restrictions to further urban development have been proposed, the city continues to expand. Regulation should be strengthened to limit urban expansion in landslide prone areas.
2. Making existing infrastructure resilient. By generating city-wide maps, resilience measures can be planned in a systematic and prioritized manner.
3. The urban expansions in Bhimtal and Khurpatal are opportunities to establish climate resilient districts by understanding landslides susceptibility zoning es and water-sensitivity opportunities.
4. Valuing water as a resource. Decoupling rainwater and sewage. Prevent faulty connections. Connecting sewers to STPs. Reducing water consumption.

Contents

Abbreviations

ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AQI	Air Quality Index
BOD	Biological Oxygen Demand
BOQ	Bill of quantities
CAST	Climate-Adaptation Support Tool
CBI	City Biodiversity Index
CGWB	Central Ground Water Board
CIPP	Cured In Place Pipe
CRC	Climate Resilient City
CRCTool	Climate Resilient Cities Tool
CWC	Central Water Commission
DRM	Disaster Risk Management
GLOF	Glacier Lake Outburst Flood
IISWR	Indian Institute of Soil and Water Conservation
IMD	India Meteorological Department
IWRM	Integrated Water Resources Management
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
GoI	Government of India
KPI	Key Performance Indicator
LGFS	Light Gauge Framing System
LID	Low Impact Development
lpcd	litre per capita per day
MDDA	Mussoorie Dehradun Development Authority
MLD	Million Litres per Day
NAPCC	National Action Plan for Climate Change
NbS	Nature-based Solutions
NGO	Non-Governmental Organization
NRW	Non-Revenue Water
PMU	Project Management Unit
RBC	River Basin Committee
RBM	River Basin Management
RCM	Regional Climate Models
SCADA	Supervisory Control and Data Acquisition
SDF	Storage-Discharge-Frequency
SDG	Sustainable Development Goal
STP	Sewage Treatment Plant
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCE	Tata Consulting Engineers

UAPCC	Uttarakhand Action Plan for Climate Change
UDD	Urban Development Department
ULB	Urban Local Body
U-SAC	Uttarakhand Space Application Centre
UUSDA	Uttarakhand Urban Sector Development Agency
WSP	Water-Sensitive Planning
WSS	Water Supply & Sanitation

1. Introduction

This is the Final Report for Nainital under the project “CLIMATE RESILIENCE MODELING, PLANNING, AND DESIGNING for DEHRADUN and NAINITAL” or formally: ADB TA-6840 IND: Uttarakhand Integrated and Resilient Urban Development Project - IND 01: Firm on Climate Resilience Modelling, Planning, and Designing (38272-044). The final report is based on the draft final report combined with input from the client and the results of the final workshop conducted in Nainital in October 2024.

Four reports precede this Final Report:

- The Inception Report, final version released in September 2023
- The Interim Report, final version released in February 2024
- The Draft Final Report, released in September 2024
- The Assessment Report, first version November 2023, final version released with this report in November 2024

The latter report provides many details of the data, modelling and assessments done. This Final Report will only provide a summary, and the reader is referred to the earlier reports for details. A similar draft final report has been prepared for Dehradun. These two reports form Deliverable P3 of the Project Work plan and contract: “Draft Final Report, including (i) situation assessment, (ii) draft customized Climate Adaptation Support Tool (CAST) tools for Dehradun and Nainital; (iii) concept designs and pre-feasibility assessment of priority adaptation measures in Dehradun and Nainital; (iv) training materials on CAST (including nature-based measures) and training evaluation; and (v) climate resilient framework plans for Dehradun and Nainital watersheds.”

1.1 Background to the Project

Urban Water Challenges in Uttarakhand

Urbanization has been increasing rapidly in India. Dynamic and vibrant social and economic interactions in urban centres made people more productive and created more market opportunities for growth. In the state of Uttarakhand, the urban population grew by nearly 42% from 2001 to 2011, and the number of urban centres increased from 63 in 2001 to 92 in 2020. This increase in urban population has put pressure on the water supply systems that need to be adapted continuously to the ever-growing number of inhabitants. The provision of urban Water Supply Systems (WSS) in Uttarakhand has improved since 2008 largely due to investment support from the Asian Development Bank (ADB), but much room for improvement remains as urban areas are growing rapidly. While access to tap water is satisfactory, only 23% of urban local bodies (ULBs) provide it at a standard rate of 135 litres per capita per day (lpcd). The average duration of water supply is 3–4 hours per day. Inadequate water pressure at the household level resulted in so-called ‘self-provisioning coping costs’ to consumers who purchase own pumps and water from other sources. The percentage of non-revenue water (NRW) is high, 45%–50%, in most towns because of aging infrastructure and poor maintenance, operational inefficiencies, unmetered water supply, and hilly terrains. As for urban sanitation in Uttarakhand, about 96% of urban households have access to toilets. Out of 92 ULB jurisdictions, 25 have partial sewerage systems, with 20% of the total urban population connected to sewer networks. Households that are not connected to sewer networks are using septic tanks. Unorganized and inadequate faecal sludge and septage management is an issue. Most wastewater is disposed of along with stormwater and flows into natural watercourses, causing severe environmental and health risks. Along with climate change, cities and towns experience more frequent and intensive flash floods and seasonal flooding during monsoon. The environmental and health impacts of flooding

can be exacerbated by overflows of untreated wastewater and illegally disposed of septage (This paragraph is based on ADB, 2021).

Nainital

Nainital is the judicial capital of Uttarakhand, home to the state's High Court and the residence of the Governor of Uttarakhand. It has a total area of 11.73 km^2 at an average elevation of 2,084 meters (6,837 feet) above sea level and is set in a valley around Lake Nainital, which is 1,433 meters long and 463 meters wide. The population estimate for 2020 exceeds 60,000 — a 50% increase on the 2011 census data of 41,377. Since Nainital is a highly popular hill station, it attracts about 72,650 daily visitors, 90% of which stay overnight. The large increase in permanent residents and the huge floating population are seriously straining the city's water supply infrastructure and service capacity, despite the recent additions financed by ADB.

The catchment of Nainital lake does not have permanent rivers or streams. During rainfall events storm drains collect the surface flow and bring it to the lake. Part of the rainwater infiltrates into the ground and part of that water will reach the lake through groundwater flow. The lake only overflows when the highest acceptable lake level is exceeded, which happens rarely.

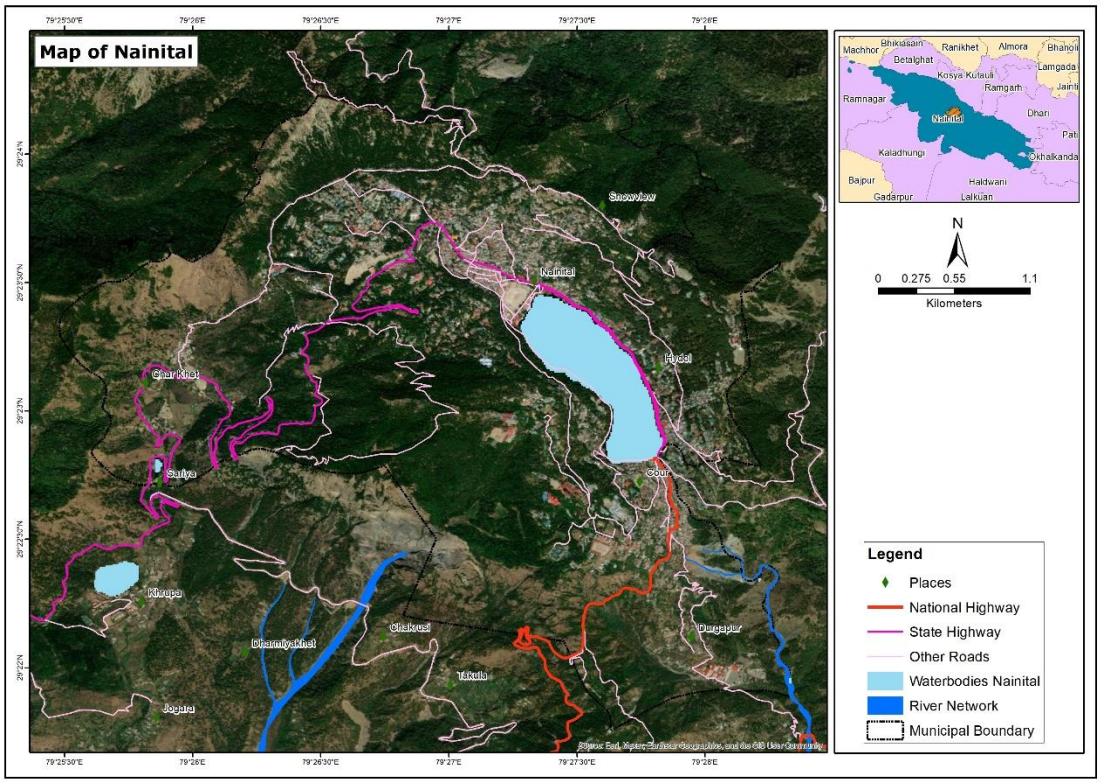


Figure 1-1: Map of Nainital area.

The most critical problem is water availability—the water authority in Nainital observed rapid groundwater depletion and a deterioration in water quality (of both groundwater and lake) and has therefore restricted water withdrawals from tube wells and lake water intake; it also reduced the hours of tap water availability. Water pollution is particularly bad in Nainital lake, because the trunk sewer that was built in 1940 is leaking and the capacity of the sewage treatment plant (STP) is far from adequate, so untreated water flows into the lake and seriously compromises the availability of clean water. Thus, upgrading the aging trunk sewer and replacing the STP in Nainital is very important for the sustainability of both water supply and sewerage systems.

The findings of the assessment phase, as presented in Chapter 4, show a very broad scope of issues regarding climate resilient urban planning including droughts, depletion of the lake, landslides and pollution. Considering all these issues together would strengthen the comprehensiveness of this project, but would also put pressure on the available resources, especially regarding the participation of a large number of stakeholders. Therefore, it was decided in a meeting with UUSDA and the ADB in February 2024 to focus for Nainital on the issue of landslides. This includes both coping with the existing and progressing landslides, such as Balia Nala, as well as including landslide susceptibility in the planning and design of future developments. This project does not aim to provide the solution for Balia Nala. The ambition is to bring together all involved departments and agencies to come to a common approach how to deal with the issue of landslide susceptibility in urban development. There are relations with storm water, sewage and road drainage, irrigation, and construction of housing and infrastructure, such as roads and STPs.

1.2 Institutional Setting of the Project

The contract for the project has been signed by the Urban Development and Water Division of ADB's South Asia Department. The Uttarakhand state government, acting through its Urban Development Department (UDD), forms the executing agency, and Uttarakhand Urban Sector Development Agency (UUSDA) acts as the implementing agency for the project.

Stakeholders from the State, local bodies and relevant departments have been and will be encouraged to actively participate in project workshops and consultations. Also inputs from academic, educational and non-government organizations, representing wards, or advocating issues, are welcomed.

The project is carried out by an experienced team of national and international experts from the associated firms Deltares and RMSI. They work in close interaction with the executing and implementing agencies and the many other organizations and stakeholders involved in the project.

1.3 Objectives and Vision

The objective of the consulting services is to support the Government of Uttarakhand in enhancing climate resilience in two major cities: Dehradun and Nainital.

The project aims to address the complexity of climate and human-induced problems, particularly floods, landslides, water scarcity from insufficient retention and detention and storage capacities, and water pollution; and to find solutions to effectively mitigate adverse impacts and enhance resilience. The project has supported:

- situation analysis, including the assessment of possible future changes in the socio-economic systems, and modelling works for scenario buildings, which should be based on participatory modelling of hydrology, flood mapping, groundwater modelling, and landslide mapping under different climate scenarios.
- the development of Climate-Adaptation Support Tools (CAST), which shall facilitate interactive planning and decision making.
- the selection and design of climate resilience measures with a special focus on Nature-based Solutions (NbS) at upstream and downstream urban cities – Dehradun, and Nainital; and
- the completion of a concept design and pre-feasibility assessment of selected measures for future investments.

An example of CAST is the Deltares' Climate Resilient Cities -tool (CRCTool) which has been modified and used to test identified Nature-based Solutions (e.g. bioswales, urban wetlands) affected by land use or urban typology, slope of terrain, groundwater depths and dynamics, soil type, and climate characteristics. Most available tools, guidelines and benchmarks for urban adaptation raise awareness of climate change impacts, assess the city's vulnerability (e.g. climate stress test) and/or address the need for adaptation at a policy level. However, tools that have the ability to implement adaptation solutions in the actual urban planning and design practice seem to be missing. Such a tool that fills this gap is the Adaptation Support Tool[1]. The CRCTool was born from the development of the original AST.

Outside Europe the CRCTool has been used in New Orleans (USA), Burnaby (Canada), Antananarivo (Madagascar), Nur Sultan (Kazakhstan), Yangon (Myanmar), Kampala (Uganda), Xiangtan (China) and for three cities in Indonesia. Using the CRCTool for Dehradun could be considered as a pilot in India. Due to its mountainous situation, the CRCTool in Nainital was mostly used as interactive Mapbox application.

The project has contributed not only to address current problems but has the ambition to develop an approach that will enable the cities to sustainably achieve water-sensitive economic development and the quality of life for their people.

The services were provided in four phases (Figure 1-2). The aim of the first, **Inception phase** was to consult with stakeholders and confirm the terms of reference, approach, methodology and work plan. The second, **Assessment phase** entailed a detailed situation assessment and analyses. In the **Conceptualization phase** climate adaptation decision supporting tools have been developed and applied in participatory sessions with stakeholders to create strategies and concept designs that increase urban resilience.

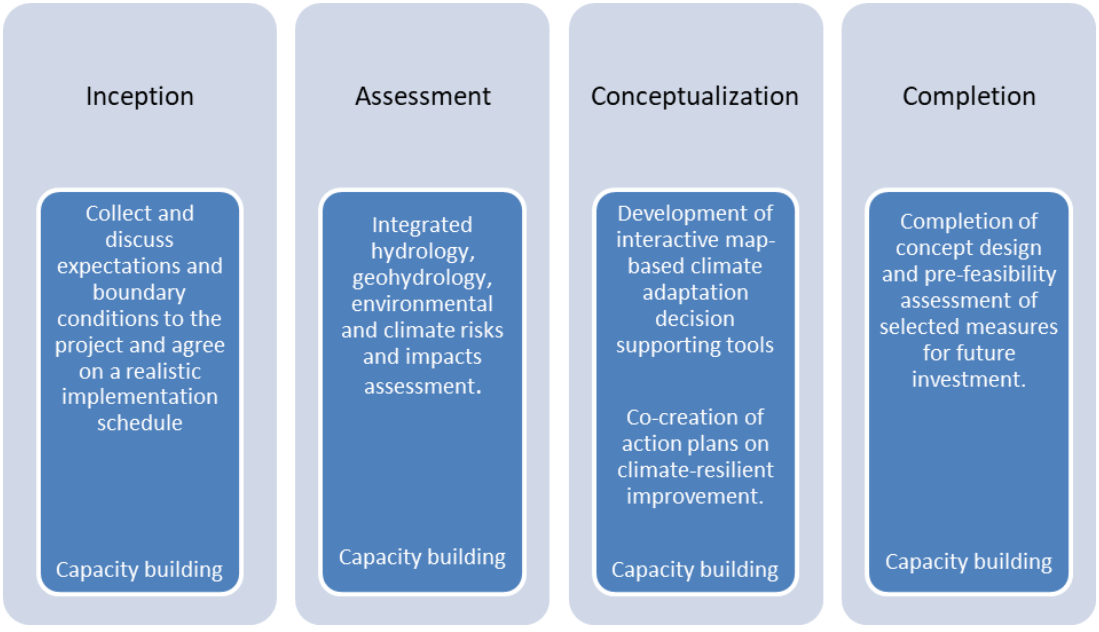


Figure 1-2: Proposed Phases in the Project implementation.

[1] Frans H.M. van de Ven, Robbert P.H. Snep, Stijn Koole, Reinder Brolsma, Rutger van der Brugge, Joop Spijker, Toine Vergroesen (2016) Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders, Environmental Science & Policy, Volume 66, Pages 427-436, ISSN 1462-9011, https://doi.org/10.1016/j.envsci.2016.06.010

This Draft Final Report presents the main results of the project for Nainital: the climate resilient framework plan (Chapter 2) and the concept design and pre-feasibility assessment of priority adaptation measures (Chapter 3). The following chapters present the building blocks: a summary of the situation assessment (Chapter 4), a report of the conceptualization workshop (Chapter 5), a description of the Climate Adaptation Support Tool (Chapter 6) and a summary of the training material and the evaluation of the training (Chapter 7). Challenges encountered and modifications made in the set-up of the project are described in Chapter 8, lessons learned in Chapter 9 and the report concludes with recommendations for the way forward in Chapter 10.

1.4 Nature-based Solutions introduction

Urban areas are under considerable pressure to provide safe and liveable environments where people have access to housing, jobs, infrastructure and services. Rapid urbanization and the effects of climate change increase the urgency of cities to address climate challenges consistently and comprehensively in urban areas.

Currently, grey infrastructure such as drains, culverts or constructed flood detention structures are the go-to solution to address water extremes. However, they follow a reactive approach that only address symptoms of a problem and not the cause. That makes grey infrastructure less flexible to adapt to the inherent uncertainty in future challenges. This is not a sustainable solution in the long term while challenges posed by climate change and socioeconomic developments are increasing rapidly. There is therefore a need to protect and enhance the functions of natural systems in the city to address flooding issues at its cause.

Nature-based Solutions (NbS), like protecting wetlands or adding urban trees and green spaces, can be effective ways of reducing flood risk and other climate challenges. While restoring the water system and providing additional benefits such as habitat for native species and recreational open space for cities and their communities.

“NbS are defined as actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.” (IUCN, 2016; EC, 2019; UN, 2020)

In India the need to integrate NbS in city planning is still growing. Although it builds on well-known approaches such as Ecosystem-based Adaptation and Water-Sensitive Planning[1]. In urban areas, NbS are also associated with urban drainage, biodiversity improvement and greening of the urban environment. Urban NbS contribute to multiple goals: achieving resiliency to climate extremes, supporting healthy urban living, and strengthening biodiversity. Urban NbS form the potential ecological nodes in the blue-green network of the city, consisting of a linked system of waterways, parks and (NbS) structures that facilitate the flow, storage and purification of urban water. There, biodiversity can be enhanced by stimulating natural processes and by focusing on diversity of habitat and species, contrasting with how grey infrastructure usually works. Table 1 illustrates a distinction between three types of infrastructure in connection with urban development networks, landscape, soil, water and ecology.

Table 1-1 Recommended hierarchy of approaches to be considered when integrating NbS in an urban context (adapted from Dolman, 2023)

Interventions in water infrastructure		**Urban planning**	**Explanation**
Soft	Nature-based Solutions (e.g. blue-green infrastructure)	Protect and restore the natural network (soil and water systems). Alternatively retrofit it if protection is no longer possible.	Nature-based Solutions and the 'regenerative' development of the natural (blue-green) network in the city. Examples are urban water buffers, rain gardens and water parks.
	Hybrid solutions (e.g. blue-grey, green-grey infrastructure)	Co-organizing in city network (occupation).	The hybrid intervention is co-organizing in the urban network by increasing multifunctional shared use, for example in a flood defence as an elevated park.
Hard	Conventional solutions (i.e. grey infrastructure)		Strongly engineered solutions such as rainwater drainage and related interventions (e.g. underground buffer facilities and water squares that collect rainwater).

In cities such as Nainital, NbS should be considered first. In some cases, though, issues such as space availability might limit their implementation. In that kind of situation, hybrid solutions that includes a mix of grey and green may be more appropriate. Only if neither of those solutions are possible, should conventional grey infrastructure be considered. Grey measures should only be the last resort when other measures do not seem a feasible alternative from a technical or cost-effectiveness point of view. The latter, however, requires a more holistic perspective to be taken on costs and benefits, since NbS provide several additional benefits and values that are difficult to quantify and are often not included in typical cost-benefit-analyses.

An important aspect for NbS is the adoption of a systems thinking approach (as illustrated in chapter 2 – Climate Resilient Framework Plan) to address the cause of a problem. This requires a system analysis on a bigger scale (e.g. for the whole lake or river basin) and an understanding of the position of the specific project area within it.

It is important to look at existing green areas and how to protect and improve them before thinking about new NbS. In urban areas, the amount of existing nature areas is already very limited. This emphasizes the urgency to protect and enhance what is left, for example through zoning schemes or neighbourhood plans. Within highly developed areas however, the emphasis typically shifts to restoration and creation of new NbS.

Urban design and city planning are crucial in solving the many transitions our cities are facing. On one hand, there is the housing and energy transition. On the other, there is a need to safeguard the green-blue spaces for health and well-being, while also tackling the wide range of challenges related to climate extremes and restoring the soil, water, and ecosystem.

In both urban retrofit projects and new urban development, the integration of water management, subsurface systems, and ecology in the different phases of design and implementation is important. Design and planning approaches such as nature-based solutions and ecosystem-based adaptation provide useful tools for strengthening the integration of both water and nature in spatial planning and urban design processes, requiring any spatial intervention or new development to be evaluated on opportunities for sustainability and innovation.

An overview of NbS for the city of Nainital has been identified during the assessment phase and discussed with participants in the design sessions as part of the conceptualization workshops in June 2024. The application of NbS elements in the situation of Nainital is introduced in Chapter 2 (Climate resilience framework plan) and illustrated in Chapter 3 (concept designs and pre-feasibility assessment of priority adaptation measures). Details of identified NbS elements for Nainital are included in Appendix A.

2. Climate resilient framework plan

This chapter presents the Climate Resilient Framework Plan for the City of Nainital in the Kumaon Himalayas. The Framework Plan provides the basis for detailed design and a district-wide strategy for climate resilience. It has been based on the outcomes of the design sessions by the stakeholders during the conceptualization workshop in June 2024 and the earlier results in the assessment report (November 2023).

2.1 Story of the lake and the town

The town of Nainital (Table 2-1) is known as the "City of Lakes" and is built around the eye shaped Naini Lake from which it got its name. Nainital is a tourist destination in the Himalayan Range in Uttarakhand, which is landlocked and mountainous. The mountains in the northern portion of the district have a general elevation of about 2,000 meters above mean sea level. Baudhansthali is the highest peak of the district, having an altitude of 2,623 m. Nainital town is the headquarters of the Nainital district located at an elevation of 1,938 m. It is also the divisional Headquarter of Kumaon Division of Uttarakhand State. The annual temperature varies from 0°C to 43°C, and the average annual rainfall is 1,500 mm.

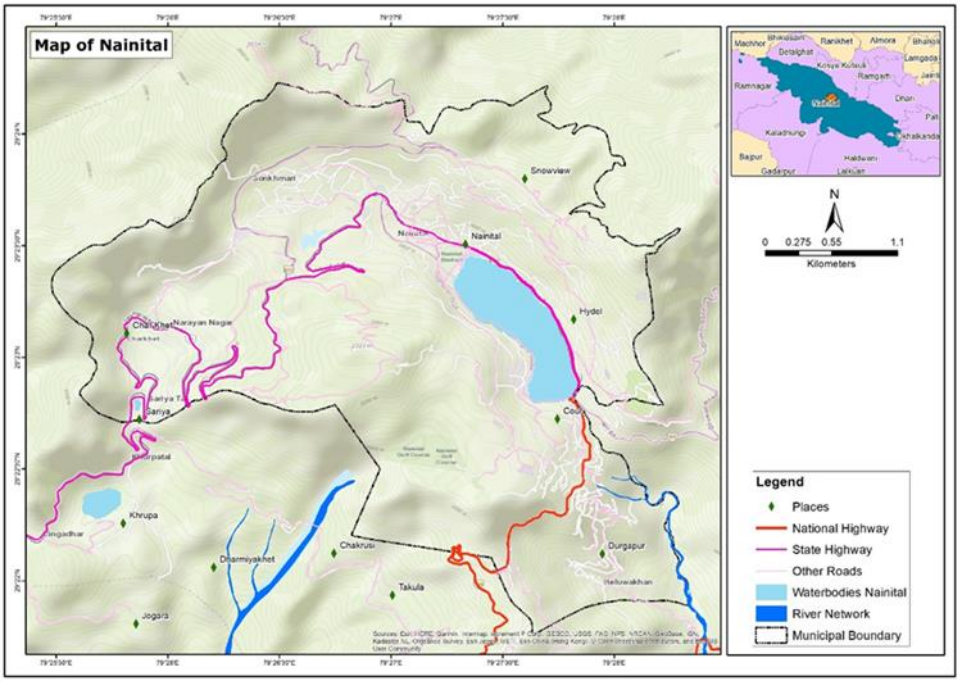


Figure 2-1 Study area of Nainital region

Nainital lake is the primary source of water for people residing in the town. Increasing human pressure, unsustainable land use practices, declining lake depth and drying of springs are some of the existing challenges within the city. Together with the sensitivity to landslides makes the city of Nainital climate sensitive (Table 2-1), underpinning the need for climate information in developmental planning. Climate data could serve as the basis for hazard mapping and risk assessment of various regions, sectors, and communities to ensure climate-proof development.

Table 2-1 Overview of characteristics of Nainital and resiliency issues

	Nainital
Population	41,400 (2011)
Area	11.73 km2
Elevation	+2,084 m
State	Uttarakhand
Water shed	Nainital Lake, and 6 associated smaller lakes
Adaptation Strategy?	2014 Uttarakhand Action Plan on Climate Change (UAPCC)
Resiliency issues (Resilient City – indicators, OECD, 2018)	• Rainfall Flooding • Pollution or environmental degradation • Water security • Landslide • …

The landslides of 1880 on the slopes of China Peak (also known as Naina Peak) caused substantial damage and created Flats ground on Mallital, which is used as public space for residents and tourists in the present times (Figure 2-2).

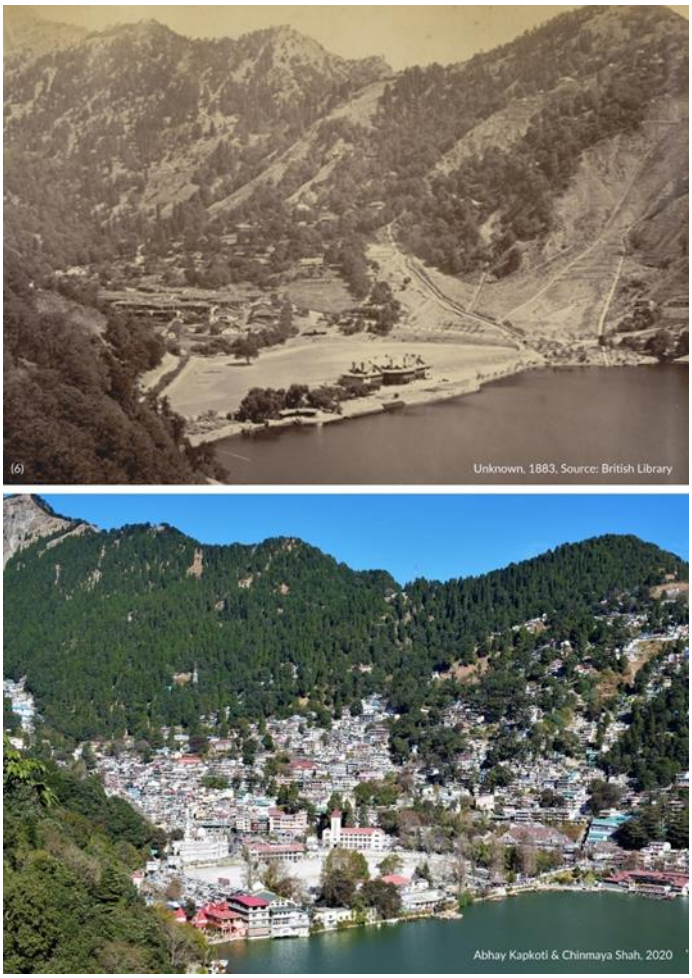


Figure 2-2 The Flats ground in 1883 (after the 1880 landslides, showing the new constructed canals) and in 2020.

2.2 Spatial hydrological types

Nainital is relatively consistent in terms of land use, land ownership, built form and subsoil conditions. Still, in developing an integrated strategy it is important to identify key urban types that inform the possible adaptation measures. A uniform approach for the entire city would overlook local conditions and therefore result in ill-fitting plans.

Figure 2-3 provides a first step into the identification of key *urban water management types* based on the 26 canals constructed by the British in 1881-1883 along the hill slopes to prevent further landslides. The 79 km of drainage comprising 26 'nullahs' and smaller canals are divided into 4 compartments or systems:

1. Sher-ka-Danda (east hills) – high density built-up area.
2. Bara Nala (north hills, including Sukhatal Lake) – high density built-up area.
3. Ayarpatha (west hills) – low density built-up area.
4. Beyond the lake basin.

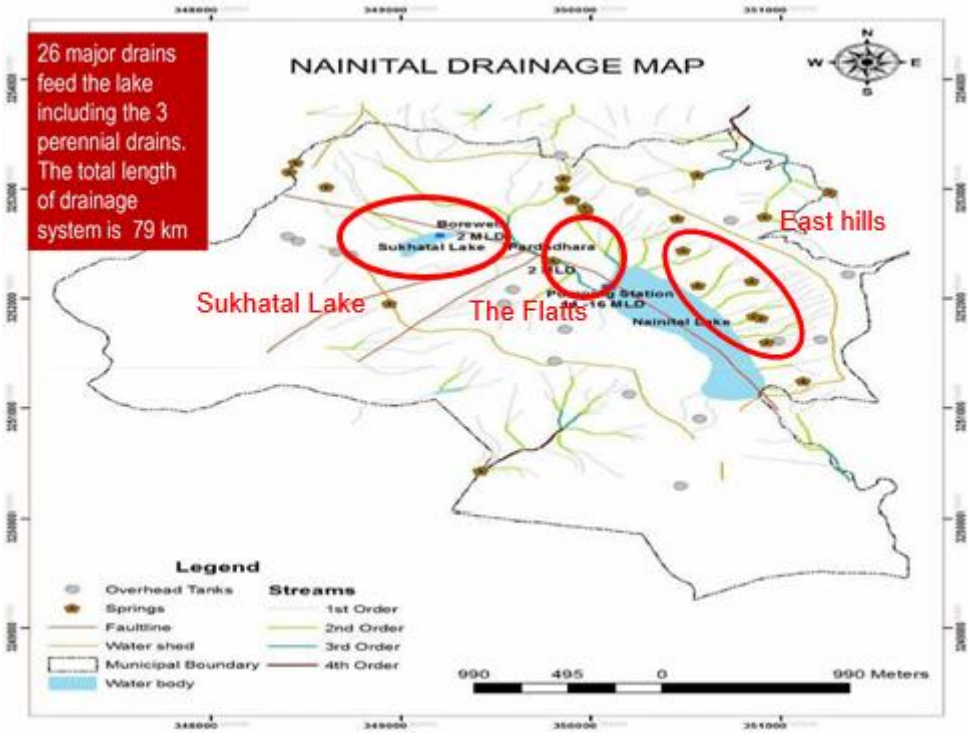


Figure 2-3 Provisional urban water management types

Lake Naini is the most important water body of Nainital, and its water level fluctuations reflects the dynamic water balance of the entire catchment of the lake. Most of precipitation in the catchment area will flow eventually to the lake either via surface or subsurface flow or via direct precipitation (see Figure 4-4 for a schematic representation of the water balance of the lake). The average daily amount of rainwater (period 2019-2022) falling in the entire catchment (including the lake) is 4.9 mm per day which in 21.9 MLD assuming a total catchment area of 4.44 km^2 (after Dash et al., 2008).

This amount of 21.9 MLD can be seen as the maximum water available in the catchment for recharging the lake and drinking water purposes. However, not all this water is available because of evapotranspiration in the catchment and subsurface groundwater flowing beneath the lake towards the lower lying Baila Nala ravine. The exact amounts of these terms are not known. The water bearing status of the lake (volume and level) is besides the inflow terms also dependent on the out-flow components like evaporation of the lake, subsurface leaking and in wet periods overflow of the lake via the sluices.

Some findings from the assessment report:

- The current water bearing capacity and water balance of Lake Naini is at a critical level. The inflow of water on an annual basis is just in equilibrium with the outflow and drinking water abstractions.
- The increase of the drinking water abstractions due to population growth is by far the major cause of the depletion of the lake. Currently, the amount of abstracted drinking water almost equals the amount of rainwater falling in the entire catchment (minus evapotranspiration) which is a clear sign of overexploitation.
- The model simulations show that an increase of drinking water abstractions due to a population growth of 20.000 people will lead to structural depletion and drying up of the lake for months during the non-monsoon season. It may even lead to a situation where the water demand cannot be fulfilled because there is not enough water available in the catchment.
- The large sensitivity of the lake to changes of outflow and inflow is caused by the relatively small catchment of the lake (~4.5 km^2).

2.3 Urbanization and urban future

Water security and landslide preparedness are the two main drivers behind the development of an integrated strategy towards climate resilience to tackle the challenges and embrace the opportunities in Nainital. And since the city is located at the foothills of Himalayas, Nainital has a temperate climate throughout the year, which attracts many tourists (“floating population”).

Currently Nainital does not have a masterplan, since the high court has ordered a ban on further construction of buildings and platforms. To curb the pressure on water sources and protect water (and air) quality, restrictions are required to limit over-tourism and traffic. The latest Masterplan dates from 1995-2011 and was reviewed in the latest Nainital City Development Plan from 2007 (Figure 2-5).

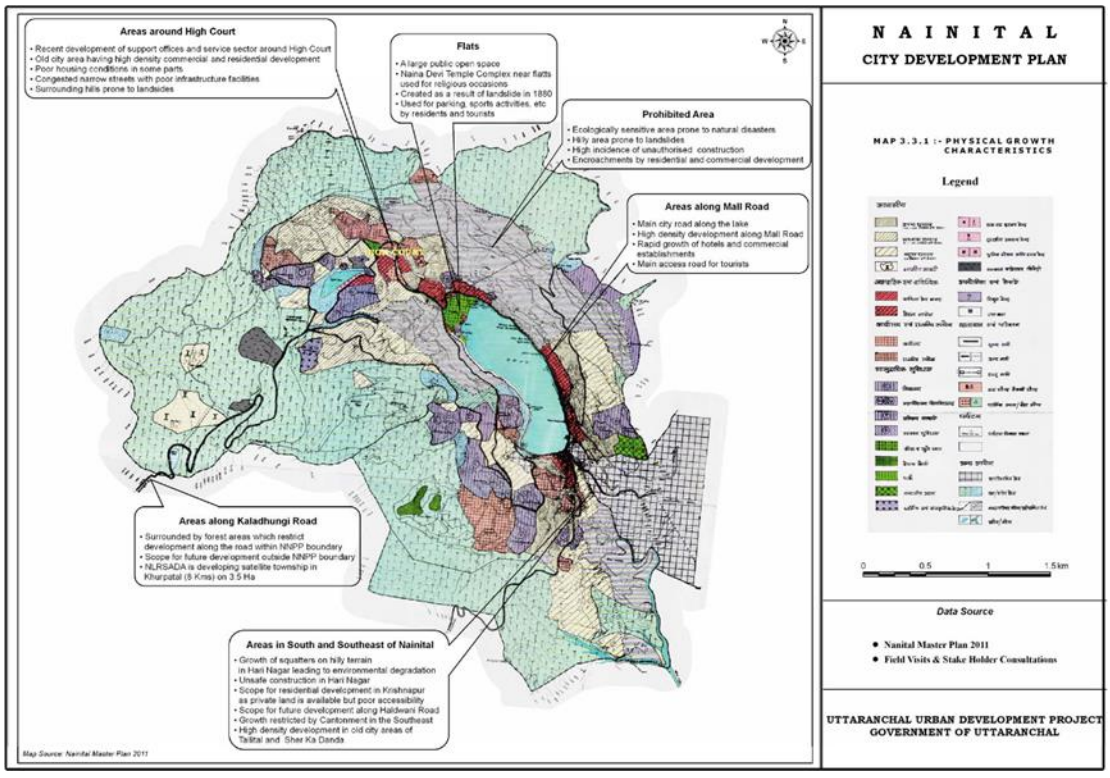


Figure 2-5 Nainital Masterplan 1995-2011 (source: Nainital City Development Plan, 2007)

The Master Plan 2011 projected a population of 54,000 by 2011. The Master Plan proposes to depopulate Nainital by 16,000 population out of the proposed projected 54,000 population by 2011 and develop the surrounding areas of Bhimtal and Khurpatal to accommodate this additional population. In keeping with this policy many of the government offices have been shifted to Bhimtal and Bhowali. Nainital is situated around the lake on hills. Ecologically sensitive areas which are unsafe for any construction activities have been declared as 'Prohibited Areas' which form a considerable part of Nainital. This leaves limited areas in the safe category for physical urban growth. The Master Plan clearly lays down land use policy and development guidelines for the entire lake region and more specifically for the Nainital area in the context of difficult terrain for urban development.

The Master Plan has proposed a comprehensive set of physical development policies for development within Nainital. The development policy restricts further non-residential development and allows residential development only to residents of Nainital. Renovation/reconstruction is allowed with: (1) restrictions on height of the building to 7.5 m or second floor whichever is less, (2) no increase in plinth and floor area and (3) no change in the use of building. The development policy promotes tourism by revamping the sightseeing points and conservation of natural resources. Regulations for Prohibited area include the following:

- No renovation, extension and urban development works shall be allowed.
- No new construction shall be allowed. Limited developmental activities such as construction of retaining wall, plantation, widening (limited to 7.5 m) and strengthening of existing roads can be allowed in special circumstances. No new road construction shall be allowed in these areas and only pedestrian walkways would be permitted.
- Division of land and land conversion for development and construction works shall not be allowed.

2.4 Challenges and opportunities

The risk assessment of Nainital provides insight into the challenges and opportunities regarding the development of an integrated strategy towards climate resilience. The assessment report (November 2023) provides a summary of the most relevant challenges and opportunities regarding the various resilience aspects. In preparation for the Conceptualization Workshops in June 2024 it was decided for Nainital to focus on the landslides and water security. This includes both coping with the existing and progressing landslides, such as the one that occurred at Balia Nala, as well as including landslide susceptibility in the planning and design of future developments. This project does not aim to provide the solution for Balia Nala. The ambition is to bring together all involved departments and agencies to come to a common approach how to deal with the issue of land slide susceptibility in urban development. There are relations with storm water, sewage and road drainage, irrigation, and construction of housing and infrastructure, such as roads and STPs.

As part of the Conceptualization Workshops in June 2024 the local stakeholders worked together in a SWOT (strengths, weaknesses, opportunities, and threats) Analysis. The highlights of this exercise have been summarized in Table 2-2.

Table 2-2 Challenges and opportunities – SWOT high lights (June 2024)

Strengths:	• Geography/ scenic beauty/ pleasant climate • Nani lake is big resource for water • Healthy benefits of nature
Weaknesses:	• Poor implementation of regulations • Lack of awareness against hazards • Poor infrastructure: drainage, transport
Opportunities:	• Promote Nature-based Solutions • Upgrading public transport • Managing of floating population
Threats:	• Hazards, such as forest fires, landslides, earthquakes • Unplanned urbanization/ floating population • Ground/ lake water depletion

Challenges

- Landslides – The history of Naini Lake Basin indicates that this beautiful city with scenic surrounding has been a victim of massive and frequent landslides, mass erosion, rock-fall, and slumping. Its location in the highest rainfall zone, weak lithology and topography are the obvious reasons for these hazards. Moreover, rapidly increasing anthropogenic interferences like construction activities and deforestation on this geo-dynamically unstable zone has added more to the problem. An AI/ML based Artificial Neural Network modelling approach has been employed for the current and future (with climate change conditions) landslide assessment. The result is presented in Section 4.3, Figure 4-7and Figure 4-8 . In the current landslide susceptibility scenario, many areas experience high to extremely vulnerable to landslides. These areas require immediate attention of all stakeholders including residents. In the future scenario the situation is likely to result in increased landslide susceptibility and pushing some of the areas with low to moderate risk to higher levels of susceptibility. The small city of Nainital has already reached its limits to withstand any additional engineering infrastructure, developments, and construction activities.
- Limited water resources possibly leading to depletion of the lake – The current water bearing capacity and water balance of Lake Naini is at a very critical level. The inflow of water on an annual basis is just in equilibrium with the outflow and drinking water abstractions. The increase of the drinking water abstractions due to population growth is by far the major cause of the depletion of the lake. The model simulations show that an increase of drinking water abstractions due to population growth led to a structural depletion and drying up of the lake for months during the non-monsoon. The climate change scenarios indicate that the precipitation surplus (precipitation minus evaporation) on an annual basis will increase, the model simulations show that this slightly benefits the water availability in the lake.

Recommendations to reduce risk

- Landslides:
  - Thorough geological and geophysical investigations around Nainital is of prime importance.
  - Strict implementation of rules and regulation for construction activities to be ensured.
  - Effective planning and implementation of policies to encourage public transport to reduce the burden of city traffic as well as construction a/o widening of existing roads in mountains.
  - Treatment of most vulnerable sections through direct engineering interventions.
  - Planning and implementation of mid- and long-term NbS for slope stabilization.
  - Interdepartmental coordination before planning and implementation of major projects including road infrastructures.
  - Public awareness for best practices re. sustainable ways of human-mountain interaction.

- Depletion of the lake:

o Reducing water use will lead to significant improvement of the water bearing capacity of the lake and the water balance of the catchment a/o population growth can be handled.
o Circular (re)use drinking water (after treatment) will reduce drinking extractions.
o Restore groundwater recharge areas to improve baseflow, but pay attention to contamination, landslide risk and possible bypassing of the lake of groundwater flow.
o Prevent infiltration of untreated sewage water near drinking water wells, like at Sukha Tal.
o Use possible water sources outside the catchment.

2.5 Building up a climate resilient Nainital

Ambitions for Nainital: Transformative and inclusive change
Collaborative spatial planning is not limited to retrofitting attractive blue-green and Nature-based Solutions (NbS) and the effectiveness of single adaptation measures. It is also about the collective; blue-green urban networks make cities sustainable, resilient and climate-proof. Working towards a liveable and attractive blue-green city must be considered at the forefront of a climate resilient pathway. By strengthening NbS and giving water more space in both the public and private domain, cities have the potential to grow into blue-green cities. Cities can therefore focus on a blue-green design based on the three spatial design scales included in Table 2-3.

Table 2-3 Design scales for a blue-green city (Dolman, 2019)

Blue-Green design principle		Spatial scale	Who?
1	Sufficient urban “sponges” for detaining (using), retaining or delaying rainwater.	Buildings, streets and neighbourhoods.	City together with its residents and actors.
2	Blue-green city network on which "sponges" can drain excess water and in which discharge, and storage takes place.	Neighbourhoods, districts and city.	City together with water authority
3	Emergency valves for the blue-green network and overflow areas where water can temporarily go in extreme situations.	City, region and delta.	City together with water authority, regional authority and neighbouring cities.

In parallel to the three Blue-Green City design scales, we propose the following strategy for Nainital:

1. Macro level: Blue-green network of Nainital
2. Meso level: Resilient neighbourhoods
3. Micro level: Small-scale interventions

The three scale levels and design principles together inform where to grow, adapt, retreat and protect:

- Grow: safe places for long-term development.
- Adapt: changing urban environments to accommodate different climate conditions.
- Retreat: relocate places that are (almost) impossible to adapt or protect
- Protect: implement measures that protect important parts from major hazards.

For each design scale, one or more scenarios to be investigated are proposed in consultation with the key stakeholders. These scenarios are a combination of urban development, climate change, and socio-economic development.

The sketches at the macro level made during the Conceptualization Workshop in June 2024 are included in the report of the workshop in Chapter 5 (Figure 5-4and Figure 5-5). Interventions on a meso and micro level are demonstrated for two sites in chapter 3.

Macro level: Blue-green network of Nainital

The macro level compromises the major system structures, which includes the streams and rivers as well as green spaces. Examples are ‘Gabions in hilltop streams’ (Figure 2-6) and ‘Contour planting along roads or with trenches’ (Figure 2-7).

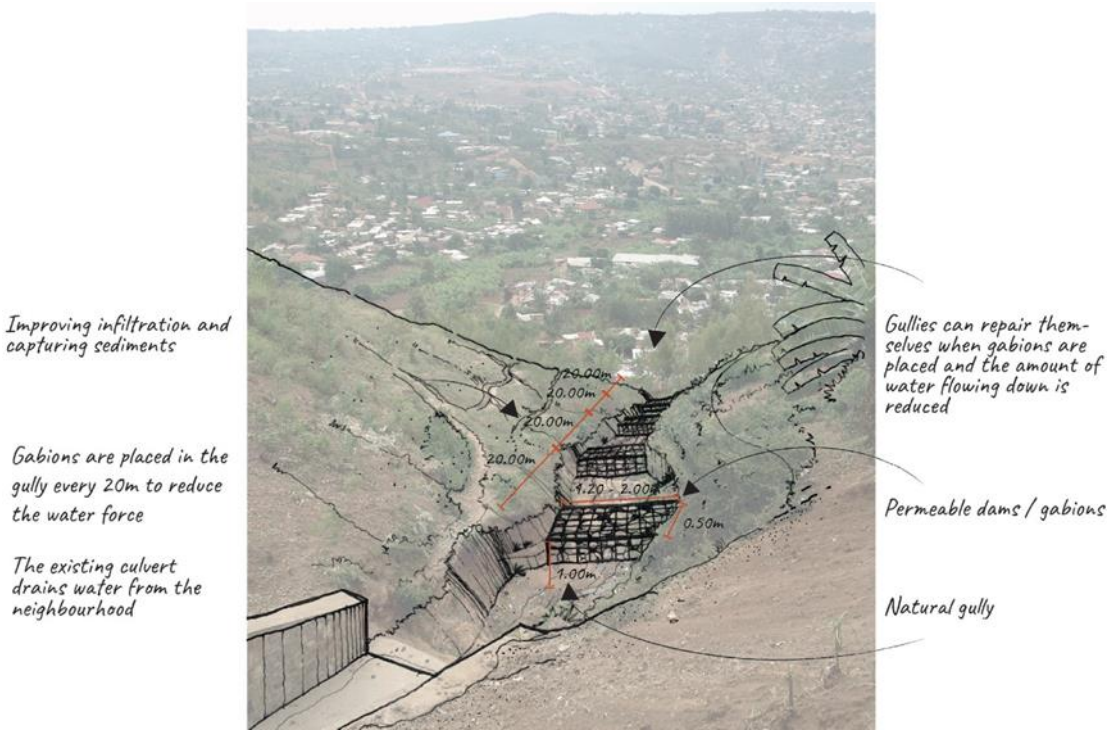


Figure 2-6 Using gabions in hilltop streams (Defacto Urbanism, 2022, page 106)

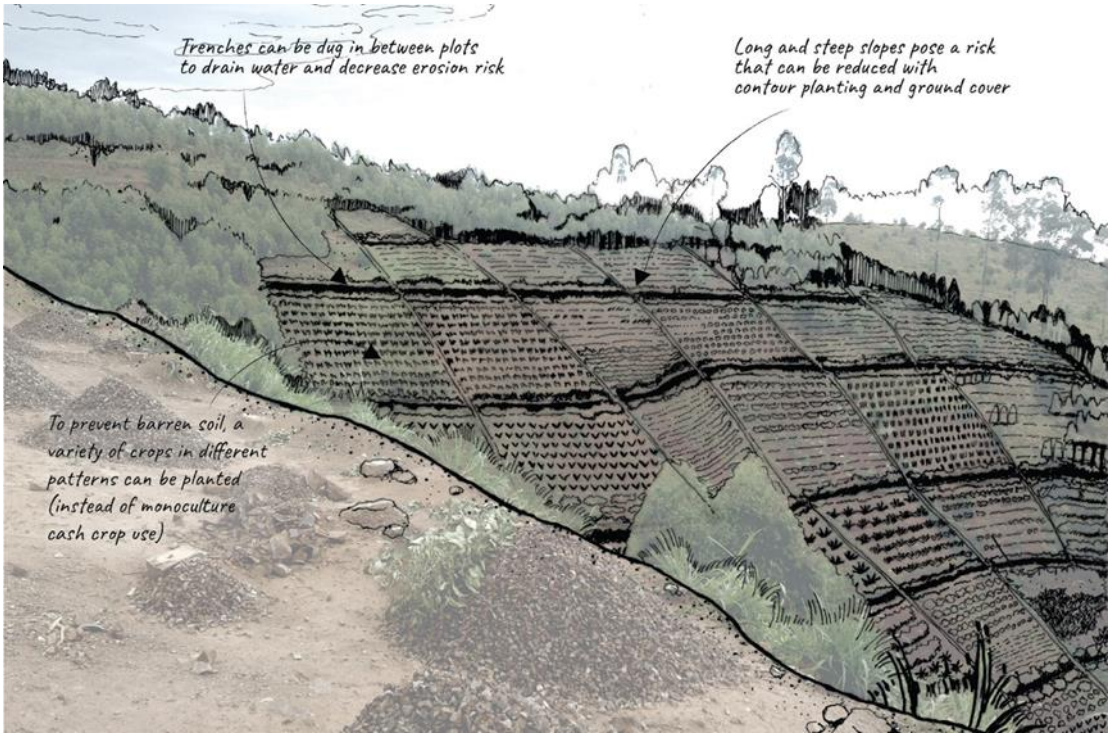


Figure 2-7 Contour planting along roads or with trenches (Defacto Urbanism, 2022, page 120)

Meso level: Resilient neighbourhoods

The neighbourhood and district scale interventions will match the urban water management typologies (see Figure 2-3). Selection of elements and solutions has been part of the workshop with stakeholders. These measures preferably connect to the water infrastructure like urban (street) drainage. An example is the integrated neighbourhood canal as linear blue-green park which collects and retains storm water runoff (Figure 2-8).

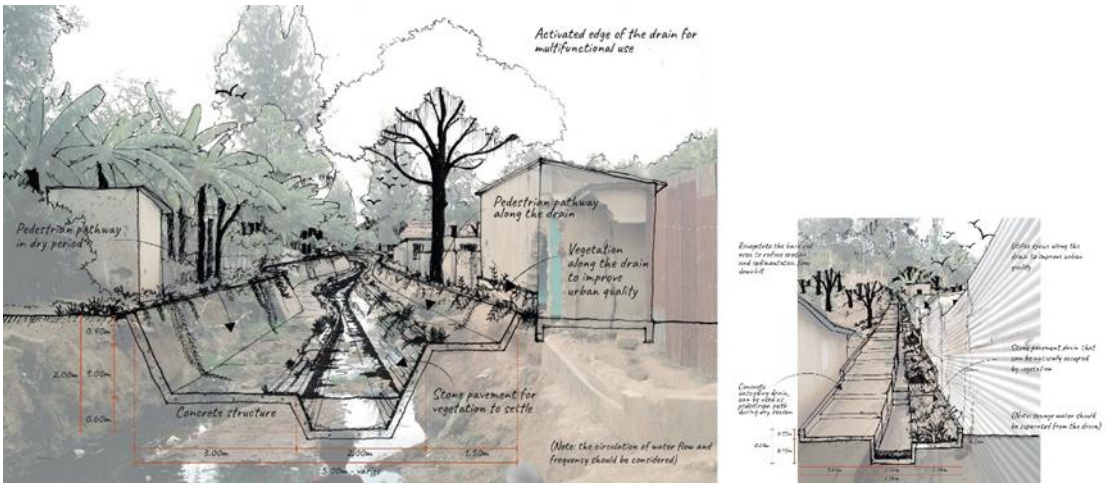


Figure 2-8 Integrated neighbourhood canal as linear blue-green park (Defacto Urbanism, 2022, pages 98 and 102)

Micro level: Small-scale interventions

At the micro level the focus lies on building and street-level interventions. Examples are the ‘stepped drain outflow’ (Figure 2-9) and ‘stepped footpath (with planters)’ which connect to the existing canals. In addition, rainwater harvesting can be encouraged to save water.

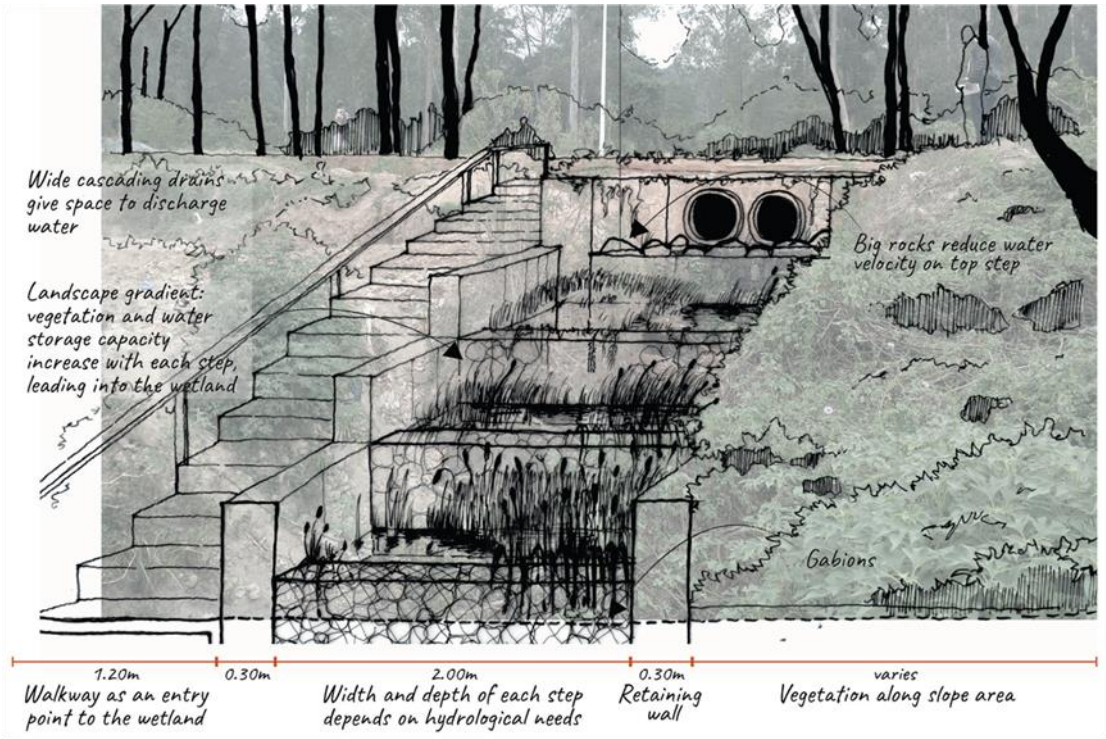
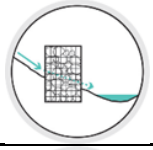
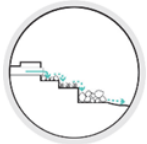


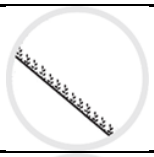
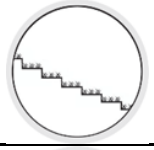
Figure 2-9 Stepped drain outflow, at the hilltop a/o slope which connect to existing canals (Defacto Urbanism, 2022, page 74)

2.6 Identified Nature-based Solutions elements

For Nainital a set of NbS elements have been identified during the assessment phase. The application of NbS elements (Table 2-4) in the situation of Nainital have been discussed in the Conceptualization workshop (design session) and are illustrated in Chapter 3 (Concept designs and pre-feasibility assessment of priority adaptation measures).

Table 2-4 Selection of Nature-based Solutions elements for Nainital

Nr.	Name	Brief description
11	Gabions 	Metallic mesh box filled with rocks, placed across gullies, forming steps to reduce further erosion along the gully.
14	Stepped drain 	Lining and slowing down the stormwater flow to prevent downcutting (such as check dams and gabion mattresses), and still feed the lake.
15	Broom grass plantation 	Planting of broom grass at barren lands and areas with frequent reoccurring landslides. Broom grass can regenerate quickly even in degraded land and does not require much maintenance. It can be used to make brooms, the leaves can feed livestock, and the stems and roots provide fuel wood. As such, broom grass planting provides multiple livelihood opportunities, as well as ecosystem services.

16	Soil nailing		Natural material (such as bamboo or wooden sticks) interlocked to make mesh on unstable slopes to stimulate natural growth.
17	Light(er) building materials		Instead of concrete, consider light(er) building materials, such as wood and steel.
18	Road drainage		Install road drainage to mitigate erosion and restrict percolation.
19	Load distribution		Avoid multistorey buildings to minimize vertical sheer (load/ stress).
20	Contour wattling		Contour wattling can be used to stabilize shallow soil structures against land sliding. This technique involves packing lengths of woody plant material into cables or bundles (also called live fascines).
21	Jute netting		Made from the woven fibres of the jute plant, jute netting, or mesh, is a biodegradable, natural, and flexible material used for temporary erosion control and selective plant establishment. Jute mesh has openings in the weaves, which trap seeds and provide a protective environment for germination.

2.7 Outlook of the communities

Both existing land use plans and planning development should be evaluated for opportunities to incorporate sustainability and innovation. For example, the process of the water assessment requires that when development plans are put forward the consequences and opportunities for water and/or spatial planning are considered at an early stage. The application of sustainable technology (“being aware of water in the design and organization”) should be determined via a referencing option in the process of the water assessment (“awareness of water”). This is partly driven by the legislation, such as for adequate water storage and good water quality.

Where the actors and parties involved come together, the joint ambition and level of involvement should also be discussed. Independence of the actors and parties involved, uncertainty about outcomes and continually changing partnerships have changed the government's leading role to a shared role with stakeholders. Planning developments are no longer just about the technicalities, but also about the way decisions are taken. Defining the quality of the environment being sought and the management approach to bringing this about (efficiency, costs/benefits) makes it possible to formulate joint agreements for the actual implementation of sustainable technologies and solutions. In this way, growing awareness and adaptation comes about and the reality of a water-sensitive city comes ever nearer.

2.8 Strategy

The Urban Framework Plan provides the basis for detailed design. It is a strategy for a climate-resilient Nainital, like a blue-green masterplan. Based on the sketches by the participants in the

Conceptualization workshop (chapter 5) the urban framework plan is illustrated in Figure 2-11 (plan map) and Figure 2-12 (3D-profile). The main elements in the framework plan for a climate and water-resilient Nainital are:
1. Restricted urban development based on landslide risk zoning, respect/ protect existing green pockets and expand green spaces.
2. Traffic/mobility: consider Park and Ride (P+R) locations outside the town, and improve/ promote public transport.
3. Water circularity: reduce water demand and promote rainwater harvesting.

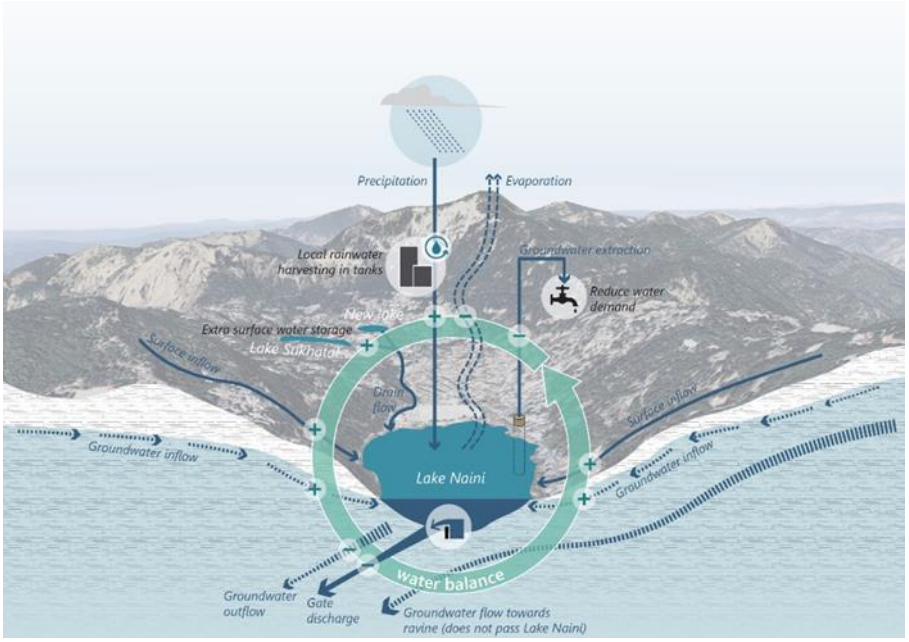


Figure 2-12 3D-profile of Urban framework plan for a climate and water-resilient Nainital

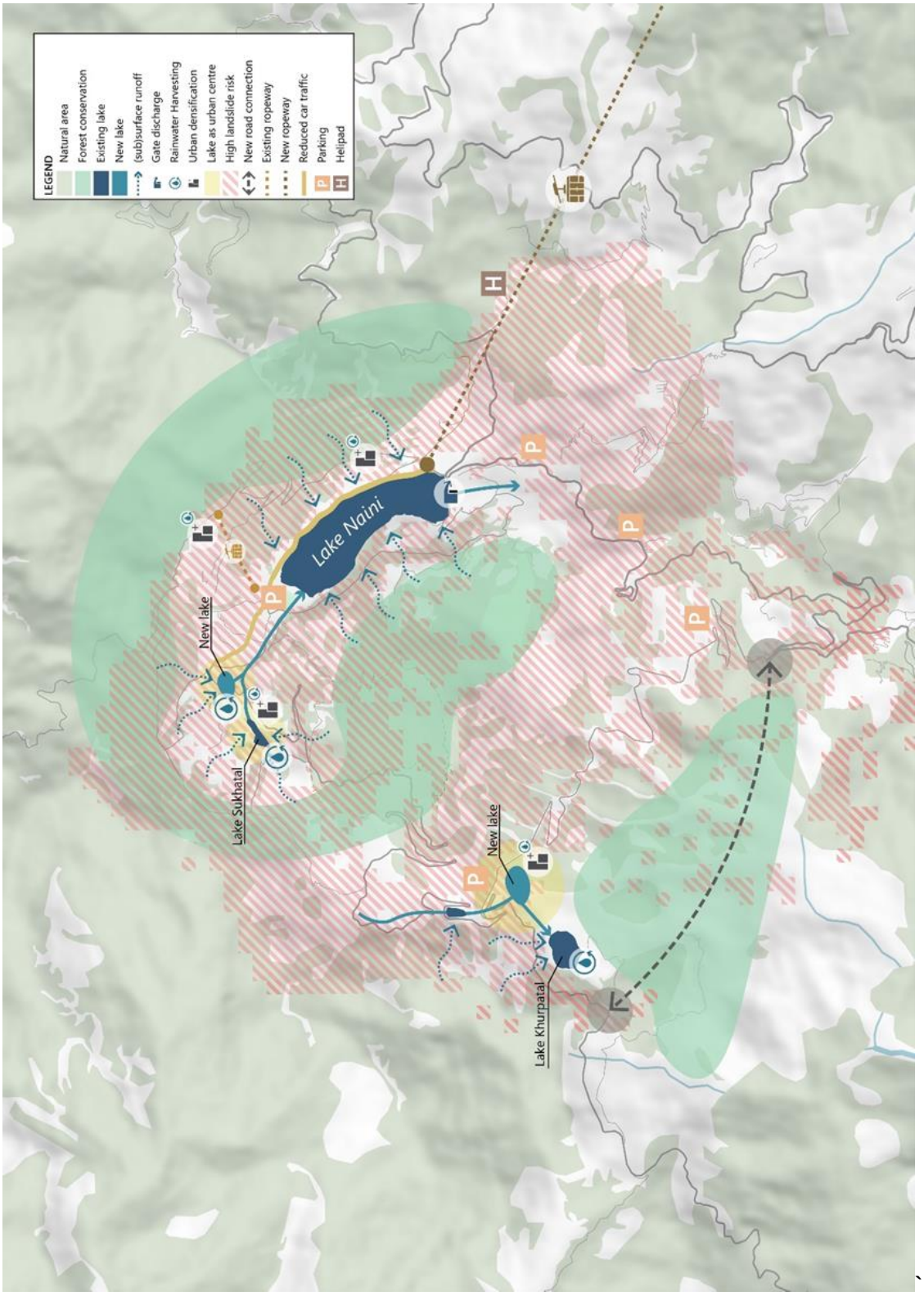


Figure 2-11 Urban framework plan for a climate- and water-resilient Nainital

2.9 Pathways to master planning

During the final workshop, in Nainital on 18 October 2024, local stakeholders reviewed and provided valuable feedback on the Climate Resilient Framework Plan. For further detail on the workshop see Annex D. The feedback provided various pathways to enable the integration of climate resilience into master planning elaborated below.

Aspects to build-on:
These aspects of the Climate Resilient Framework Plan exist within projects, general awareness and the enabling environment at large. Some aspects that have already been tested may contain feedback from previous implementation. This feedback is crucial for effective implementation and upscaling.

1. Parking and use of cable cars to transport tourists during peak seasons
A cable car line provides access to the snow view from (snow viewpoint towards northeastern hill)). The current cost per person per ride on is INR 300. Currently tourist groups spend much less per person using rented automobiles, where several adults and children can be accommodated. A large surface parking exists at Metropol (NW of Naini Lake). A new cable car line is suggested to provide access from the national highway to Nainital.

To enable a transition from automobiles to cable cars there is a need for a combination of measures that include: regulating access by automobiles, improving parking infrastructure and distributions along all major roads, increase in cable car infrastructure, and appropriate ticket pricing.

2. Water collection tanks for rainwater harvesting
The government currently provides water collection tanks for every household. This scheme can be extended and also include tanks to encourage rainwater harvesting (RWH), to supply water for non-portable uses. A subsidy for RWH tanks in every house, could mimic those provided by the government for solar panels

Aspects to pioneer:
These aspects of the Climate Resilient Framework Plan require awareness building, buy-in by key decision makers and the creation of an enabling environment for their uptake.
1. Use of rainwater harvested in tanks for non-potable use.
2. Additional bypass route from Baldia Khan to Khurptal, would be beneficial to reduce traffic load through Nainital.
3. Lighter building materials, such as local wood for construction and plants for insulation. This should be required within building permit processes.

Aspects to strengthen:
These aspects of the Climate Resilient Framework Plan must be considered while developing the Climate Resilient Framework Plan further:
1. Real time monitoring of slope movement (or slope creeping). Slope creeping measurements should inform the prioritization of locations, phases and types of measures related to landslide prevention measures are implemented.
2. Sewage management aspects to be integrated within the framework. This includes the separation of wastewater from stormwater flows. Currently wastewater incorrectly released in drains results in eutrophication of lake. Awareness building is necessary among hotels and tourism related businesses to reduce such illegal connections to stepped drains. NGOs should be engaged to enable solid waste management. Additionally, separate provision of Faecal Sludge Treatment Plants (FSTP's) may be considered.
Another issue is that in certain locations tree roots enter sewer lines (e.g. along Metro road). Robotic survey is being used to mitigate this issue.
3. Comprehensive transport planning, including new/ alternative route identification, widening of highways, where appropriate, to reduce traffic congestion, to and from the city.

4. Review of sustainability of lakes and water bodies to be extended to the regional scale.
5. Decentralize tourism load to several locations. By developing a constellation of alterative destinations, and restricting growth within tourism hotspots like Nainital, the tourism load can be distributed. New destinations (like Kaichi) can learn from Nainital to prevent overtourism and unsustainable growth. This involves aspects like positioning recreational centres to periphery of the town; regulate number of homestays, data monitoring of footfall, numbers of taxi- bikes etc.

Key parties to involve

For the effective uptake of the Climate Resilient Framework Plan the following parties have to be engaged

1. Lead: District Administration (DA) Nainital.
2. Support: Public Works Department, Nagar Palika, Tourism Department,
3. Other entities to involve: DA of Kaichi, Public utilities for RWH component, Public/ private players for Shuttle services for tourists, Compact EV's
4. Community through awareness campaigns and incentive schemes.
5. Funding sources: DA Nainital, State gov. Of Uttarakhand, ADB, Central funds

Links to ongoing projects and masterplans

The following links demonstrate the ongoing projects where aspects of the Climate Resilient Framework Plan have/ are being tested. These can provide proof of concept and lessons learnt to enable uptake. In other cases, these projects can unlock funding necessary for the Climate Resilient Framework Plan.

1. A parking and bus shuttle service has been planned by Nagar Palika, Zilla Parishad. This involves parking 10 kilometres before the city. This service is operated during peak season. The status of effectiveness of this measure is to be confirmed by the Urban Local Bodies (ULBs).
2. DPR prepared for the parking at Metropol, Nainital.
3. DPR by DLDA in 2024 prepared for Saita Tal. This includes water supply, sewage and planning.
4. Balia Nala Masterplan, by the Irrigation department, ongoing in the last 3-4 months. This includes landscape mitigation measures such as deep drilling, slope stepping. It also includes the use of spring water.
5. 2040 plan for State of Uttarakhand, by Chief Minister Uttarakhand.

3. Concept designs and pre-feasibility assessment of priority adaptation measures

Nainital, situated at an altitude of 1,938 meters, centred around the Naini Lake and surrounded by mountains faces major environmental challenges. The fast expansion of built-up areas and climate change patterns have resulted in erratic rainfall and temperature variations affecting water availability and the overall ecosystem. Despite the presence of the Naini Lake, the region experiences water shortages, particularly during peak tourist seasons, due to increasing demand and diminishing water sources. Hilly terrain and deforestation make the area prone to landslides, especially during the monsoon season, posing risks to life and property. The conceptualization workshop identified that Nainital needs to focus on the reduction of landslide risk and depletion of the lake, reducing water scarcity.

3.1 Case study 1 – Ayarpatha, Nainital

Ayarpatha district in Nainital, is approximately located at 29.3953° N, 79.4644° E at an elevation if 1,938 meters, the same as for the lake and the town. The area is predominantly covered by dense forests but an increase in built-up areas has been linked to higher risks of landslides due to deforestation and construction activities (Rawat et al., 2022).

The case study area in Ayarpatha region covers an area of 6.145 ha and a perimeter of 922 m, this area experienced a landslide affecting road connectivity and services, including polluting the lake.

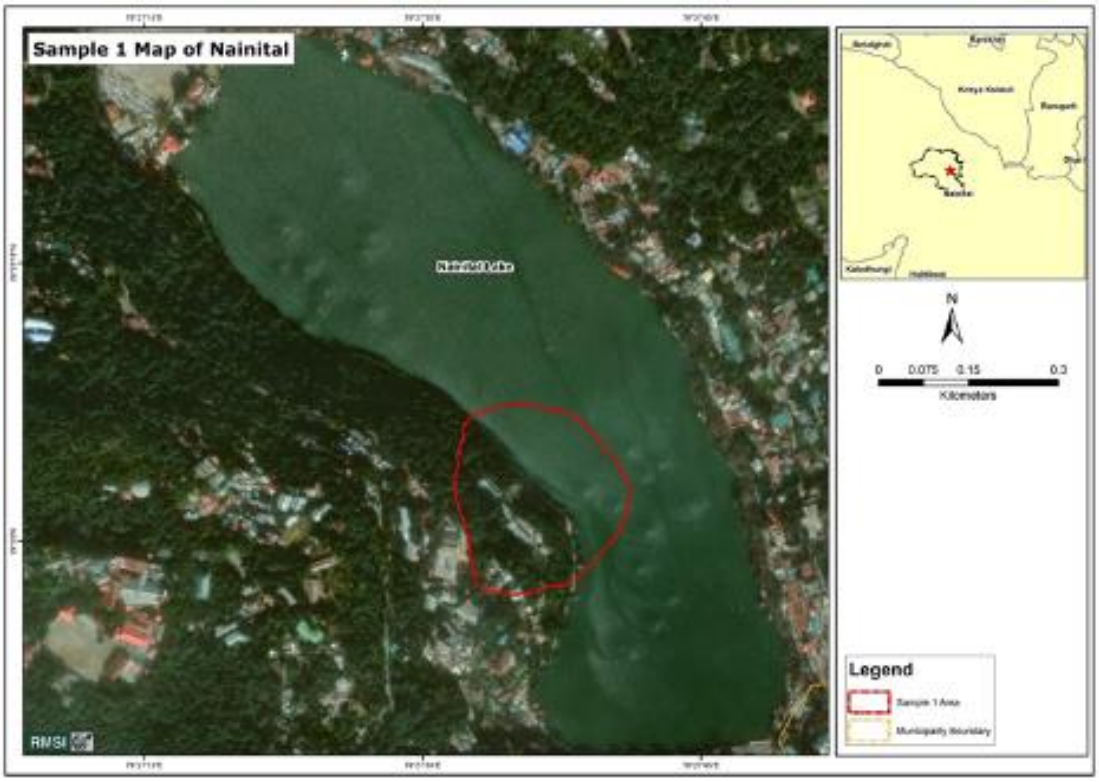


Figure 3-1 Case study area, Ayarpatha.

Site analysis

Water system
Ayarpatha itself does not host significant water bodies but contributes to the watershed areas feeding Naini lake. In the case study area, increased pollution from residential and commercial activities has led to deterioration in water quality. This includes sewage discharge, runoff from surrounding areas, and improper waste disposal practices. Lack of sewerage network was observed in the north of Naini lake area in Ayarpatha and south of Naini lake in Tallitall bazaar.

Monsoon rainfall volumes are likely to increase in the future. The characteristics of the area and the good drainage system in Nainital, rainfall itself is not likely to cause (flash) floods but will affect the lake volume and water level. However, rainfall can have a negative impact on landslides.

The current water-bearing capacity and water balance of Lake Naini is at a critical level. The increase of the drinking water abstractions due to population growth is by far the major cause of the depletion of the lake. Scenario analysis indicates that an increase of extraction rate of 4 to 8 MLD (currently 8.5 MLD) will lead to the depletion of the lake.

Water systems are essential for sustaining life, supporting economic activities, and maintaining ecological balance. Proper management and conservation of water systems are crucial to address challenges such as pollution, overuse, and the impacts of climate change. Better management of drains can help in mitigating landslide risk and quick water supply for the lake. Springs provide the base flow to the lake and local drinking water supply. The linkages between stormwater, sewage and road drainage, irrigation, construction of housing, and infrastructure, such as roads and STPs need to be considered for future planning.

Current land use
Current land use around Naini Lake is characterized by a mix of urbanization and conservation efforts. Balancing economic development with environmental sustainability remains a critical challenge for the region. Expanding urban areas around Naini Lake have encroached upon the natural catchment areas of the lake, reducing its ability to replenish naturally. This urban sprawl also leads to more runoff and pollution entering the lake. Hotels, restaurants, and recreational facilities have proliferated, contributing to economic growth but putting pressure on the local environment. The likelihood of a landslide occurring in the area based on local terrain conditions is high. The area's climate and weather patterns, such as heavy monsoon rains, significantly influence the local LULC. Extreme weather events, including cloudbursts, have been recorded, leading to flash floods and increased landslide activity.

Horizontal and vertical urban expansion has been observed at two assessment points in Ayarpatha region. The built-up areas mainly consist of residential buildings, hotels, and commercial establishments. The case study area consists of built-up areas like girls' hostel, bank, etc. The landslide started from the area close to the girls' hostel to the lake, damaging Thandi road, a scenic route connecting the north and south of Naini lake.

The region's susceptibility to landslides is a major concern, exacerbated by deforestation, construction, and heavy rainfall events. Recent studies have highlighted the need for better land management and disaster preparedness [1].

Continuous population growth and urbanization has led to land use change leading to reduced infiltration, encroachment of drainage channels, increased wastewater generation and landslide risks. Traffic congestion, poor Air Quality Index (AQI) and noise pollution is observed in the eastern side if Naini lake in Upper Mall area.

Current open space

Ayarpatha has seen increased residential development, leading to a reduction in open spaces. New housing projects have encroached on previously open areas, impacting the availability of green spaces. Unauthorized constructions and informal settlements remain a challenge in maintaining open spaces. Encroachment by private entities and individuals has led to disputes and efforts to reclaim and protect these areas. Continuous monitoring and adaptive management strategies are essential to ensure the long-term sustainability of these open spaces.

Thandi road in Ayarpatha is a scenic route, running through the case study area, from the south of Nainital lake to the north connecting the famous Naina Devi Temple in Nainital. Thandi road has good proximity to landmarks like Naini peak, which offers breathtaking views of the Himalayas, and the Tiffin Top (Dorothy's Seat). Other public/ community access spaces frequently visited in the case study area on Thandi road are Pasan Devi Temple and Viewpoint Memorial. The area around Thandi Road is susceptible to landslides, especially during the monsoon season. The steep slopes and loose soil can become unstable, posing risks to residents and visitors.

Future land use and urban developments

The City Development Plan - Nainital Revised 2007 had set out a vision that could control and balance urban development with environmental conservation, aiming to make Nainital a more liveable and resilient city. Due to hilly terrain and ecologically sensitive areas, it majorly restricts physical expansion within the Nainital Notified Planning Area (NNPP). Unfortunately, unauthorized construction issues are compounded by the location in a high seismic zone, posing a risk of landslides.

Recently, on 7th August 2024, a flash flood in Nainital caused significant damage, with the historic Dorothy's Seat located in the case study area being reduced to rubble[2]. Rescue operations are being conducted by the authorities trying to assess the full extent of the damage as the region grapples with the aftermath of the flood. Many houses in the area are in dilapidated conditions and face the peril of breaking down.

Considering the expansion of the built-up area in Nainital, future developments and planning need to be water-sensitive and climate resilient considering the linkages between storm water, sewage, and road drainage, irrigation, construction of housing, and infrastructure, such as roads and STPs.

There is a need to stimulate pro-active planning to prevent future problems by considering future developments including adaptation mechanisms such as zoning, especially with respect to landslide risk.

Main risks/ challenges and (urban) opportunities to address with NbS

The main risk identified in the case study area is landslides. Various challenges identified are:

- A major part of Nainital city is vulnerable to landslides.
- Climate change scenario is likely to increase landslide vulnerability.
- The city has already reached its capacity to withstand further constructions.
- Balia Nala slide has reached a situation where natural and long-term solutions will not work and hence require direct engineering interventions.
- Most of the existing wards in Nainital are prone to landslides and primarily located on debris of old slide sites.
- New constructions and road infrastructure developments require better coordination and proper due diligence.

[1] Tehrani, F.S., Calvello, M., Liu, Z. et al. Machine learning and landslide studies: recent advances and applications. Nat Hazards 114, 1197–1245 (2022). https://doi.org/10.1007/s11069-022-05423-7

[2] https://www.newindianexpress.com/nation/2024/Aug/08/flashflood-in-uttarakhand-dorothys-seat-in-rubble

Potential of interventions in context of framework plan

During the conceptual workshop conducted on 27-28 June in Nainital, stakeholders worked together to discuss the development of projects and materials. The aim was to bring together all involved departments and agencies to come to a common approach in terms of dealing with the issue of landslide susceptibility in urban development. The discussions included assessment findings, challenges and opportunities, guidance, and training on the development of climate-resilient decision-supporting tools, that facilitated interactive “Water-Sensitive Planning “. A design session on local-scale interventions and urban NbS was conducted to understand the possibilities of decision-making. This led to the selection and prioritizing of the design of climate resilience measures with a special focus on nature-based solutions (NbS) to address pressing environmental challenges in the area. The scope was limited to the reduction of landslide risk and depletion of the lake in Nainital., as mentioned in Section 1.1.

The chosen solutions focused on enhancing key ecosystem services, such as improving water quality, mitigating landslides, and preventing soil degradation. These interventions were selected based on their ability to not only restore natural habitats but also support local livelihoods and community well-being.

Throughout the discussions, several major concerns were raised. These included ensuring the long-term sustainability of the solutions, the cost and feasibility of ongoing maintenance, and guaranteeing that the benefits are shared equitably among all community members. Participants also highlighted the need to consider potential conflicts with current land-use practices, especially in areas where agriculture or development pressures exist.

The selected NbS align with a resilience framework by enhancing the capacity of both natural and human systems to adapt to future climate risks and environmental stresses. They aim to build ecological health while fostering social inclusivity and economic viability. By integrating these solutions into local planning, communities can strengthen their ability to withstand shocks from landslides and other water-related challenges, ensuring long-term environmental and social resilience.

Some of the suggested Interventions for site 1 are:

A. Road drainage/ Roadside drainage

Roadside drainage focuses on managing water that collects alongside roadways, typically through shallow ditches or channels running parallel to the road. These drains prevent water from flowing onto the road surface, reducing the risk associated with road damage. The primary purpose of roadside drains is to channel water away from both the road and the surrounding land, preventing erosion and protecting nearby infrastructure. Well-designed roadside drainage is crucial for maintaining the stability of the road embankments and preventing water from pooling at the road edges.

The use of regular open RCC (Reinforced Cement Concrete) drains in roadside drainage offers significant benefits. RCC drains provide robust and long-lasting solutions for managing water runoff. The strength of RCC ensures that these drains can withstand harsh weather conditions and heavy traffic without deteriorating. Regular open RCC drains are also easy to maintain, as their accessible design allows for straightforward cleaning and the removal of debris, ensuring continuous water flow and preventing costly road repairs caused by water damage.

Once collected, the runoff is directed into stepped drains, which are sloped or vertical channels that safely carry water down steep terrains. By controlling the water flow and breaking it into smaller, manageable steps, stepped drains reduce the speed and force of the runoff, minimizing soil erosion on slopes. This process is crucial for mitigating landslides, as uncontrolled water flow can erode the soil and weaken the stability of the land. Additionally, by efficiently conveying water away, RCC drains prevent

the soil from becoming waterlogged, which would otherwise increase the risk of slope failures. In this way, these drains play a vital role in maintaining slope stability and protecting the surrounding landscape from erosion and landslides.

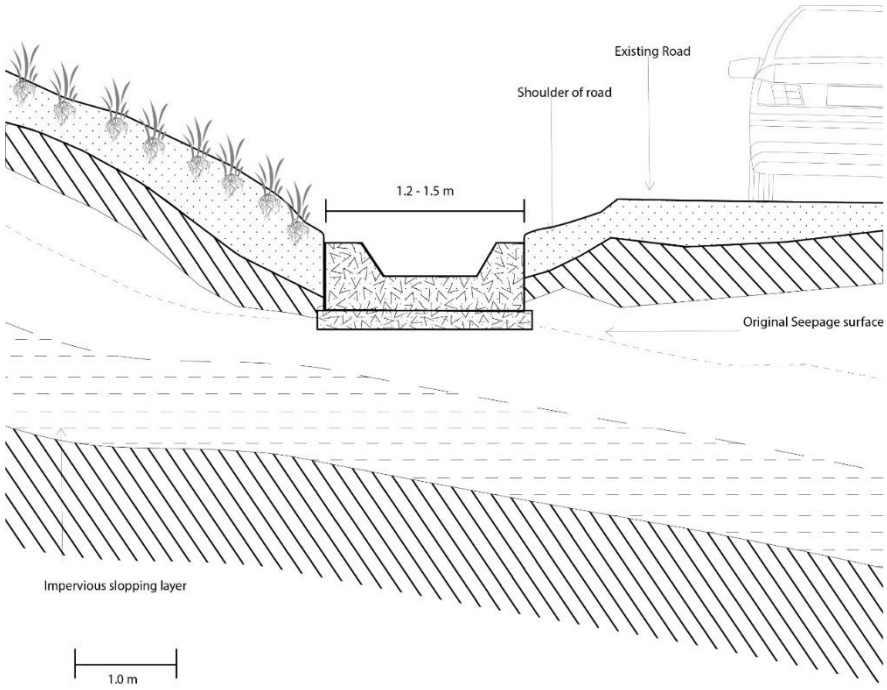


Figure 3-2 Road drain

A. Gabion in drain

Steep slopes pose challenges in stabilizing the soil and safely managing runoff. Since these areas are highly susceptible to drainage and erosion issues, land use activities should be carefully planned to suit the terrain and preserve natural features.

Stepped drains help in slowing down the stormwater flow and in reducing the erosive force of the water flow. It is beneficial in areas prone to landslides, as it breaks the flow of water and also prevents excess sediments from being carried downstream [1].

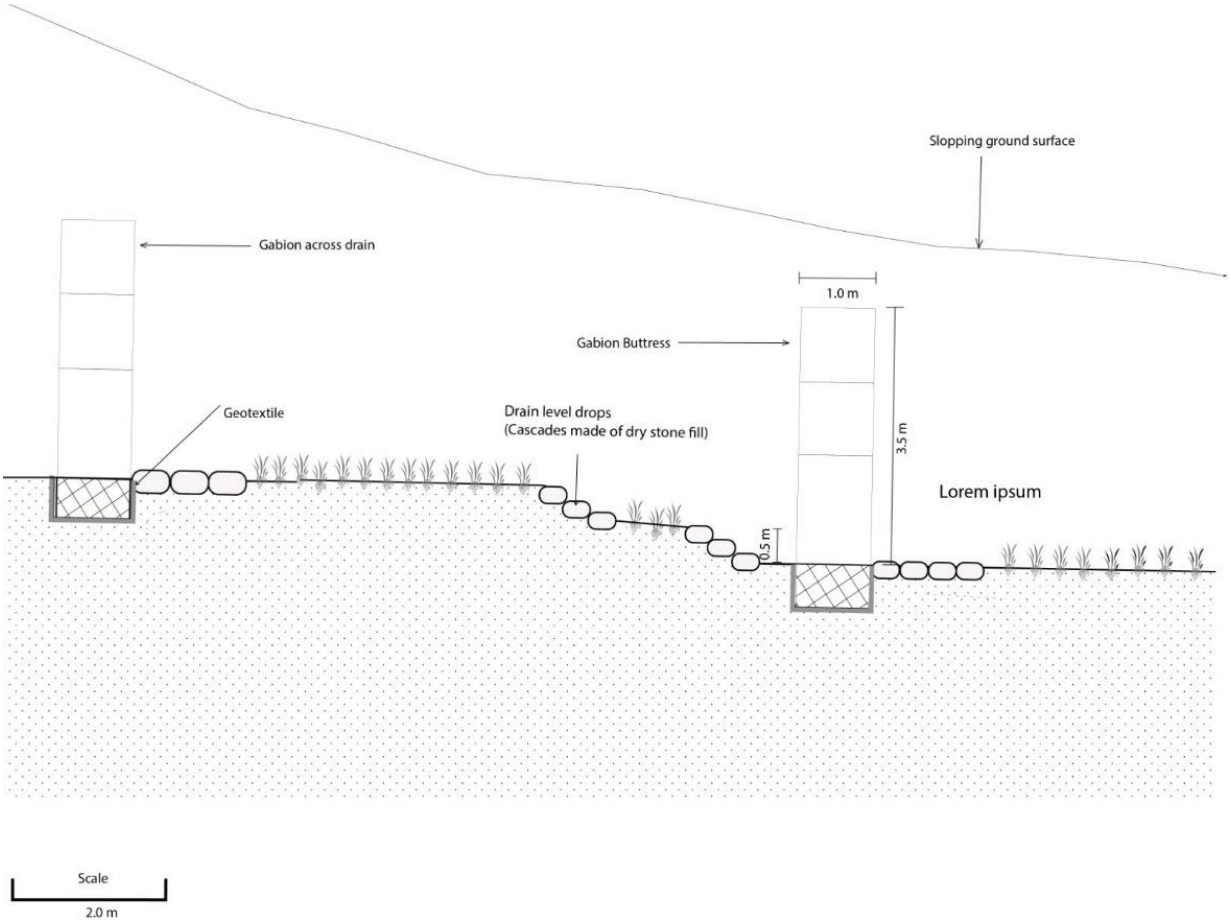


Figure 3-3 Stepped drain with gabion buttress

B. Gabion retaining wall

Gabion retaining walls are an effective solution for stabilizing slopes in landslide-prone areas. These walls are made by stacking wire mesh baskets filled with locally available stones, which create a flexible and permeable structure. Gabion walls can adapt to ground movements, making them ideal for unstable terrain where landslides are a risk. The gaps between the stones allow water to drain naturally through the wall, reducing water pressure on the slope, which is a major cause of landslides.

Additionally, gabion walls use natural materials, which are often locally available, making them cost-effective, easy to install and environmentally friendly. Over time, plant roots can grow through the gaps in the stones, further stabilizing the wall and enhancing the strength of the structure. This ability to blend into the environment, combined with their flexibility, lower cost, and natural drainage, makes gabion walls a preferred choice in landslide-prone areas.

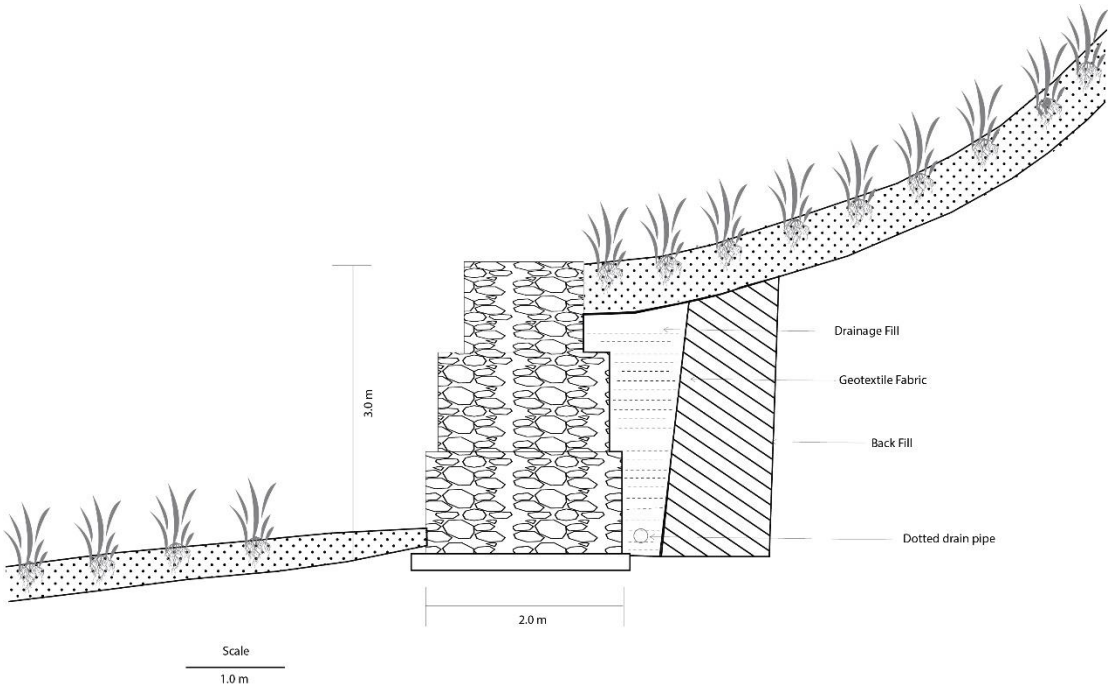


Figure 3-4 Gabion retaining wall

As per schedule of rates provided by Central Public Works Department (CPWD) New Delhi[2], India, " ` Providing & making Gabion structure with Mechanically Woven Double Twisted Hexagonal Shaped Wire mesh Gabion Boxes as per IS 16014:2012,MORTH Clause 2500, of required size, Mesh Type 10x12 (D=100 mm with tolerance of ± 2%) Zinc coated, Mesh wire diameter 3.0 mm, mechanically edged / selvedged with partitions at every 1m interval and shall have minimum 10 numbers of openings per meter of mesh perpendicular to twist, tying with lacing wire of diameter 2.2mm, supplied @ 3% by weight of Gabion boxes, filled with boulders with least dimension of 200 mm, as per drawing, all complete as per direction of Engineer-in-charge." is INR 3727.70 per cum.
How ever, after estimating quantity of each item the per cum cost is coming 5415 INR per CUM. As the DSR rates are based on 2021 Schedule of rates, The reader is suggested to add appreciation value to make for the year 2024. Based on Southern Tier Central Regional Planning & Development Board (2021) and Government of Ireland (2023).

Other interventions

Bioswales

Bioswales are basically plantations of diverse vegetation over artificial channels. They are essential for managing road drainage near lakes, such as Naini Lake in Nainital's Ayarpatha region. Unlike hard, impervious surfaces like roads and parking lots that rapidly direct stormwater filled with debris, pollutants, and heat into drainage systems, bioswales are designed to slow down and treat this water. Planners have a choice to place bioswales anywhere depending on the need as it mimics natural hydrology. These constructed, vegetated low-lying areas resemble natural marshes. As stormwater flows into the bioswales, the vegetation and soil absorb some of the water, allowing sediments and pollutants to settle or be absorbed by the plants. By the time the water exits the bioswales and reaches the lake, it is cooler, slower-moving, and has fewer contaminants. This natural filtration process helps prevent problems like algae blooms and bacterial contamination, thereby improving water quality and preserving recreational activities. Additionally, bioswales offer important habitats for local wildlife.

[2] . Delhi Schedule of Rates (Vol –2) - 2021, Director General , CPWD, New Delhi

Furthermore, bioswales play a crucial role in reducing soil erosion and minimizing the risk of landslides. The plants and roots within the bioswales help stabilize the soil, preventing it from being washed away by heavy rains. By slowing down the flow of water, bioswales reduce the pressure on the surrounding soil, which can otherwise lead to erosion and increase the likelihood of landslides. This makes bioswales a valuable tool for both stormwater management and the protection of the natural landscape in regions prone to such geological events.

Demonstration: concept design

Figure 3-5Concept design Ayarpatha, Nainital

The concept design for Ayarpatha presented in Figure 3-5 combines drains along the road and stepped drains for the stream to manage the flow of run-off to the lake with a gabion retaining wall, soil nailing and jute netting to increase slope stability.

Governance

In Nainital, the governance structure operates within the broader framework of the Uttarakhand state government. The District Magistrate (DM) oversees administrative functions and coordinates disaster management efforts at the district level. The Nainital Municipal Corporation (NMC) handles urban planning, infrastructure, and local services within the town. At the state level, various departments, led by the Chief Minister, are responsible for setting policies and allocating resources for environmental management. Additionally, the central government's Ministry of Environment, Forest and Climate Change (MoEFCC) provides national guidelines and support for climate action.

Lead party and stakeholders
The Nainital Municipal Corporation (NMC) serves as the primary body for local governance and environmental management within the town. Several stakeholders are involved in addressing environmental and climate issues. The District Administration coordinates emergency responses and disaster management. State government departments, including those focused on forests, water resources, and urban development, develop and implement relevant policies. Local communities, especially those in vulnerable areas, have a direct interest in sustainable development and disaster risk reduction. Non-governmental organizations (NGOs) such as the Himalayan Environmental Studies and Conservation Organization (HESCO) contribute to environmental conservation and community resilience. Additionally, local universities and research institutions provide essential scientific research and data for planning and policymaking.

Societal support and needs
Community support for environmental and climate resilience is evident through local initiatives such as afforestation programs and participation in environmental awareness campaigns. The state government has also initiated various programs, including the Uttarakhand State Action Plan on Climate Change (SAPCC), to address these issues. However, additional support is needed to enhance community engagement in decision-making processes, ensuring that policies and interventions are practical and culturally appropriate. Capacity building through training on climate resilience strategies and disaster preparedness is crucial.

Increased financial support from both government and private sectors is necessary to implement and sustain climate resilience projects. Improved data collection and research are also essential for understanding climate impacts and developing targeted interventions.

Creating a climate resilience framework for Nainital requires a collaborative approach involving all stakeholders. By leveraging existing community support, enhancing capacity-building efforts, and securing necessary resources, Nainital can develop an effective strategy to address its environmental and climate-related challenges. The combined efforts of local governance, state authorities, communities, and supporting organizations will be key to ensuring a sustainable and resilient future for the region.

Impacts, co-benefits and effect
Table 3-1 presents an overview of impacts, additional benefits and maintenance and monitoring requirements for the proposed interventions.

Table 3-1 Overview of impacts, additional benefits and maintenance and monitoring requirements for the proposed interventions of case study 1 – Ayarpatha

Intervention	Co-benefits	Effect
Roadside (RCC) drainage	**Landslide /Flood mechanism**	Manages surface water by reducing peak flow and water accumulation, increases slope stability
	Additional Benefits	• Prevents gully formation to avoid soil erosion and potential landslides • Long lasting infrastructure protecting roads and foundations
	Maintenance	Regular cleaning of debris, sediments or vegetation
	Monitoring	Inspect regularly for • cracks due to ground movements /heavy rainfall • altered water flow dynamics due to change in land use and weather patterns
Stepped drain	**Landslide /Flood mechanism**	Reduces peak flow, protects from erosion reducing the chances of landslides
	Additional Benefits	Adds green spaces,
	Maintenance	• Trimming and cutting the grass on vegetated steps or sloped banks • Remove excess sediments
	Monitoring	Inspect accumulation of • sediments on the inlet • solid waste that prevents runoff
Gabion retaining wall	**Landslide /Flood mechanism**	Stabilizes slopes, protects from erosion reducing the chances of landslides
	Additional Benefits	• Gabions conform to ground contours and distribute loads evenly, stabilizing the slope • Breaks the energy of flowing water, especially for near water bodies
	Maintenance	Check for structural integrity and debris accumulation
	Monitoring	Inspect for • any potential deformations or failures in the gabion structure • Changes in local water flow

Costs and pre-feasibility assessment
The estimated cost of case study 1 - Ayarpatha - is INR 97,700,507,40. See Annex A for details of the calculations of the Bill of Quantities.

To assess the pre-feasibility of the project for case study 1, a qualitative assessment has been made of the scoring of this case study on a number of criteria. Scoring is based on the information presented above and expert judgement by the Consultant. The result is presented in Table 3-2. The conclusion regarding the pre-feasibility is positive as this case study is expected to contribute substantially to landslide risk reduction with limited negative impacts. Costs are high but seem acceptable compared to the damage prevented. It is recommended to execute for this project a complete feasibility analysis including detailed designs and a cost-benefit analysis to decide whether the project should be implemented.

Table 3-2 Qualitative pre-feasibility assessment for case study 1 – Ayarpatha (+ indicates positive, 0 neutral and – negative)

Criterium	Score (+,0-)	Remarks
Contribution to desired impact	+	Project is expected to reduce landslide risk in the area substantially
Positive co-benefits	0	Limited co-benefits, mostly from improvement of water security by rainwater harvesting
Negative side-effects	0	Limited negative-side effects
Societal support	0	There is no indication that there is opposition to the proposed interventions
Cost – value for money	0	The project is expensive, but is expected to provide a substantial reduction of the landslide risk
Overall score	+	The project is expected to contribute substantially to landslide reduction with limited negative impacts and at a cost that could be comparable to the prevented damage

Pathways to implementation
During the final workshop, in Nainital on 18 October 2024, local stakeholders reviewed and provided valuable feedback on this concept design, which are elaborated below. For further detail on the final workshop see Annex E.

Key parties to involve
For the effective implementation of the concept design the following parties have to be engaged
1. Landowners: The Degree College, Forest Department and a number of influential residents (Padma Shree Awardees) live in the vicinity and need to be brought into confidence in the build up to such a concept design.
2. The District Level Development Authority (DLDA) is another important actor to be engaged through the project.

Opportunities and Roadblocks to implementation

1. Appropriate tree planting is an opportunity and should be included in the wider NBS strategy. Baaj (local oak species) is an indigenous species. It retains water and releases it slowly. It has fire resistance and is the source of springs. It is forbidden to cut this tree. Pine trees in comparison are a foreign species, they release water quickly and result in forest fires.

3.2 Case study 2 – Sri Krishnapur, Nainital

Sri Krishnapur in the vicinity of Nainital, is approximately located at 29.3680°N, 97.4638°E at an elevation of approximately 2084 meters above sea level. The area's high altitude contributes to its cool climate and scenic mountain views and is considered as an area for future expansion of the city.

The case study area in Sri Krishnapur region covers an area of 16 ha and a perimeter of 1485 m, majorly a built-up area that experienced landslide affecting road connectivity linking Krishnapur to Nainital. Considering the terrain in the area, the movement of rock, debris, or soil down a slope due to gravity and soil erosion is common. At times, earthquakes can trigger these events, and landslides frequently occur alongside seismic activity in the hills. These landslides disrupt road services, forcing residents to take longer routes. A notable location in this region is the Gufa Mahadev temple, situated at an elevation of around 1829 meters above sea level.

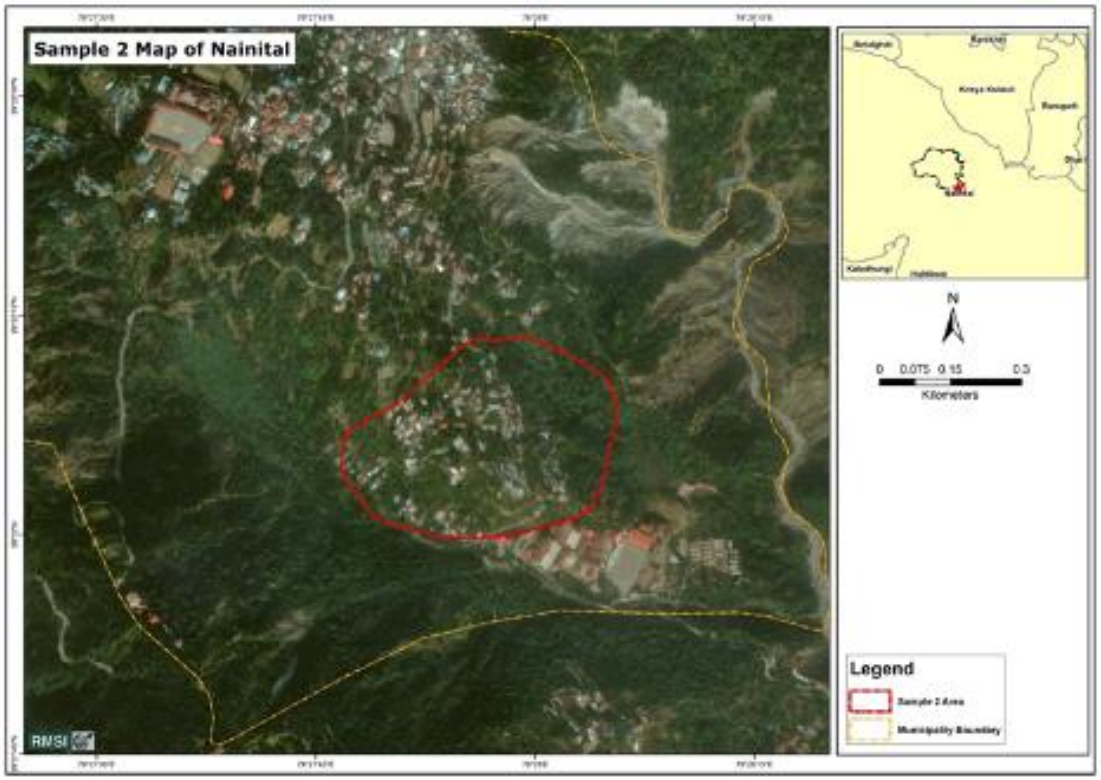


Figure 3-6 Case study area, Shri Krishnapur

Site analysis

Water system

The area of Sri Krishnapur in Nainital is primarily impacted by small streams and tributaries, as well as the nearby Naini Lake, which is the central water body of Nainital. While there is no major river directly affecting Sri Krishnapur, the region experiences the influence of rain-fed streams and runoff from surrounding hills, which can affect local water drainage patterns, especially during heavy monsoon rains.

Rainy season provides enough water but consistent rainfall over time can cause significant erosion, removing the top layers of soil and vegetation that help to stabilize slopes. Without this protective cover, slopes become more vulnerable to landslides.

The Kosi River and Gaula River, which are in the broader district of Nainital, play a role in the water systems of the region but are not directly impacting Sri Krishnapur in a significant way. The streams feeding into or out of Naini Lake might have more localized impact. Encroachment of riverbanks and unsustainable ground water exploitation is adding pressure on water resources.

The region's susceptibility to landslides and soil erosion exacerbates wastewater management challenges. Wastewater management is critical as untreated sewage is discharged directly into streams, leading to water pollution.

The area needs to look at strategies to restore the hydrological balance by storing the rainwater, delaying the flow, retaining and reusing the water in order to build a water sensitive Nainital by 2050.

Current land use

The land in the region is considered to be vulnerable to landslides with limited water resources. Apart from many landslides observed in the northeast direction of the case study area, storm water drainage, traffic congestion, poor AQI and noise pollution, forest fire, etc. have been identified as major concerns around the region. Issues of encroachment, horizontal and vertical urban expansion and lack of sewerage network were identified in the northern part of Sri Krishnapur. Unplanned solid waste disposal has also been observed in the case study area.

The likelihood of a landslide occurring in the area on the basis of local terrain condition is high, as the slope declines in the southeastern direction in the case study area. The slope aspect significantly influences the type and extent of landslides in an area. In Nainital town, regions with steep slopes are more susceptible to mass wasting and are prone to slides and falls. Conversely, areas with gentle slopes are more likely to experience slow creeping movements. However, these areas generally pose less risk if they are covered with vegetation.

Current open space

Krishnapur is being considered as an area for future expansion of the city. Unused land parcel can serve as potential spaces for future development or community projects. The quality and extent of vegetation, trees and shrubs, grass can play a significant role in utilizing the open spaces.

Future land use and urban developments

As of 2020, the population growth rate of Ayarpatha and Sri Krishnapur ward has been less than 5 as compared to snow view ward at about 20.68[1]. Solutions such as retaining rainwater, reducing the flow of water, creating buffer/ storage and construction of drains in the area would make water management efficient. The idea of storm water management can be inspired by natural processes. Low Impact Development (LID) approach focuses on reducing rainfall runoff at its source through the use of uniformly distributed, decentralized, micro-scale hydrologic controls. LID is defined as a strategy for stormwater management and land development that prioritizes conservation and integrates on-site natural features with small-scale, engineered hydrologic controls to better replicate pre-development hydrologic conditions.

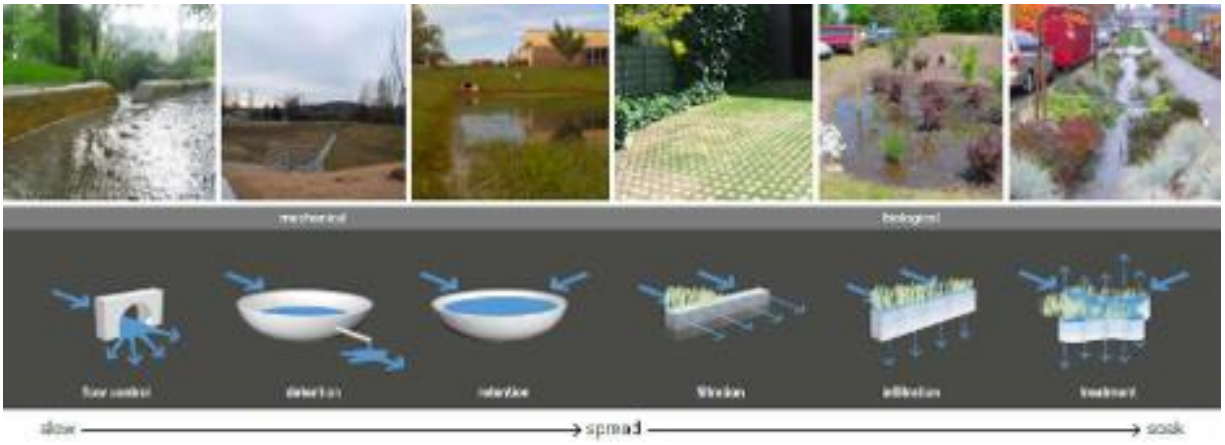


Figure 3-7 Stormwater management systems (Manual on storm water drainage systems, (CPHEEO), May 2019)

Relocating or shifting of administrative/judiciary buildings from Nainital town to alternative areas such as Krishnapur and transitioning to electric vehicles in the town were also highlighted for reducing AQI levels.

Main risks/ challenges and (urban) opportunities to address with NbS

The main risks identified in the case study area are landslides and limited water resources possibly leading to depletion of the lake. Various challenges identified are:

- Lack of proper sewage and solid waste management leads to environmental degradation, putting immense pressure on the local ecosystem.
- Horizontal and vertical urban expansion is leading to haphazard construction increasing the risk of landslides and soil erosion.
- There is significant potential to adopt NbS for better infrastructure and water management, such as rainwater harvesting, increasing green spaces, and using vegetation to stabilize slopes and reduce landslide risks.
- Develop strategies to restore hydrological balance by capturing rainwater, slowing its flow, retaining and reusing it, and only resorting to drainage as a last option.

[1] DOI: https://doi.org/10.21203/rs.3.rs-106891/v1

Suggested Interventions

A. Gabion in drain

Gabion is a structure made of metallic mesh box filled with rocks and stones. Gabions are porous, allowing water to flow through slowly, at the same time allowing to hold back soil. It can be placed across the drain, forming steps to reduce further erosion (see Figure 3-3). It is commonly used for slope stabilization, controlling erosion particularly in areas with steep terrain for better drain management.

Gabions have structural stability and allow vegetation to grow in-between the rocks, integrating the system with the surrounding environment. Gabions are relatively inexpensive to construct as compared to concrete walls, making them cost effective and long-term solutions in drainage systems for managing water flow.

B. Bamboo Soil nailing

Bamboo soil nailing is an eco-friendly technique used to stabilize slopes in hilly, landslide-prone areas. In this method, strong bamboo poles are driven into the soil at regular intervals to reinforce and anchor the slope. Bamboo's natural strength and flexibility make it an ideal material for stabilizing loose or unstable soil, preventing landslides.

One of the key benefits of bamboo soil nailing is its cost-effectiveness compared to other interventions, such as steel nailing or concrete retaining walls. Bamboo is readily available in many regions, especially in tropical and hilly areas, making it an affordable and sustainable option. Additionally, bamboo is lightweight and easy to work with, reducing labour and transportation costs. Over time, bamboo integrates with the soil, further enhancing stability while allowing vegetation to grow naturally, which adds an extra layer of protection against erosion. This makes bamboo soil nailing a practical, low-cost, and environmentally sustainable solution for landslide prevention in hilly areas.

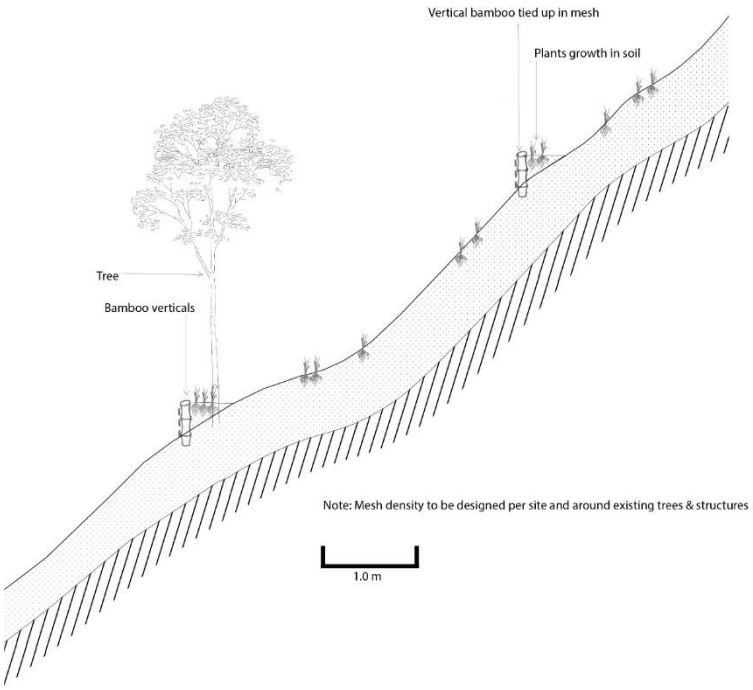


Figure 3-8 Soil nailing

C. Rainwater tank

Rainwater tanks are designed to capture, store and utilize rainwater, particularly in hilly terrain that face inconsistent water supply or scarce water resource challenges. The water collected from rooftops and other surfaces can later be used for household, agriculture and irrigation purposes. Hilly areas that have limited access to groundwater or have distant water supply systems can benefit from these rainwater tanks. Rainwater tanks can be cost effective solution as it can save water transportation cost or investing in extensive infrastructure. It is also effective because it can reduce the volume of water flowing into the drainage system, reducing water clogging and flooding risks.

Proper construction methods and integrating tanks with the local landscapes have benefitted many communities to manage water resources more efficiently.

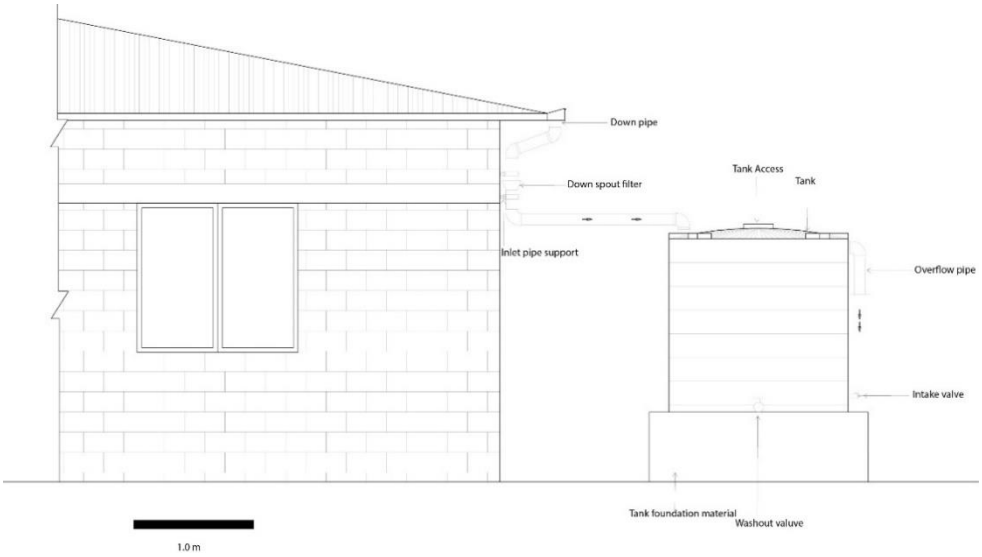


Figure 3-9 Rainwater harvesting to tank (Defacto Urbanism, 2022)

Bill of Quantities:

Example: 20 lpcd (q), is agreed upon and a dry period of 100 days (t), is not exceeded a storage of 10 cum is required for a family of 05 members (n)
V = 100 (t) x 5 (n) x 20 (q) = 10000 litres =10 Cum
As per Schedule of Rates vol 2, CPWD 2021, Polyethylene water storage tank with cover and suitable locking arrangements is INR 6.10 per litre.

So estimated amount for 10000 litres tank
= 6.10 x 10000 = INR 61,000/-

Other Interventions

Broom grass plantation

Planting of broom grass in areas with frequent recurring landslides has been valuable in stabilizing soil. Its extensive root system anchors the soil and minimizes the risk of landslides. By covering the soil surface, broom grass mitigates the impact of heavy rains, reducing soil washouts. Additionally, its roots enhance soil structure and increase its water-holding capacity providing protection to vulnerable landscapes.

Demonstration: concept design

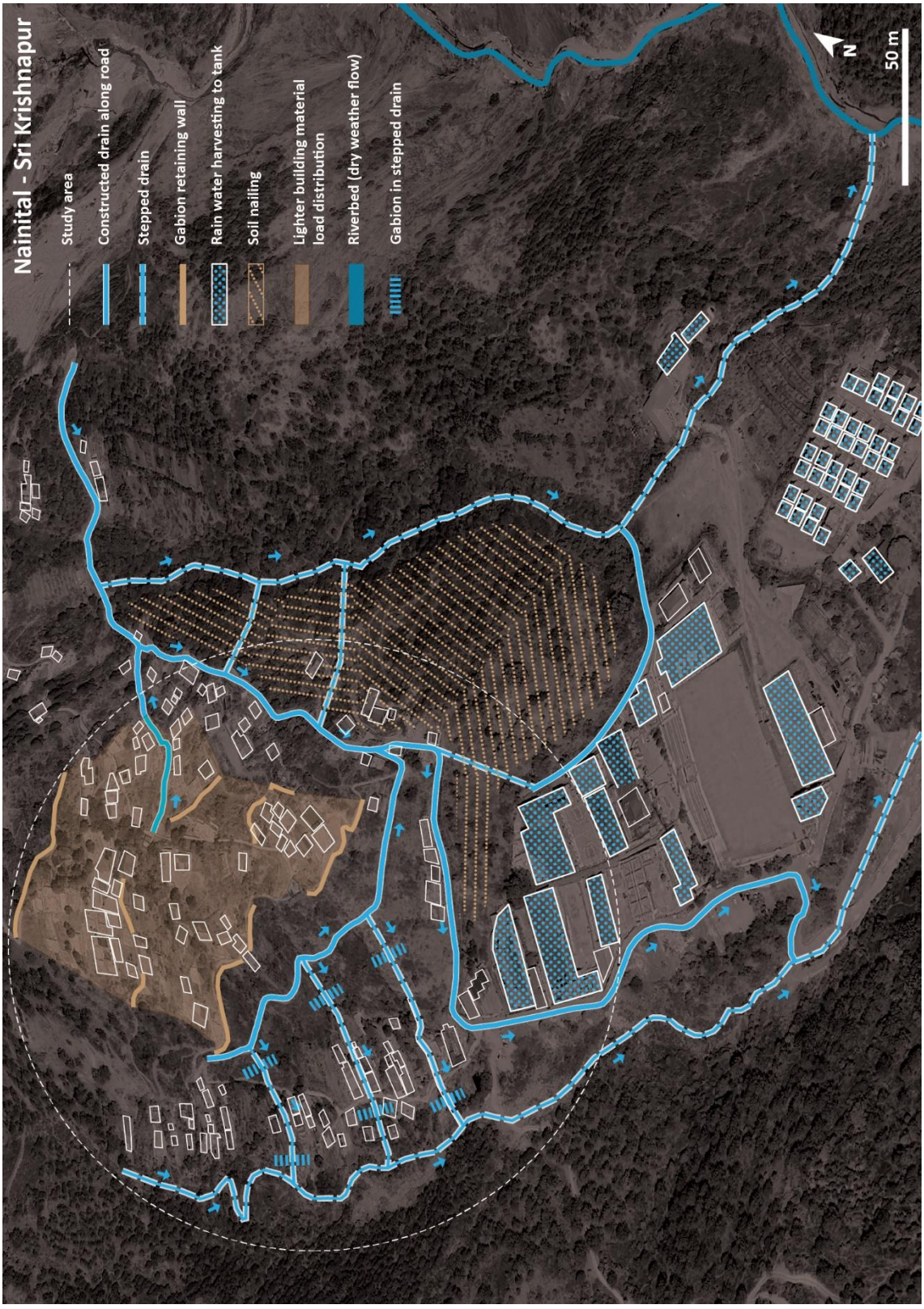


Figure 3-10 Conceptual design Shri Krishnapur, Nainital

The concept design for Sri Krishnapur presented in Figure 3-10 combines stepped drains for the stream with gabions to manage the flow of run-off with bamboo soil nailing to increase slope stability and rainwater tanks to reduce run-off and to increase water security.

Governance

As the governance situation is the same as for case study 1, the reader is referred for this discussion to the governance paragraph in Section 3.1.

Impacts, co-benefits and effect

Table 3-3 presents an overview of impacts, additional benefits and maintenance and monitoring requirements for the proposed interventions.

Table 3-3 Overview of impacts, additional benefits and maintenance and monitoring requirements for the proposed interventions of case study 2 – Sri Khrisnapur

Intervention	Co-benefits	Effect
Gabion in drain	**Landslide /Flood mechanism**	Reduces peak flow, increases slope stability, protects from erosion reducing the chances of landslides
	Additional Benefits	Quick implementation, low cost
	Maintenance	• Repair minor or structural damage to the gabion • Remove or maintain vegetation from the gabion
	Monitoring	Regular inspection to identify any damage, erosion, unwanted vegetation
Bamboo soil nailing	**Landslide /Flood mechanism**	Natural porous structure with better soil drainage prevents waterlogging and reduces risk of soil slippage
	Additional Benefits	Carbon-friendly, low cost
	Maintenance	Durable but also biodegradable, needs material treatments
	Monitoring	Stress changes in the soil or bamboo nails
Rainwater tank	**Landslide /Flood mechanism**	Reduces peak flow by storing rainwater for later use
	Additional Benefits	• Provides a clean alternative supply for various activities excluding drinking • economic benefits by reducing the cost of water supply • quick implementation

	Maintenance	• Cleaning gutter and downpipes • Repair and replace leakages • Scrub the bottom of the tank and flush the water
	Monitoring	Check clogging, leakages in the pipes and tap

Costs and pre-feasibility assessment

The estimated cost of case study 2 – Shri Khrisnapur is INR 97,563,563,20. See Annex A for details of the calculations of the Bill of Quantities.

To assess the pre-feasibility of the project for case study 2, a qualitative assessment has been made of the scoring of this case study on a number of criteria. Scoring is based on the information presented above and expert judgement by the Consultant. The result is presented in Table 3-4. The conclusion regarding the pre-feasibility is neutral to positive as this case study is expected to contribute to landslide risk reduction with limited negative impacts. Costs are high but might be acceptable compared to the damage prevented. It is recommended to execute for this project a complete feasibility analysis including detailed designs and a cost-benefit analysis to decide whether the project should be implemented.

Table 3-4 Qualitative pre-feasibility assessment for case study 2 – Sri Khrisnapur (+ indicates positive, 0 neutral and – negative)

Criterium	**Score (+,0-)**	**Remarks**
Contribution to desired impact	+/0	Project is expected to reduce landslide risk in the area, but current landslide risk appears less than for case study 1
Positive co-benefits	0	Limited co-benefits, mostly from improvement of water security by rainwater tanks
Negative side-effects	0	Limited negative-side effects
Societal support	0	There is no indication that there is opposition to the proposed interventions
Cost – value for money	0	The project is expensive, but is expected to provide a substantial reduction of the landslide risk
Overall score	+/0	The project is expected to contribute to landslide reduction with limited negative impacts and at a cost that might be comparable to the prevented damage

Pathways to implementation
During the final workshop, in Nainital on 18 October 2024, local stakeholders reviewed and provided valuable feedback on this concept design, which are elaborated below. For further detail on the final workshop see Annex D.

Key parties to involve
For the effective implementation of the concept design the following parties have to be engaged
Leading:
- Administrative Department
- Forest and Revenue Department (natural drains)
- Irrigation Department + consultants (constructed drainage)
- PWD (a.o. roads and its drains)

Participating
- Subject experts (e.g. geologist)
- Development authority

Supporting:
- Funding agencies

Beneficiaries:
- School/ institution -> beneficiary
- Individual households -> beneficiary

Opportunities and Roadblocks to implementation

1. Collecting No Objection Certificate (NOC) from various departments is a roadblock. This can be streamlined into a single window application process.
2. Funding opportunities include skill development funds, differentiation of funds, new business model etc.
3. Improving technical expertise is an opportunity through such a project. The opportunity is to develop training and local technical capacity for Nature Based Solutions.
4. A lack of integrated management is a roadblock for NBS which is integrated in its performance and will require cross department collaboration for operations and management.
5. Lack of support from community is seen as a roadblock which can be overcome by mainstreaming community engagement across all project stages.

4. Findings of the situation assessment

The situation assessment forms the basis for the rest of the project. It started with collection of available reports and information in the Inception phase and then followed a structured approach. First a baseline assessment has been conducted for:

- The Socioeconomic and infrastructure situation and existing plans.
- The Natural resources system, which includes, geologic, water resources and water quality systems.
- Institutional and governance system where we look at both the theoretical and the practical functioning of the system in view of the set policy agenda.

Parallel to the baseline assessment different climate and socio-economic scenarios were developed. These scenarios describe realistic possible future developments in terms of factors (e.g., population and tourism developments, water needs and wastewater generation, but also rainfall variability and drought occurrence) that will define and scope the needs for sustainable solutions.

Both the baseline assessment and scenario building benefit from modelling works based on modelling of hydrology, flood mapping, water balance modelling, and landslide mapping under different climate scenarios. The situation assessment is reported in a separate volume (Deltares, 2023). In this Chapter we summarize the main findings.

4.1 Climate change

The climate in Nainital is changing. When looking at data of the Indian Meteorological Department (IMD) for Uttarakhand (no long-term data for Nainital were available), a strong trend in the annual average temperature in Uttarakhand can be observed, with currently a rise of temperature of around 2 ºC per century (Figure 4-1, right panel). There also seem to be a trend in the annual total rainfall volumes, although the trend is not statistically significant and total precipitation for Nainital is much higher than reported here. The trend in the rainfall becomes clearer and more significant when looking at the number of days with intense rainfall (Figure 4-2), which shows that both the number of days of more than 50 mm and 70 mm of rainfall are increasing already.

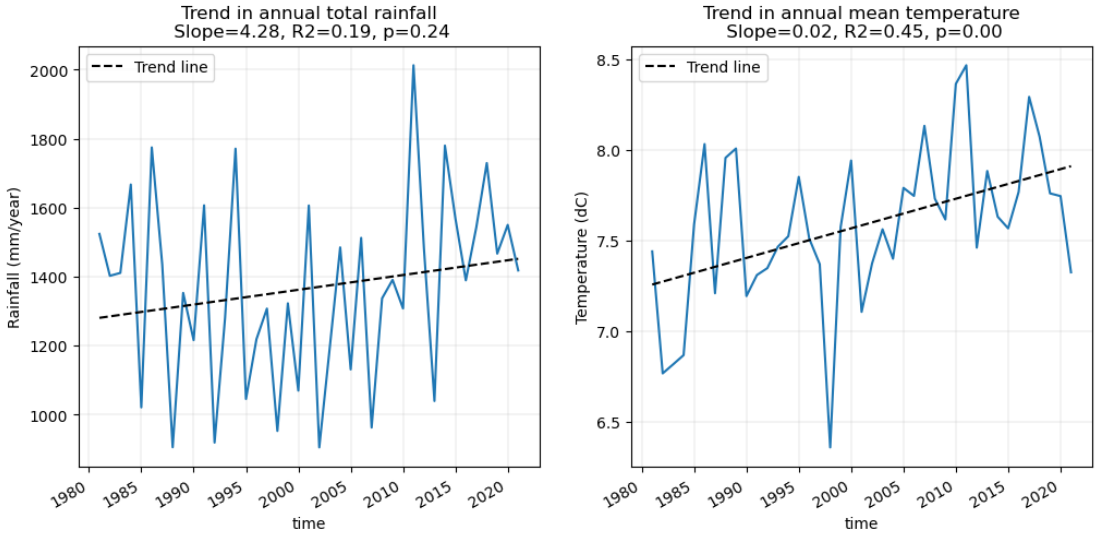


Figure 4-1 Region average trend in the annual total precipitation (left) and the annual average temperature (right figure).

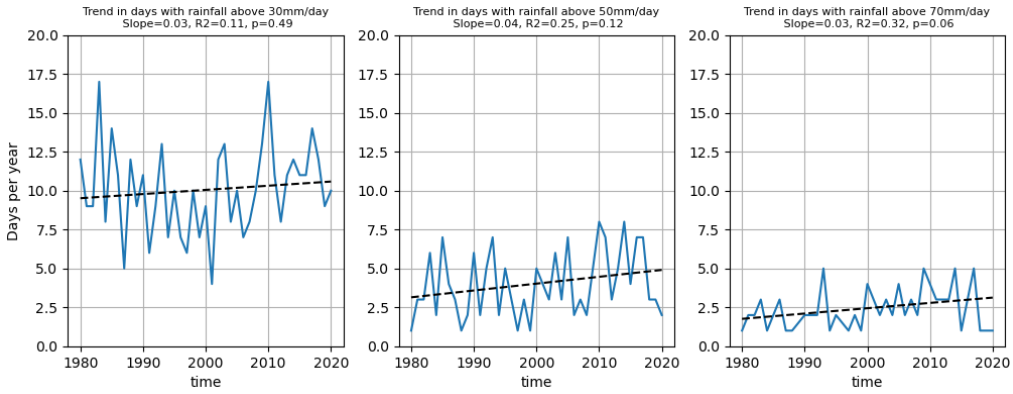


Figure 4-2 Region average trend in the number of days with very high rainfall (right figure).

When looking ahead, climate change scenarios are used to explore the different futures. For this study the recently published CMIP6 dataset is used to assess how the climate is going to change and how this could impact the water balance of Lake Nainital. The CMIP6 dataset consists of a set of climate models that have been used to generate future climate projections based on the so-called Shared Socioeconomic Pathways (SSP) scenarios. The SSP scenarios are basically story lines of how the world is developing in terms of greenhouse gas emissions. There are different SSP scenarios, ranging from SSP126 which reflects the emissions agreed upon in the Paris agreement, up to SSP585, which reflects the “business as usual” scenario. In terms of climate change, the SSP126 scenario would result in the lowest temperature increase, whereas the SSP585 scenario would result in the largest change in temperature.

Figure 4-3 shows the projected changes in temperature (left panel) and precipitation (right panel) for the region. The lower end SSP scenarios project a further increase of temperature for the short horizon up to 2050 after which the temperature increase comes to a hold, whereas the higher end SSP scenarios project the temperature to keep increasing at an even accelerated pace until the end of the century.

The trend in total annual rainfall volumes is less profound, although the average projected change in the high end SSP scenarios indicate an increase of rainfall of 20-40% towards the end of the century.

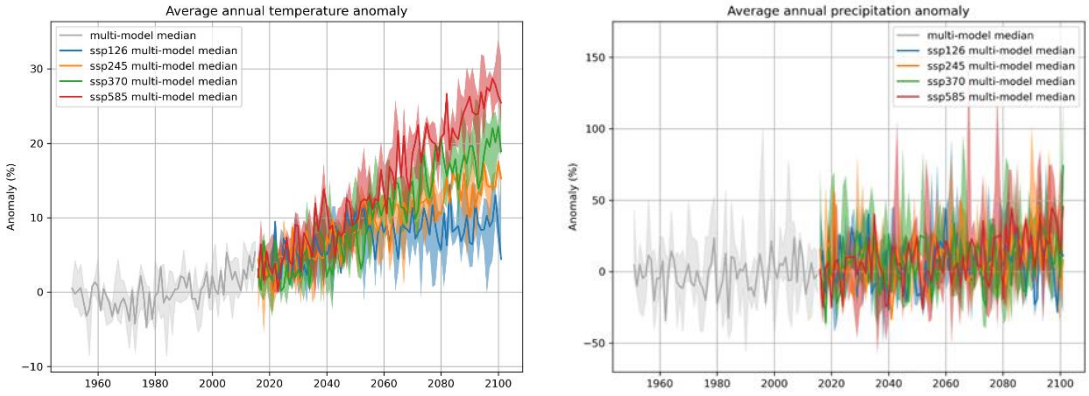


Figure 4-3 CMIP6 climate change projection for the period up to 2100 for different SSP scenarios. The left panel shows the region average change in annual average temperature and the right panel shows the region average change in annual total rainfall.

In Table 4-1 the change in monsoon and non-monsoon rainfall is presented. In general, the rainfall is projected to be going up in the monsoon period, whereas the rainfall is projected to be going down in the non-monsoon period. For the monsoon period, the rainfall is projected to increase while the potential evaporation is projected to only increase slightly. The combined effect is a likely a strong increase in the projected monsoon water availability in the streams and lakes. For the non-monsoon (or dry) period, the rainfall is projected to decrease, and the potential evaporation is projected to increase. Combined this leads to a decrease in the non-monsoon water availability and drawdown of the lake water volumes.

Table 4-1 Average change in rainfall in the monsoon and non-monsoon period.

Scenario	Average rainfall (in mm) per period of the year			
	monsoon		non-monsoon period	
INM-CM4-8_historical	926	-	470	-
INM-CM4-8_ssp245_near	975	5%	431	-8%
INM-CM4-8_ssp245_far	1094	18%	454	-3%
INM-CM4-8_ssp585_near	1045	13%	478	2%
INM-CM4-8_ssp585_far	1282	38%	425	-9%

4.2 Lake water balance

Figure 4-4 presents a conceptual overview of the different terms of the water balance of Lake Nainital. These terms have been quantified in a water balance model, allowing for the analysis of what-if scenarios. Figure 4-5 presents the most important results of the water balance model for the period 2006 - 2022. The observed and calculated water levels show very similar dynamics, although there are also some marked differences. We simulated three scenarios with no groundwater extractions, a constant groundwater extraction at a high extraction volume and a constant extraction at a low extraction volume. The scenario analysis clearly shows how sensitive the lake level is to changes in drinking water abstractions. Lower abstractions than currently (no extraction and minimum extraction) result in a much higher mean lake level and longer periods that the lake is overflowing through the sluices. This corresponds with reports and historical observations mentioning the large amounts of lake water flowing through the sluices in the past and the increasing depletion of the lake visible by lower lake levels. Implementing maximum drinking water abstractions of 16.5 MLD, like in 2015, will lead to a structural decline of the lake level whenever a relative dry year occurs (2019-2022), which eventually will lead to a dry lake during the non-monsoon period. Results of other simulations show that the lake level is much less sensitive for climate change scenarios. In the evaluated scenarios the increase of precipitation during the monsoon period outweighs the decrease during the non-monsoon period and the increase in evaporation, leading to a slight increase in non-monsoon lake levels.

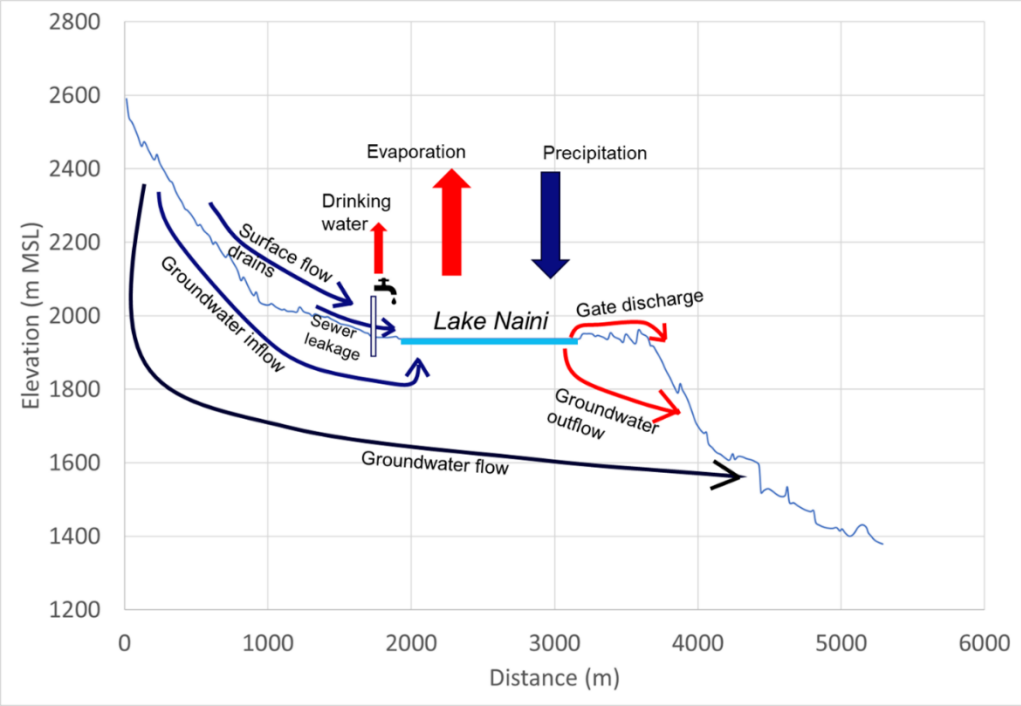


Figure 4-4 A conceptual representation of the water balance in-flow and out-flow terms of Lake Nainital

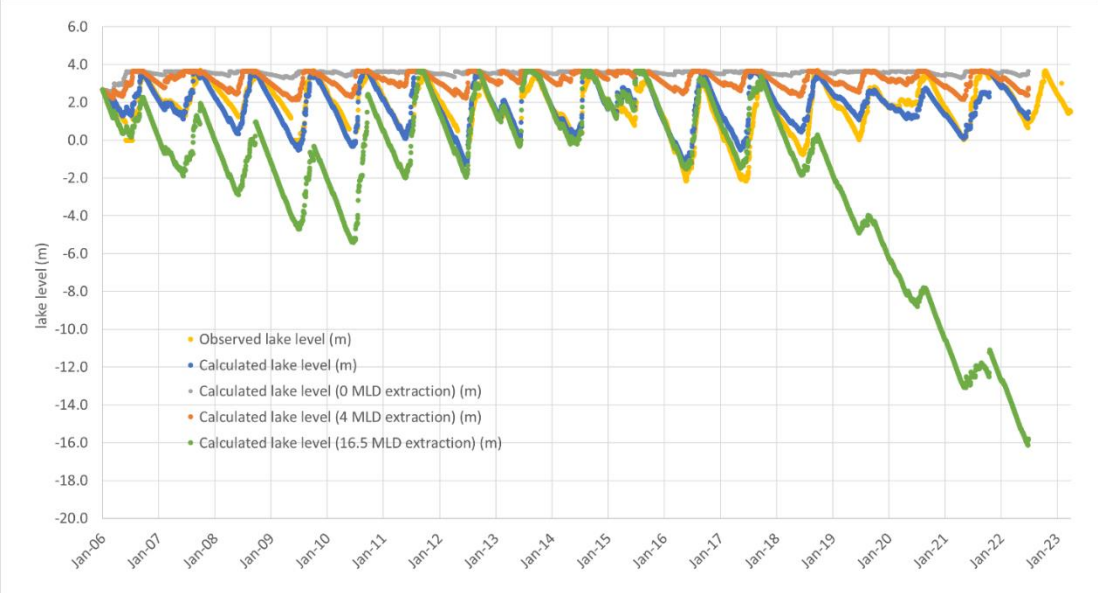


Figure 4-5 The calculated lake level for four different drinking water abstraction volumes

The results of the scenario analysis of the water balance show that the current water bearing capacity of Lake Naini is at a critical level. Increase of water abstractions might lead to depletion of the lake in the non-monsoon period. Climate change is expected to have a limited, but positive impact on the lake level. However, the expected increase of dry spells (not simulated in the water balance model) may have an adverse effect on the lake's bearing capacity. During such extreme dry years, lack of precipitation and an increase in evaporation may lead to accelerated depletion of the lake.

Depletion of the lake potentially also reduces the flushing events of the lake, leading to an increased residence time and accumulation of litter from the urban surroundings that poses a direct risk to the water quality of the lake. Especially sewage leakages entering the lake via storm drains have a

negative effect on the oxygen concentrations. If BOD concentrations in surface flows into the lake are reduced the oxygen levels will increase as the oxygen demand will be lowered. This makes the (current) oxygen concentrations less dependent on the two air-injection facilities installed in the lake that stimulate the reaeration capacity of the lake.

4.3 Landslides

The history of Naini Lake Basin indicates that this beautiful city with scenic surrounding has been a victim of massive and frequent landslides, mass erosion, rock-fall and slumping. Its location in highest rainfall zone, weak lithology and topography are the obvious reasons for these activities. Moreover, rapidly increasing anthropogenic interferences like construction activities and deforestation on this geo-dynamically unstable zone has added more to the problem.

A detailed landslide susceptibility assessment has been carried out using an Artificial Neural Network modelling approach (Figure 4-6). The model assesses the landslide susceptibility based on input parameters, such as maps of slope, rainfall and lithology, and is trained on historical observations of landslides.

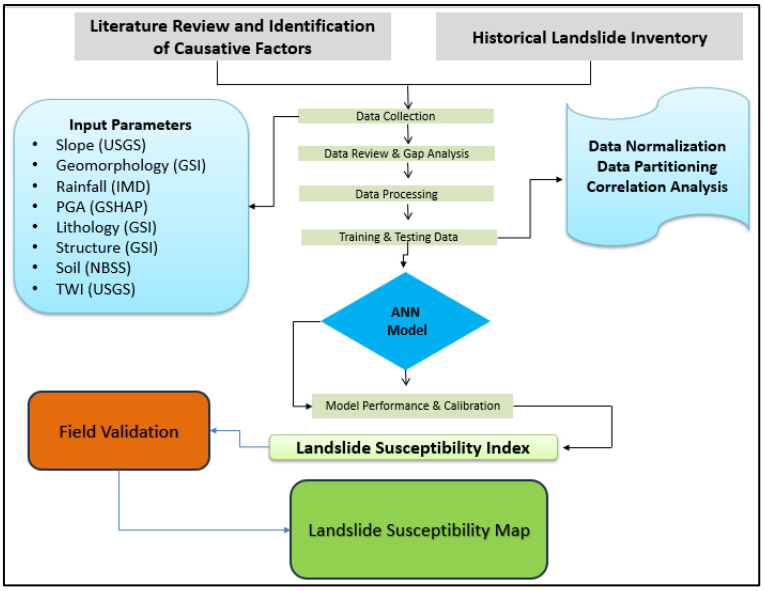


Figure 4-6 Input Data and Artificial Neural Network modelling methodology

The result of the model is a landslide susceptibility map (Figure 4-7). The sensitivity for climate change, development activities and population dynamics has been assessed by running the model with rainfall data for a climate change scenario and adapted land use. The resulting landslide susceptibility map is presented in Figure 4-8.

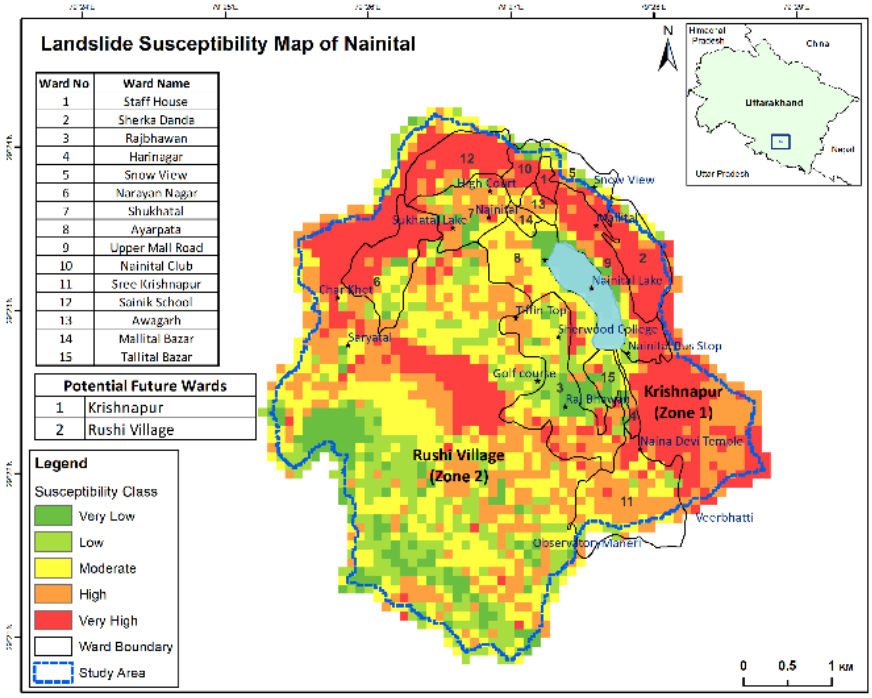


Figure 4-7: Landslide Susceptibility Map (current scenario) of Nainital study area

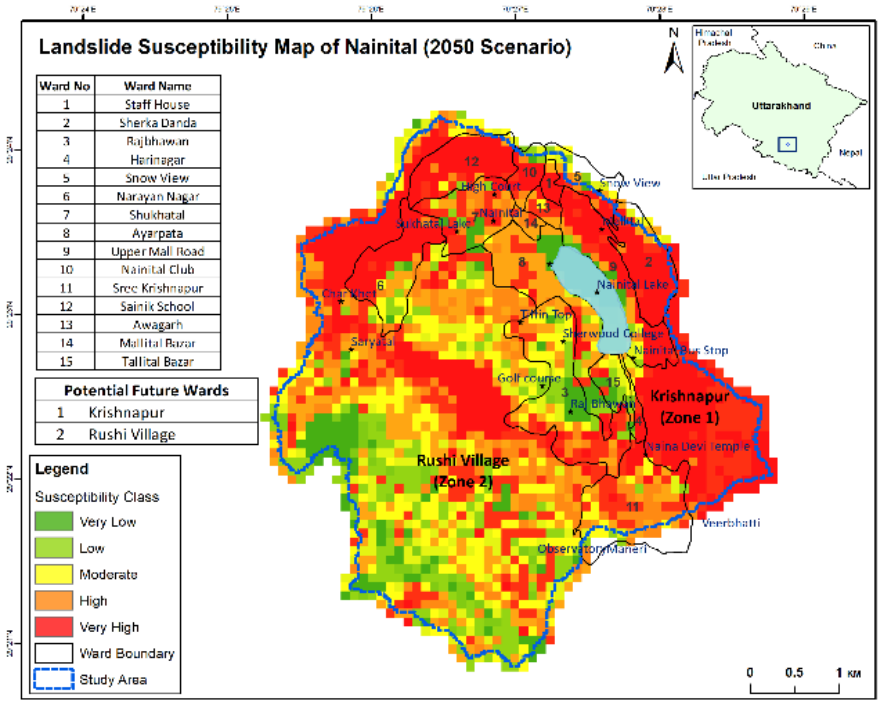


Figure 4-8: Landslide Susceptibility Map (2050 scenario) of Nainital study area

The main findings of this landslide susceptibility analysis are:

- Large areas around Lake Naini are highly to very highly susceptible to landslides.
- Landslide susceptibility is expected to increase in the future due to higher rainfall intensity and increase in population pressure.
- The small city of Nainital has already reached its limits to withstand any additional engineering infrastructure, developments and construction activities. However, ever increasing population and

tourism in the city is putting continuous burden on the local authorities to provide necessary facilities resulting into further increased burden on already loosened and fragile geology.

It is suggested to use the landslide susceptibility maps for zoning with respect to future developments, such as construction of roads, houses and other infrastructure. Furthermore, it is recommended to refine the landslide susceptibility map based on detailed geological and geophysical investigations.

4.4 Governance and Institutional

Both the permanent population of Nainital and the amount of visiting tourist have increased significantly in the recent past. This has led to unplanned developments which increase both the occurrence and the impact of landslides. Urban development has been largely unregulated as there has been no new Master Plan since 2011.

City-level institutional capacities to address urban risks are constrained by a lack of technical/ scientific knowledge, financial, and human resources available. The use of land use controls and building regulations and their enforcement could be improved to manage landslide risk.

5. Conceptualization workshop

Workshop context

The Project's Inception phase was started with the collection of studies and documents. The first Workshop was organized to involve the main stakeholders in the project and inform them about the objectives and workplan as well as to invite them to be active in the project. In March 2023 the Assessment phase started and the situation analysis was carried out by various Experts from Netherlands along with Indian Counterparts which formed the basis for the project. The results from Assessment phase were integrated in an integrated risks and impacts assessment in key watersheds and urban areas in Nainital providing a good insight into the vulnerability of different parts of the city to present and future hazards. To discuss the Assessment made by the Experts with the Stake holders (various Departments) and to know their feedback the Conceptualization workshop of two days was organized at Nainital from 27 to 28 June 2024.

The workshop was organized on behalf of the Asian Development Bank (ADB) in collaboration with the Uttarakhand Urban Sector Development Agency (UUSDA), Deltares and RMSI on Enhancing (Water & Climate) Resilience in Nainital Urban Development.

Workshop objectives & goals

The Conceptualization Workshop focussed on developing map-based climate adaptation decision-supporting tools and the co-creation of action plans on climate-resilient improvements. The main goal was to explore how the involved departments and agencies can come to a common approach to pro-actively plan future developments:

- Check-in with stakeholders' re-development of project and materials.
- Guidance: Development of climate-resilient decision-supporting tools, which facilitate interactive "Water-Sensitive Planning" and decision-making.
- Training: climate-resilient planning and development, including watershed-level climate-resilient water resources management and infrastructure development in Uttarakhand.
- Measures: Selection and design of climate resilience measures with a special focus on nature-based solutions (NbS).

It was decided to focus on the landslides. This includes both coping with the existing and progressing landslides, such as Balia Nala, as well as including landslide susceptibility in the planning and design of future developments. This project does not aim to provide the solution for Balia Nala. The ambition was to bring together all involved departments and agencies to come to a common approach, how to deal with the issue of land slide susceptibility in urban development. It was also intended to realize that there are relations between storm water, sewage and road drainage, irrigation, and construction of housing and infrastructure, such as roads and STPs in and around Nainital. The detailed Schedule of the workshop is presented in Annex B.

Details of Workshop:

Day 1

The Conceptualization Workshop was inaugurated on 27th June. The Registration session went on till 11.00 hrs as it was raining heavily and the Opening Session started at 11.00. It was encouraging to see participants representing various Departments of Uttarakhand Government, despite heavy rain since midnight of 26th June.

Opening Session started with the Welcome address by Neeraj Upadhyay, Project Manager, USSDA. He explained the Project in brief and expressed his happiness that such a workshop could be organised. He

wished the Workshop a success. It was followed by opening remarks by Mr Pratul Shrivastava, RMSI, explaining about the schedule of the first day and the objective of workshop. The detailed Schedule of the workshop is presented in Annex B.

The workshop was attended by Scientists from National Institute of Hydrology, Roorkee and Professional and Practitioners from UUSDA, USDMA, Jal Sansthan (Water Resource Division), Public Works Department (PWD), Irrigation Department Uttarakhand, apart from the Organizing Experts from Deltares, RMSI and UUSDA. The detailed list of Participants is given in Annex C.

The inauguration session was followed by a Presentation by Mr. Marnix van der Vat of Deltares. He Introduced the Project, about the problems in India due to Climate Change. How the Nature-based Solutions (NbS) could be introduced that are effective and minimize the hazards and maximise the liveability. He explained that the workshop's main aim was to see "Work together to address these challenges". He explained the Project phases like Inception, Assessment, Conceptualization, and Completion phase. He added what are the added values of this Project. He explained the project results and explained the detailed assessment, especially the assessment of water resources, wastewater management and related issues. He also emphasized the relationship between water supply, wastewater disposal and pollution of water.

This was followed by Mr Shafique Ahmad's presentation about the Landslides (Figure 5-1). He introduced the Landslides, explaining the causes, impacts and importance to be given for proper understanding of Landslides in every project during the planning phase itself. He explained about the susceptibility of the area to Landslides – for the current situation and under a future scenario including climate change. Participants from the line Departments took an interest to clarify more on this issue, as it was very relevant and was related to day-to-day life. There was a lively discussion on this issue with the participation of organizing experts and participants. Mr. Marnix explained the impact of Climate Change in the project area, especially with reference to water resources and landslides. The lively discussion set the stage of the workshop.

Figure 5-1 Participants eagerly listening to the presentation on Landslides

SWOT Analysis was introduced by a brief presentation by Nanco Dolman of Deltares (Figure 5-2), followed by a Group Exercise on SWOT by two groups. Both the groups comprising of mixed groups with practitioners from State and Central agencies and experts from research Institutes actively participated in the discussion on SWOT and could identify a number of Strengths, Weaknesses, Opportunities and Threats. The **Strength** included Scenic beautiful geography of the area with pleasant climate; Nature as health benefit; Presence of Naini lake for the livelihood of people depended on tourism and as a source of water supply for all the residents and tourists; Administration and Judiciary hub with presence of Raj Bhawan, Commissioner Office, High Court and Administrative Training Institute. The **Weakness** included poor implementation of regulations under Building Bylaws for new as well as for existing buildings and infrastructure; lack of awareness about hazards of nature; poor drainage system; poor public transport facilities. The **Opportunity** to adopt nature-based solutions; promotion of nearby areas for tourism in addition to Nainital; upgradation of public transport; adoption of light weight structures for construction; rainwater harvesting and more recharge pits; proper drainage plan incorporating catchment hydrology; proper traffic management and multi-level parking facilities in nearby areas; adaptation of lake revival techniques are some of the opportunities identified. And finally, the **Threats** included Forest fire; unplanned urbanisation; Frequent traffic jams during the day; No solid waste management due to floating population; Earthquake and landslide prone area; Water level of Lake depleting at alarming level; silting, Eutrophication, Seepage from lake and Lake contamination; Reducing Forest area and Ground water depletion.

Both groups very well presented their SWOT analysis as they were very familiar with the locality in and around Nainital. Both the Groups highlighted various issues during their brief explanation session which showed their level of understanding of the area. During the group presentation both group members were made to realise the attention required to understand the viewpoint of the other group as well.

Figure 5-2. Workshop Session under progress with participants keenly attending the lecture

In the fore noon before breaking for lunch, Mr. Shafeeq and Nanco Dolman (Deltares) briefly explained and made a presentation on – “Introduction of case study sites and geo-visualization tool”.

In the afternoon session, group work in two groups to study the map of two case study areas selected for exercise purposes was facilitated by the organising team. The Groups identified various interventions and marked them with numbers on the map after a detailed discussion among the group. Both the groups

actively participated in the discussion and marked the areas as they were familiar with the locality and could identify the areas and structures that could be planned as interventions to reduce the risk of landslides (Figure 5-3).

Figure 5-3 Group exercise during the workshop in Nainital on June 27, 2024

At the end of the first day, the organizers thanked the participants and invited them for further fruitful discussion on Day 2.

Day 2

The Conceptualization Workshop of the Second day on 28th June 2024 started at 11.00 hrs again due to rain. It was encouraging to see number participants representing various Departments of Uttarakhand Government in addition to Day 1 participants.

Recapitulation of the first day of the workshop was done by Mr. Nanco with active interaction from the participants. His presentation also included the SWOT outcome. The Group work done on the first day was presented by the groups in brief.

This was followed by a presentation by Mr. Nanco on Enhancing resilience in Urban areas. He discussed the five capacities of Climate resilience; the connecting challenges and he explained that water is the foundation of our cities. And also, that water related issues will be heavily affected by climate change. He went on to explain three pillars of action of building a city. He presented several international and Indian examples so that the participants could understand the context of the discussion.

The Group Exercise consisted of the identification of additional risks/issues other than Landslide and lake depletion in Nainital. Participants actively could identify additional risks in two groups and plot them on the map with the help of Google maps and the Landslide risk map. The groups discussed various issues like storm water drainage, sewage, traffic congestion, forest fire etc. which was facilitated by Mr, Saurav Sen (Figure 5-4 and Figure 5-5). After this, the detailed discussion was continued by Mr, Shafeeq on various Landslide sites and other issues with the help of Google Earth map and cross section across various locations in Nainital. This was well appreciated by the participants.

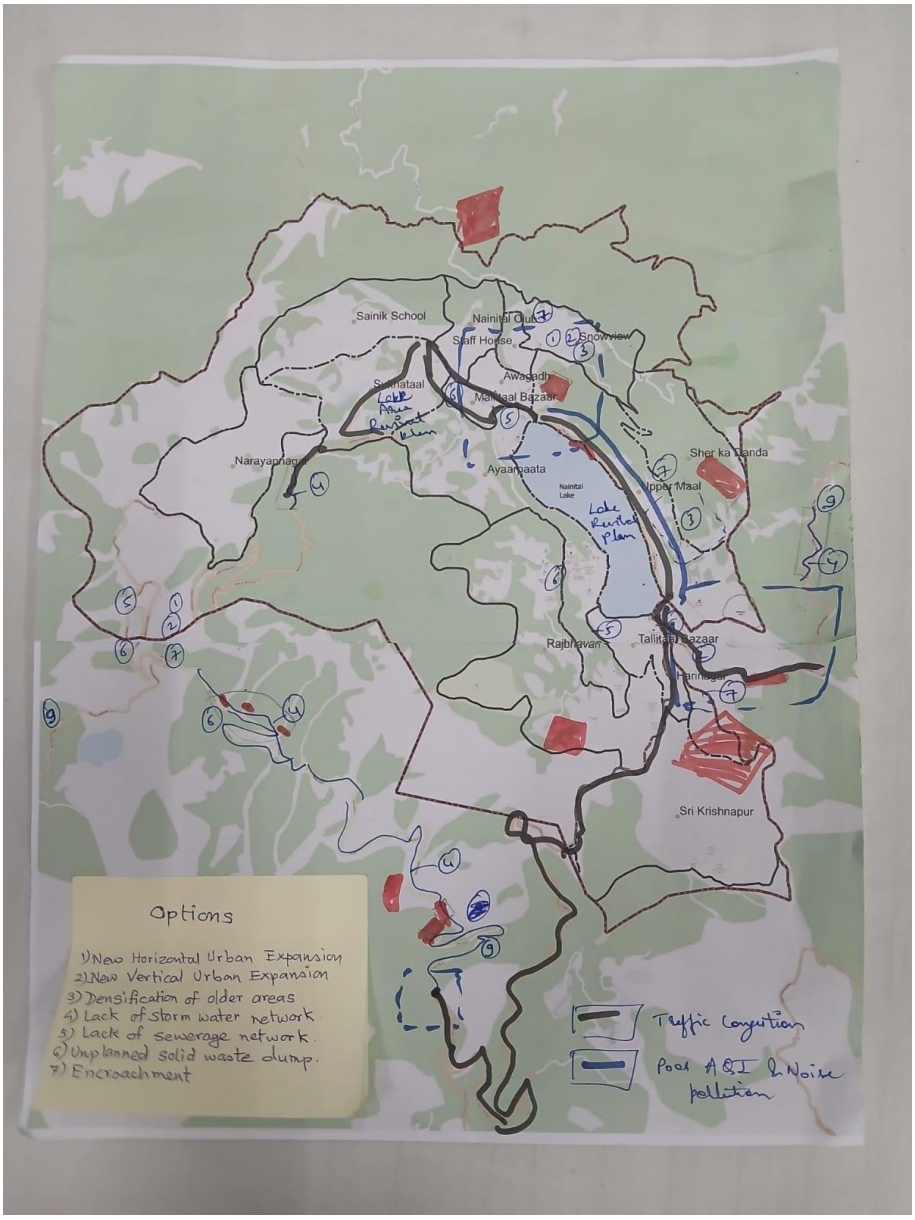


Figure 5-4 Outcome of Group Exercise of one of the groups.

This group Exercise was continued after the lunch on Strategies for mitigation and future plans for the Scenarios in 2050 and to develop Water Sensitive Nainital by 2050. Both the groups could come up with several issues and solutions for both scenarios with facilitation led by Mr. Nanco.

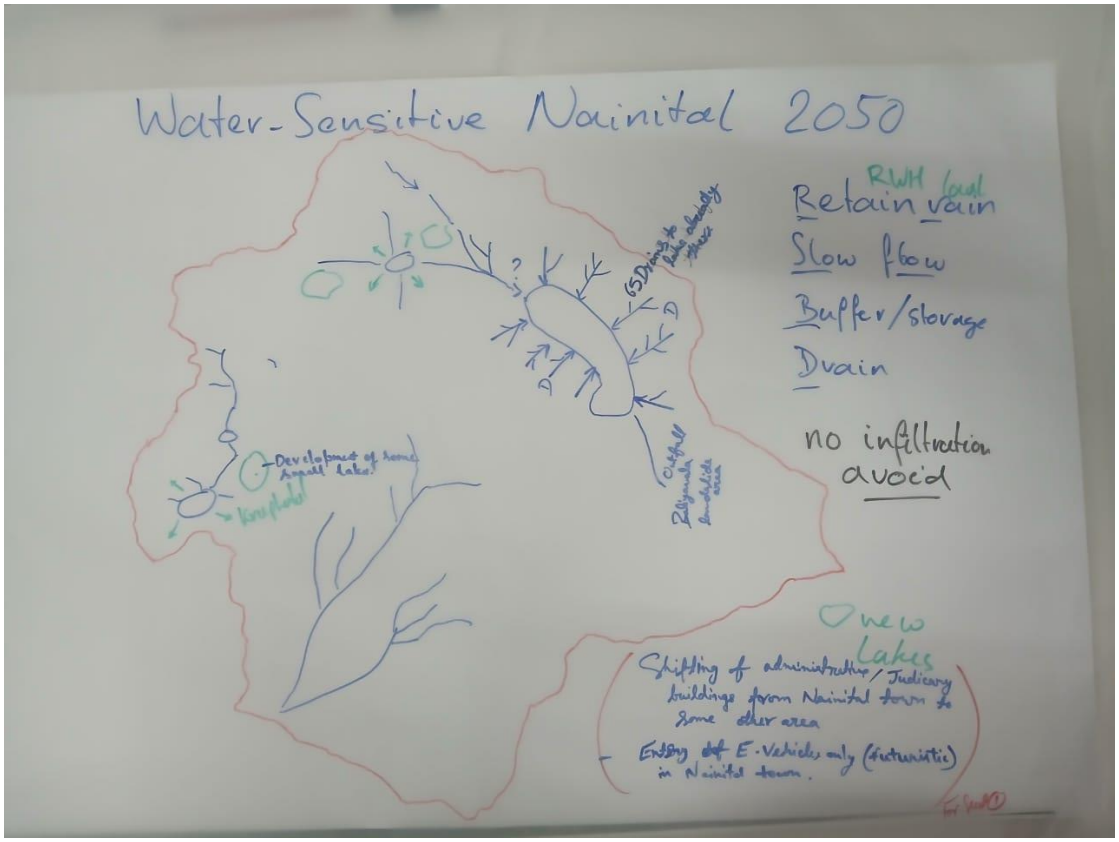


Figure 5-5 Group Exercise of Strategies for mitigation and future plan for the Scenarios in 2050 and to develop Water Sensitive Nainital by 2050

This was followed by a discussion by Mr. Marnix on What next and filling up of Post Assessment Form by the participants with their oral feedback. The details of Evaluation of the Conceptualisation workshop are discussed later in the chapter on “Training material and Training Evaluation”. The feedback of the Workshop was given by Neeraj Upadhyay PD, USSDA, Dr Surjeet Singh, Sc-G, NIH and all others. Most of them felt that the Group Exercises were nice to discuss, and they realised that how important is the need to discuss with other Department to implement any Project in such a fragile and sensitive areas prone to Landslides and where the water resources are limited. They also thanked the Deltares and RMSI for the Workshop. One of the Participant suggested that we should also invite higher authorities for such a workshop as the implementation decision lies with them. So, that their presence will be very useful. Some participants felt that field visit could have been a boost to the Workshop. Discussions were also held on the next workshop where the draft final report will be submitted, and its results will be discussed with all the Stake holders. There was a suggestion to invite Secretary, UDB, Govt. of Uttarakhand, so that need of implementation of such eco-friendly interventions are realised and executed by the higher authorities. Further, it was suggested that we may invite the Civil Society of Nainital who are very active in such measures, and it will strengthen our suggestions. ATI is suggested for next workshop venue as it is a Govt. venue which will invite more participants due to its respect amongst the Government servants.

Mr. Neeraj Upadhyay, PD, USSD delivered closing remarks for the workshop thanking the organisers for the successful organisation of the workshop. He said that they have learnt a lot of things through hands-on exercise and gained lot of knowledge through this workshop. He tanked all the Experts from Netherlands and their Indian counterpart. Vote of thank was proposed by Dr K J Anandha kumar, to end the workshop.

Results & Conclusion

Main goal of the workshop was to explore how the involved departments and agencies can come to a common approach to pro-actively plan future developments. Landslides and Depletion of Lake were the two major issues in Nainital which required attention and involvement of stake holders realise and come out with some NbS solutions, to protect and improve the existing situation and plan development, keeping in mind the Climate Change and Urbanisation. For this, the organizers facilitated the participants in a systematic way to conduct SWOT to understand the situation and appreciate the discussion about existing natural hazards in the area like earthquake, landslides, and all the triggering factors which deteriorate the situation. The NbS interventions were introduced to the participants to understand and participate in planning and map-based planning for interventions which will help in strategy framework. Thus, the objective of the workshop was successfully achieved with stake holders' participation.

The assessment by the project team was agreed by the stakeholders in principle in the workshop. During the discussion lot of further suggestions for the reasons for such a situation was informed which was very useful. In addition, further innovative suggestions to improve the situation and accordingly plan development for future like for the year 2050 was discussed. This outcome will be an added advantage for the project team in developing the strategic framework of the draft final report and ultimately in the final report.

The results of the interactive sessions of the conceptualization workshop, thus, will form the basis for the project outputs regarding the concept designs and pre-feasibility assessment of priority adaptation measures and the strategy framework on climate resilience. Based on the feedback from the workshop the final draft report can be prepared incorporating the suggestions and submitted to Asian Development Bank and final Workshop can be organized to discuss the Final draft report with the stake holders.

6. Climate Adaptation Support Tool

6.1 CRCTool introduction

The Climate Resilient City Tool (CRCTool) is a type of Adaptation Support Tool (AST) to aid decision-makers in the process of urban climate adaptation. The CRC Tool supports the co-creation of climate resilient designs for urban areas in stakeholder sessions by providing an easy-to-use tool to make spatial designs and immediately show the effect on resilience of the different adaptation options that are chosen by the group.

The tool supports the selection of nature-based adaptation options in urban adaptation planning and stakeholder dialogues. The tool provides information on the hydrological effectiveness and an indication of the construction and maintenance costs. The CRCTool can be used on a computer to explore and compare adaptation options, or on a touchscreen for the co-creation of urban designs with stakeholders.

6.2 CRCTool configuration

This section provides the most relevant information regarding the CRCTool configuration. For more information regarding the hydrological model behind the CRCTool, please visit the online documentation.

The configuration of the CRCTool requires a combination of static and dynamic data and must always be tailored to a specific region. Local (geo)hydrology, subsoil conditions and climate influence the effectiveness of Urban Nature-based Solutions. We piloted the CRCTool for Dehradun which has been tailored from the original (climate) Adaptation Support Tool[3]. Static data consists of information regarding urban land use, stormwater drainage system, and subsoil system and infiltration capacity. Dynamic data is the represented by climate forcing (precipitation and potential evapotranspiration time-series).

The tool can be expanded by providing geo-referenced background layers that can be switched on or off in the map window. Furthermore, client information regarding their adaptation targets serves as concrete goals to work towards. The sections below give a brief overview of the most relevant input data to the Dehradun version of the CRCTool.

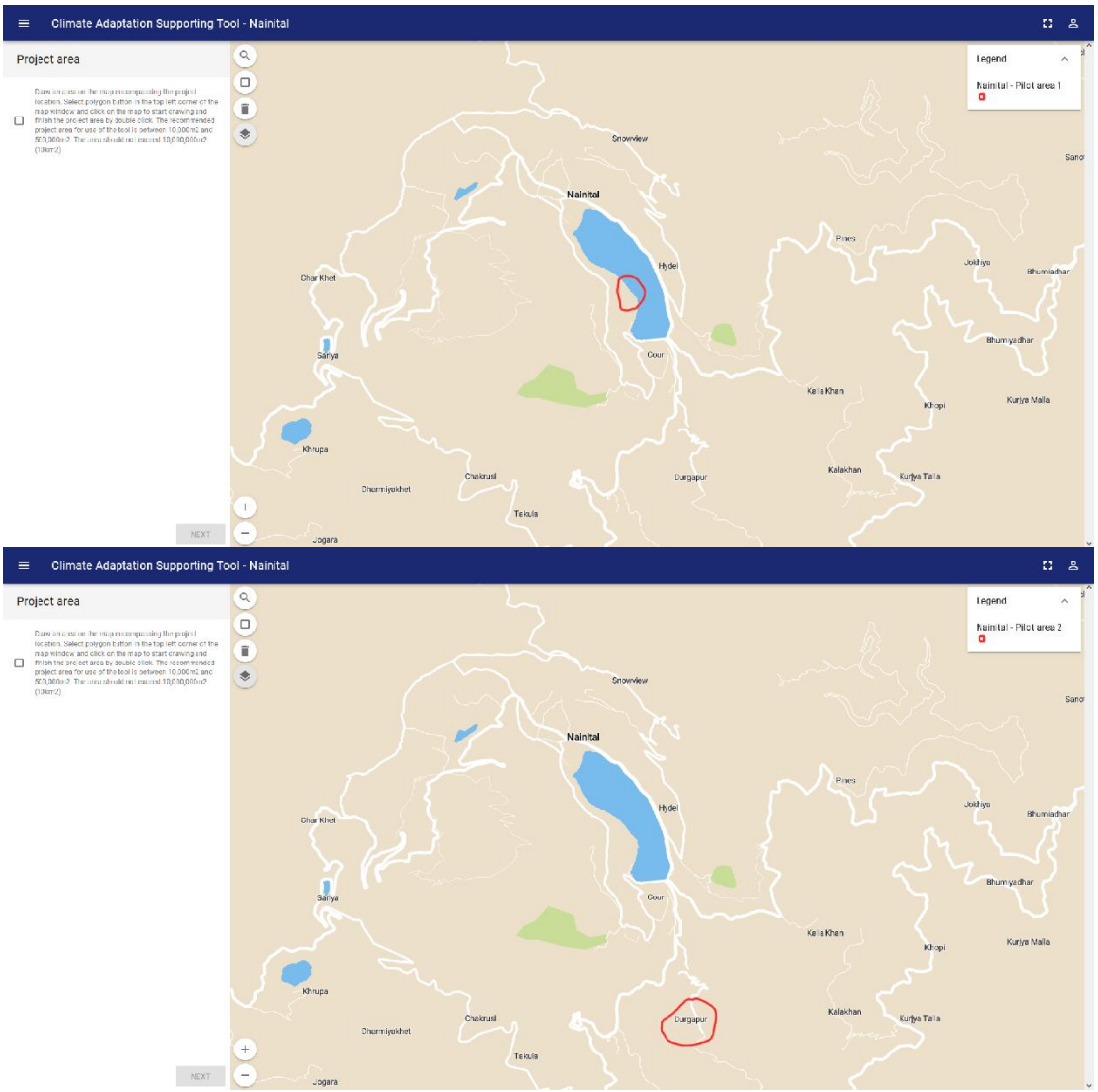
As the tool is originally designed for an area that is relatively flat, has quantifiable groundwater levels and a stormwater drainage capacity, the decision was made to not configure the CRCTool for Nainital hydrologically. Instead, the tool was deployed as an interactive Mapbox application to highlight the complex challenges in Nainital.

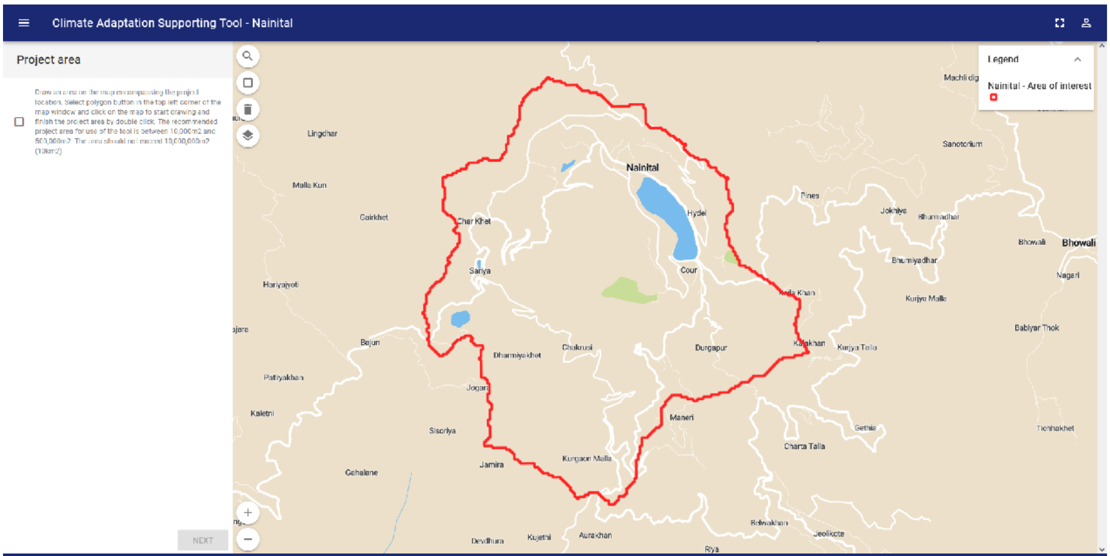
Background layers
Using the CRCTool in Nainital mostly as interactive Mapbox application, the available background layers are of importance. Below is a list of the implemented background layers, accompanied by a screenshot.

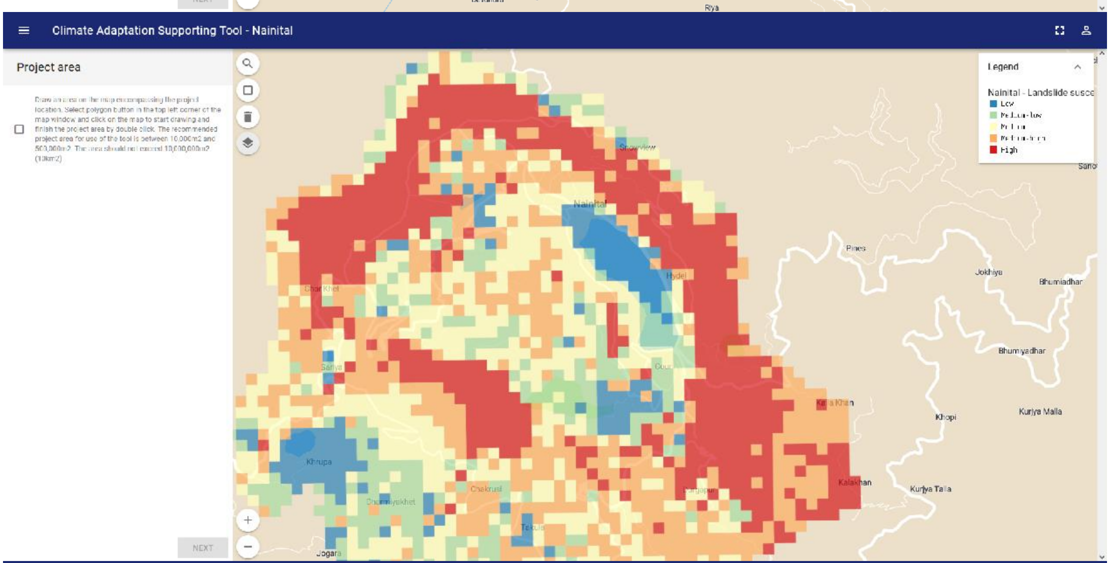
[3] Ven, van de F.H.M, Snep R., Koole S., Brolsma R., Brugge van der R., Spijker J., Vergroesen T. (2016) Adaptation Planning Support Toolbox: Measurable performance information based tools for co-creation of resilient, ecosystem-based urban plans with urban designers, decision-makers and stakeholders, Environmental Science & Policy, Volume 66, Pages 427-436, ISSN 1462-9011, https://doi.org/10.1016/j.envsci.2016.06.010.

Included background layers (see screenshots below):

- Outline of case study area 1
- Outline of case study area 2
- General Nainital area of interest
- Landslide susceptibility (current)
- Landslide susceptibility (2050)
- Digital Elevation Model (DEM)
- ESRI satellite imagery
- Irrigated land
- Structural discontinuities
- Geomorphology




Climate Adaptation Supporting Tool - Nainital
Project area
Legend
Nainital - Area of interest
NEXT
Nainital
Lingchar
Malla Kun
Gairkhet
Char Khet
Sariya
Hariyajyoti
Hydel
Cour
Pines
Jokhiya
Bhumiadhar
Bhowali
Nagari
Sanotorium
Kurjya Malla
Babiyar Thok
Kurjya Talla
Bajun
Patiyakhan
Kaletni
Dharmiyakhet
Chakrusi
Durgapur
Maneri
Siscriya
Jamira
Kurgaon Malla
Gahalane
Charta Talla
Tionhakhet
Devdhura
Kujethi
Aurakhan
Riya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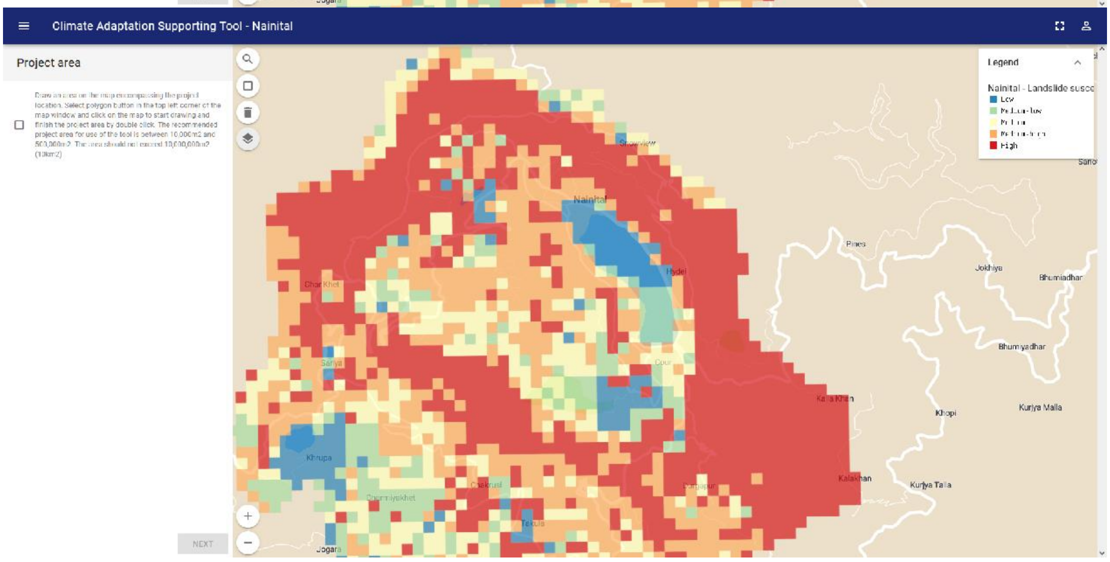
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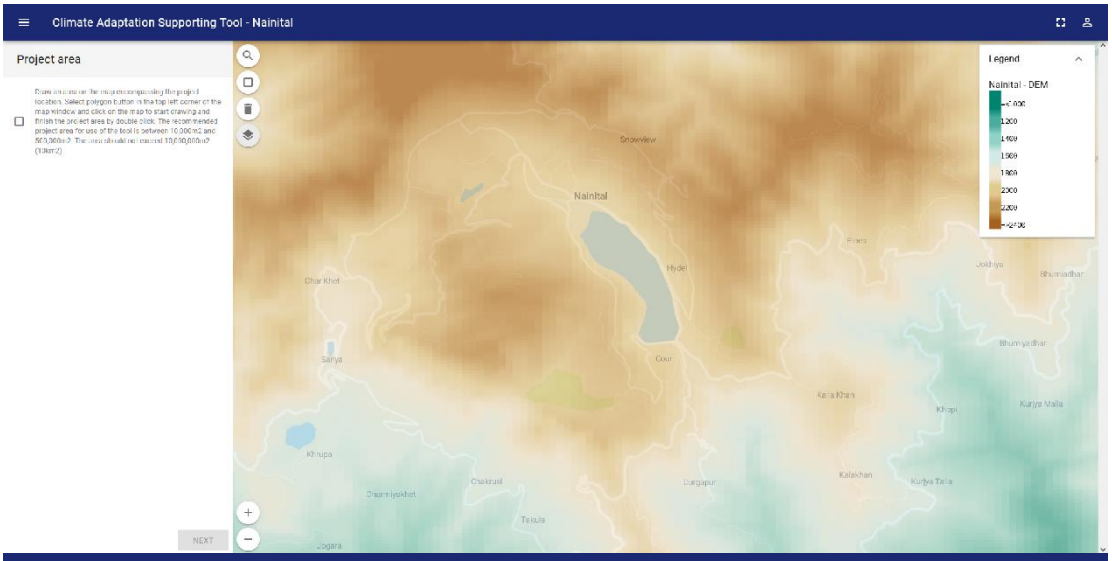
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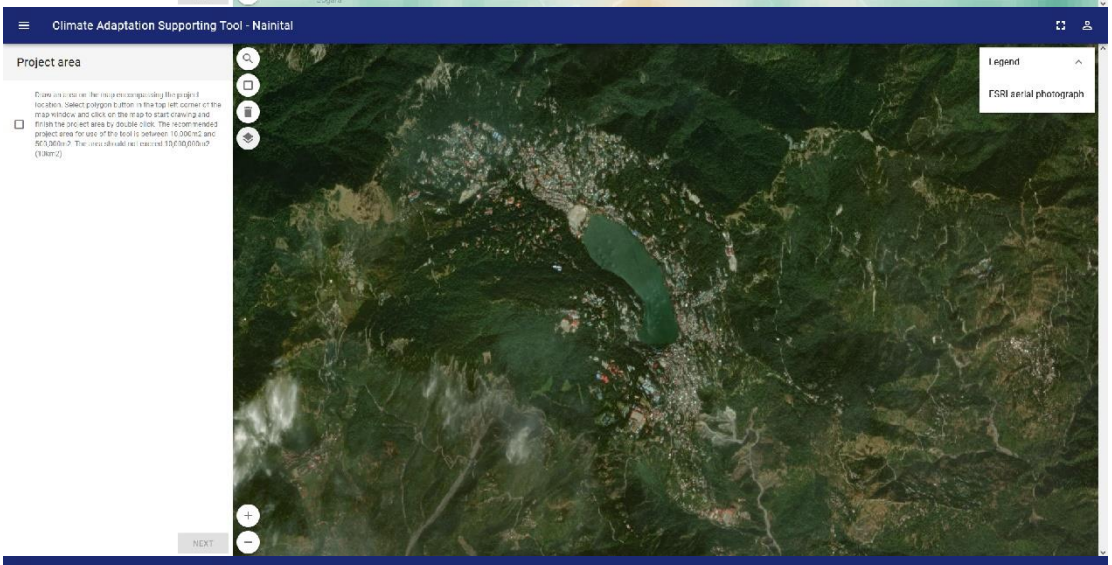
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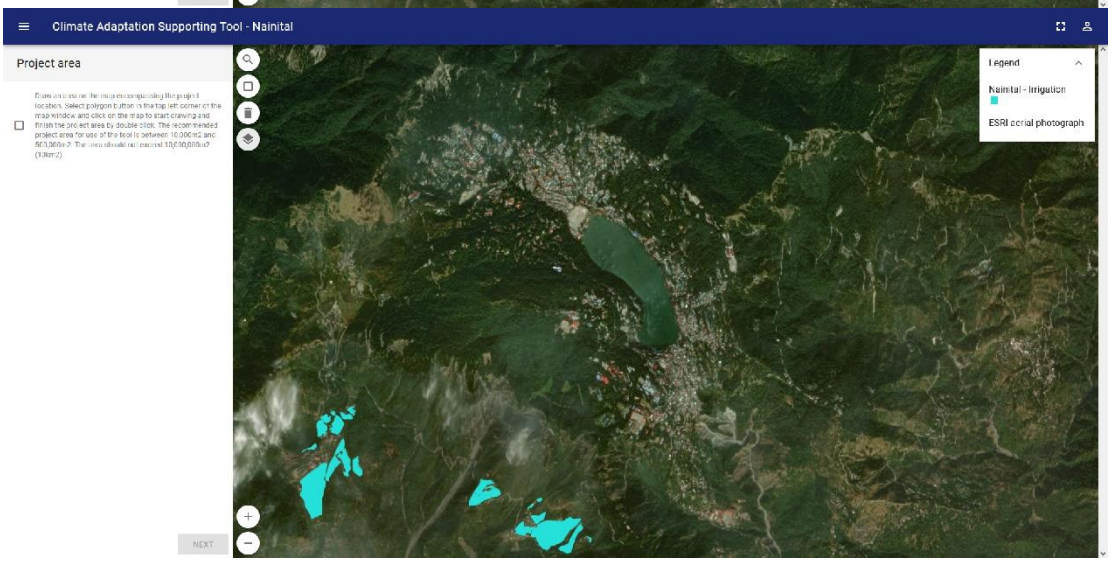
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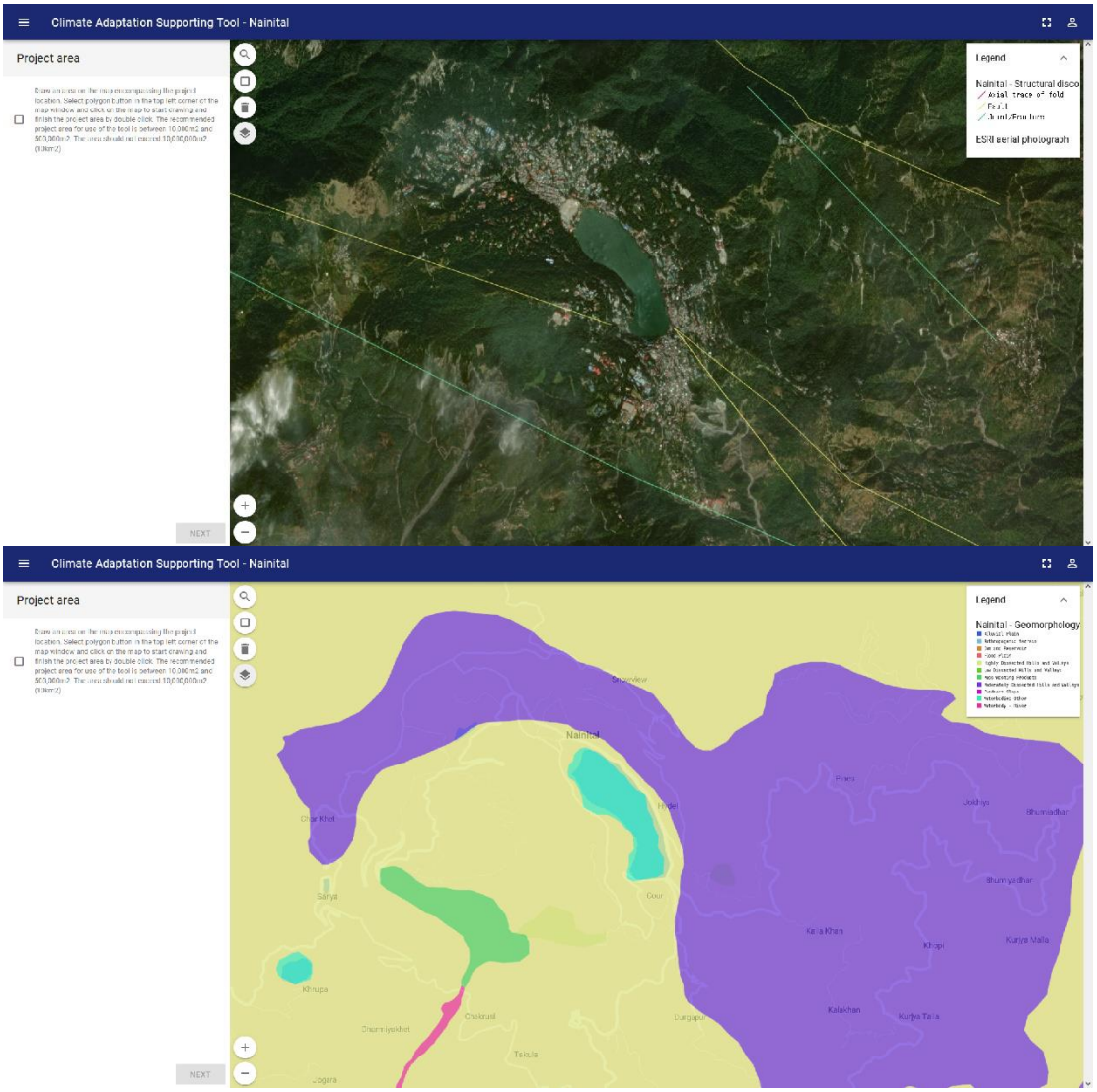

During the conceptualization workshop, the CRCTool was used as a mobile mapbox to map out various interventions. However, since the CRCTool lacks measures related to slope stability and landslides, no workshop results were captured in screenshots. Consequently, these specific aspects were not visualized during the session.

7. Training material and training evaluation

7.1 Training material

In the “Enhancing Resilience in Uttarakhand Urban Development” project we have considered training around ‘learning’ rather than simply ‘training’. This is because ‘learning’ is what the target audience does, we as adults learn through actively doing and participating. Whereas ‘training’ is only what the instructor does. We have included capacity building and ‘mutual learning’ in all four phases of the project as part of the workshops (Table 7-1).

Table 7-1 Workshops in “Enhancing Resilience in Uttarakhand Urban Development”

Workshop	Capacity building	When?
Inception workshop	Climate-resilient planning and development approach.	Dehradun: 28th February 2023 Nainital: 2nd March 2023
Assessment phase	Assessment and modelling of scenarios and smart urban planning.	Approach of Assessment Phase & Impression of Results: virtual 22nd November 2023. Result of Assessment Phase & Risk Assessment: virtual 29th November 2023.
Conceptualization workshop	Building on tool development, function and use & Climate-resilient planning and development, including watershed-level climate-resilient water resources management and infrastructure development in Uttarakhand.	Dehradun: 24th & 25th June 2024 Nainital: 27th & 28th June 2024
Final project workshop	Adaptive planning and implementation.	Nainital: 18th October 2024 Dehradun: 21st October 2024

Materials and learning activities (practical exercises, design sessions) have been orientated around the target audience (i.e. the stakeholders in Dehradun and Nainital). For the conceptualization workshops a two-day program per city was held. After the workshop each participant received a certificate. Table 7-2 shows an overview of the material that has been developed and shared with the participants.

The link below provides access to all materials, both for Nainital and Dehradun:
https://rmsiindia-my.sharepoint.com/personal/pratul_srivastava_rmsi_com/_layouts/15/onedrive.aspx?ga=1&LOF=1&id=%2Fpersonal%2Fpratul%5Fsrivastava%5Frmsi%5Fcom%2FDocuments%2Fconceptualworkshop%5F24%2D27june2024%2FTraining%20Materials

Table 7-2 Training material for Nainital

Workshop	Material type
Inception workshop	Slide deck
Assessment phase	Slide deck
Conceptualization workshop	4 pager Brochure Slide deck day 1 Slide deck day 2 NbS elements baseball cards CRC-tool weblinks
Final project workshop	Presentation Poster (to be added)

7.2 Training evaluation

This section presents an evaluation of conceptualization workshop with officials of relevant Government Departments and Agencies held at Nainital. The purpose of this evaluation is to determine whether the workshop met its stated objectives, and whether a change in perspectives has occurred, with the intent to modify programme and inform programme improvements for future adoption of approaches, techniques, and concepts. The objectives of the workshop include building conceptual clarity of the officials of the concerned Departments/ Agencies on climate resilience in urban development and making wise decisions.

The responses collected on the self-assessment survey forms scheduled identical pre-test and post-test questions, as designed to determine whether change has occurred. The participants answered on the Likert Scale of 0 to 5 for each question, choose from a range of answer options e.g. 0 = 'No', 1 = 'very little', …. and 5 = 'very much', before and after the workshop. Broadly the questions are to assess in understanding on climate resilience, urbanizations challenges and opportunities, gather perspectives on need for specific strategies, tools and techniques, and explore applications of on-the-job use. In addition to that, an observation of during workshop sessions and reactionary feedback discussion at the end by training facilitators also included to triangulate evaluation results.

Results Pre- and Post-Assessment

Altogether there are eight completed pre-assessment (N= 8) responses and ten post-assessment (N= 10) responses as some participants joined the workshop on the second day. The partially responded forms are excluded from the computation and analysis purpose. The responses are analysed for a numerical summation. For this small convenience sample, descriptive statistics are collated and calculated including an arithmetic mean for each survey question to illustrate how responses are distributed and therein difference in participants' perceptions between the pre-test and the post-test (see Table 7-1). There is no reverse score as all the ten questions are Likert-type and positively phrased.

Table 7-1 Overview of Assessment Results

#	Statements/ Questions	Pre-Test Mean (a)	Post-Test Mean (b)	Difference (b-a)
1.	How would you rate your understanding of climate resilience in urban development?	3.3	3.9	0.7
2.	How would you rate your understanding of challenges in urbanization, water extremes and climate change?	3.1	3.8	0.7
3.	How would you rate your understanding of opportunities in urban development / town planning processes?	3.1	3.5	0.4
4.	Do you think it's useful to interact with other disciplines/ stakeholders, i.e. engineers, planners, decision makers?	4.5	4.4	-0.1
5.	How great is your need to learn more about specific techniques, e.g. Nature-Based Solutions?	4.5	4.2	-0.3
6.	How great is your need to learn more about urban planning concepts, e.g. Water-Sensitive Planning?	4.4	4.4	0.0
7.	How great is your need to learn more about strategy development based on broad principles, e.g. Sponge Cities?	4.3	4.3	0.0
8.	Do you think it's useful having a map-based decision support tool, such as Climate Adaptation Support Tool?	4.4	4.6	0.2
9.	Do you think there should be a working group for future strategic climate adaptation planning processes?	4.5	4.7	0.2
10.	Would you like to participate in the future climate adaptation planning processes?	4.3	4.7	0.5
		N = 8	**N = 10**	
E1	How useful have you found this two-day workshop?		4.5	
E2	How likely is it that you will apply anything from the workshop in your work?		4.5	

The results are analysed into four overarching attributes as follows: participants' understanding/ perception (Questions 1 - 3), learning needs (Questions 5 - 7), process/ procedures (Questions 4, and 8 - 10), and relevance (Questions E1 and E2).

Understanding/ Perception: The Questions 1 – 3 are used for participants' self-assessment about their understanding/ perceptions and their own self-knowledge, how informed are the participants on the subject matter of climate resilience in urban development, challenges and opportunities, and therein urban development/ town planning processes. The Pre-assessment results indicate that participants have some understanding of the subject matter (<3 out of 5) and there are significant changes occurred in their understanding during the training workshop. The maximum change observed i.e. 0.7, evenly in their understanding of climate resilience in urban development as well as understanding of challenges in urbanization, water extremes and climate change. The minimum (0.4) increase noted on

understanding of opportunities in urban development planning process. Even though these notable differences, the post-assessment mean score confined to ≥ 4 out of 5 in view to participants' understanding across the subjects and seems that requires consideration in approaching capacity building programmes.

Learning Needs: In regard to measure the learning needs of the officials, particularly the Questions 5 – 7 are asked about specific techniques, urban planning concepts, and strategy development on broad principles. These Questions are guided with example e.g. specific techniques 'Nature-based Solutions' (NbS), urban planning concepts 'Water-Sensitive Planning', and strategy development 'Sponge City'. The findings indicate that the Officials very much appeared to learn more about specific techniques, and more so to learn about urban planning concepts and strategy development based on broad principles and correspondingly score <4 out of 5 before and after the training workshop. The pre and post assessment differences point out absolutely no change with respect the need to learn more about urban planning concepts and about strategy development, and while learning about specific techniques ascertained on the contrary slightly negative value (-0.3).

At the end of workshop an open-ended question asking participants about the materials in development strategy framework, and conceptual design. The responses might help gauge relevance of the knowledge by being able to articulate needs. Participants commended the strategy framework; conceptual design; quality of technical materials and expertise information. The handwritten responses noted by participants as:

"Strategy framework – informative and constructive; conceptual design – meaningful"

"Strategy framework at initial stage is very important and will provide basis for further planning in futuristic manner. after strategy framework and survey at initial stage, conceptual design for resilient modelling can be incorporated"

"Plan first then implement - with the ideas of local will be useful"

"Excellent technical material both verbal, and written information were of high quality and practically applicable"

"For a sustainable development and enhancing resilience strategy framework and conceptual design is very important to identify any problem"

"Lightweight materials and design should be implemented as by laws and restricted"

"Strategy framework --First we should complete our survey and information about the area then we should plan and do some strategic work"

Process/ Procedures: The participants' opinions/thoughts on future strategic planning process/ procedures are explored through the Questions 4, and 8 – 10, categorically asked about usefulness to interact with other stakeholders, map-based decision support tool, working group, and their keenness to participate in future climate adaptation planning process. Overwhelmingly, officials' mean score >4 out of 5 and almost all of them think that it's useful to interact with other disciplines/ stakeholders; having a map-based decision support tool, such as Climate Adaptation Support Tool; working group for strategic climate adaptation planning; and very much interested to participate in the planning processes. The pre and post assessment differences increased just as by 0.2 for Question 8 about map-based decision support tool and Question 9 about working group; and by 0.5 for Question 10 about to participate in future planning process. Except for the Question 4 about useful for interacting with other disciplines/stakeholders i.e. engineers, planners, decision-makers, indicates insignificantly negative value (-0.1).

The participants are further asked their point of view about other aspects around enhancing resilience in urban development that they would like to see in the final workshop. The effort is to glimpse whether the learning exposure of training workshop instigated the participants' aspiration for their participation in future climate adaptation planning process. Respondents pointed out about the site visits, participation of more representation from different departments including top management/ bureaucrats, subject experts- geologists, engineers, and urban planners. One of the participants mentioned engineering solutions more to enhance resilience; others noted floating population, carbon emission, water resources availability, and minimal landslide activities. Opinions of the participants expressed as:

"O*n-site visits to be included; and stress on sensitization and capacity building"*

"Participation of more representation from different department as well as top management, bureaucrats in upcoming workshop"

"Controlling floating population, less carbon emission, better water resource availability, minimal landslide activities"

"a nearby site visit with the experts like geological expert as well as engineering aspects"

"As having an engineering background, I would like to know the engineering solutions more to enhance resilience"

"To discuss with subject expert like urban planner is required for remedies, suggestions; and to introduce new technology, which are associated with urban planning"

"Participating of maximum stakeholders should compulsory; defined locations or identify locations can visit during workshop"

"I think we are talking about urban development, so firstly we should have a good connectivity traffic plan, parking, etc."

Relevance: Above and beyond the post-assessment and soon after following the training sessions at the end, participants (N = 8) are asked their feedback about the relevance of workshop i.e. Question E1- *How useful have you found this two-day workshop*?; and the supporting Question E2- *How likely is it that you will apply anything from the workshop in your work*?. The participants demonstrated a very high involvement and affirmative response about the relevance of the training programme workshop and score 4.5 out of 5 for both the usefulness of the training workshop as well as for the likelihood that they would apply anything from the workshop in their work.

Conclusions and Recommendations:

The workshop is successful in meeting the learning objectives of the training programme. The evaluation of the conceptual workshop resulted in an encouraging appraisal from the participants that demonstrated very high involvement and affirmative response about the relevance of the training programme. Participants have improved their understanding on climate resilience in urban development, and planning process; however, that further requires consideration in approaching capacity building programmes. Participants commended the strategy framework; conceptual design; quality of technical materials and expertise information. They found practicality in the imparted information and were eager to use it immediately. Participants very much appeared to learn more about specific techniques and approaches e.g. NbS, and more so to learn about urban planning concepts and strategy development based on broad principles of urban resilience. The capacity building programme could be improved by adding site visits to the program engaging on place-based analyses to support decision making in exact locations and specific contexts. Involve subject experts e.g. geologists, town planners, engineers and climate scientists

besides more representations of relevant departments/ agencies with upper management to endorse a shared sense of responsibility and affiliation among all stakeholders to solve climate change problems.

8. Challenges encountered and modifications to the initial scope

A major objective of this project was to improve urban climate resilience by promoting a more integrated approach to urban planning. In the current situation, urban planning is divided over a number of departments and agencies with a limited coordination of activities between these actors. The aim has been to achieve active participation by as many as possible of these actors in the project mainly through the four workshops that have been / will be organized. This has not been completely successful, although a large effort has been put into approaching the different actors individually and several times before each workshop trying to convince them to participate. However, the combined convening power of the Consultant and the Counterpart was not always sufficient to convince all relevant actors to participate. Participation was mostly from actors with a direct relation to water management and landslides, while representatives from actors with a more over-arching mandate, such as the Magistrate's Office and the Planning Department, has been limited so far.

Related to this is a modification in the scope of the project. The findings of the assessment phase, as presented in Chapter 4, show a very broad scope of issues regarding climate resilient urban planning including droughts, depletion of the lake, landslides and pollution. Considering all these issues together would strengthen the comprehensiveness of this project, but would also put pressure on the available resources, especially regarding the participation of a large number of stakeholders. Therefore, it was decided in a meeting with UUSDA and the ADB in February 2024 to limit the scope of the Conceptualization and Completion Phases to dealing with landslide risk in urban planning.

Furthermore, it proved challenging to adapt the CRCTool to support urban planning dealing with landslides as the tool has been developed to deal with water management. Therefore, the tool has played a limited role in the stakeholder interaction with respect to the design of the framework plan and the concept designs, mainly focused on the use of the mapping functionality, omitting the analysis part.

9. Lessons learned

The following four insights were generated through the course of the “CLIMATE RESILIENCE MODELING, PLANNING, AND DESIGNING for DEHRADUN and NAINITAL” project, where comprehensive strategies were developed for Dehradun and Nainital illustrated across four locations in both cities.

1. Integrating an ecosystem-based approach within urban planning

Urban planning in Uttarakhand is primarily driven by city growth and mainly consists of infrastructure and real estate development projects. Since becoming the capital in 2000, the city of Dehradun has grown rapidly, and the 2041 Masterplan proposes a doubling of the city footprint to accommodate the growing population of the city. However, the Master Plan 2011 for Nainital proposes to depopulate Nainital by 16,000 population out of the proposed projected 54,000 population by 2011 and develop surrounding areas of Bhimtal and Khurpatal to accommodate this additional population.

Both cities could consider developing a Water Management Strategy and can learn from other cities in India like Chandigarh, Chennai, Delhi, Kochi, Kolkata, Udaipur among others, where Water-Sensitive Planning (WSP) is already being practiced. The study illustrates how city growth can integrate water and subsurface management to enable urban resilience. Additionally, urban development could be made more resilient by including the protection and provision of ecosystem services by maintaining and growing forests, managing waste (wastewater, solid waste and industrial waste) and enhancing biodiversity. For example, the banks of the river Bindal at Bhamnanwala had been cleared of all encroachments. Currently, a wholesale market is being constructed on this site. This study proposes that the development at this location should be reserved as a green belt for flood water detention as well as the collection and treatment of wastewater which is then released into the river. The site would serve as a park providing vital public space as well as several ecological services. The wholesale market can be designed to accommodate flood events, while enabling normal activity during non-flood periods.

2. Mainstreaming climate change action
Climate change action should be driven by increased local monitoring, data collection and awareness building. The current climate change data available for Dehradun and Nainital are based on IPCC models. The detailing of such models using local metrological data is crucial to develop accurate local climate change models and action plans. Rapid urbanization is exacerbating the effects of climate change in both cities. Increased runoff because of soil sealing, and heat stress because of the lack of green-blue infrastructure affect the overall resilience across both locations.

The role of residents and communities is vital in addressing climate change. For example, abstraction of groundwater for consumption is threatening the lake water level (see Section 4.2). Increasing population growth and tourism pressure combined with stresses of erratic and unpredictable rainfall is bound to increase water stress in cities like Nainital.

3. Designing community-inclusive solutions
Engaging with communities has been highlighted as a key aspect for the successful implementation and long-term sustainability of Nature-based Solutions (NbS). Climate-vulnerable settlements have different manifestations in both cities. In Nainital, several structures and properties lie within landslide susceptible zones. In Dehradun, informal settlements are located along and within the flood plains of rivers. The implementation of NbS within these sites requires the involvement and participation of local communities, landowners and beneficiaries. For example, the implementation of broom grass along the slopes of Ayarpatha, in Nainital, requires extensive consultation with landowners. A model of

community owned and managed urban resilience measures with the support of local governments will enable the longevity of such projects. Therefore, these beneficiaries and local communities should be seen as an integral part of the solution to enable resilience.

4. Increasing local ownership
This (and similar) project(s) produced by international and local teams require a strong commitment and ownership from the local counterpart to ensure implementation. In this process, there is the need for a high-level official to act as a champion for the project with enough convening power to bring all relevant actors around the table. This prevents local input from becoming fragmented and enables integrated project development. Such a setup would include the participation of planners, engineers, project managers and asset managers etc. throughout the formulation of such projects, but also the involvement of local representatives from academia, community-led organizations and NGOs to ensure comprehensive input.

Local data generation and scientific assessment are essential for detailed proposal and feasibility. For example, when planning large infrastructure such as an STP in landslide susceptible areas, sound scientific analysis is essential.

10. Recommendations, opportunities, and the way forward

10.1 Recommendations for Nainital

1. Strengthen regulation to limit urban expansion
The vulnerability to landslide and the limited water availability are essential factors to limit the urban expansion of Nainital. Although the masterplan has already proposed restrictions to further population growth, in practice the city continues to expand. Therefore, increased regulation from the municipal authorities is essential to prevent further degradation of the scenic city. Existing communities should be undisturbed and made climate resilient. Policies should be implemented in collaboration with hotels and tourism companies to restrict and distribute the floating population during tourist seasons.

Strict implementation of rules and regulations for construction activities, such as land use regulations and building code, should be ensured.
New construction should be limited to the minimum and when approved should be planned to distribute load across the sloping terrain. Building refurbishments, when performed, should be designed to reduce loading on the land. Enforcement by the responsible authorities is an essential part of the implementation of the rules and regulations.

2. Making existing infrastructure resilient
Thorough geological and geophysical investigations around Nainital city are of prime importance to develop an accurate and comprehensive picture of landslide risk and to inform resilience strategies. By generating city-wide maps, resilience measures can be planned in a systematic and prioritised manner. This will also inform the nature of interventions across the city, defining where NbS are sufficient and where direct-engineering solutions are necessary. Existing residents should be made aware of the risks of landslide and should involve in stewardship programmes to manage their immediate open spaces to restrict soil erosion and manage runoff.

To reduce the burden of traffic on existing road infrastructure effective planning and implementation of policies to encourage public transport are essential. This will also limit the need for construction, maintenance and widening of existing roads in the mountains. It is recommended to ensure that existing roads have road drains on both sides to reduce vulnerability to landslides. Other measures such as retaining walls, plantation of deep-root plants along slopes are essential to reduce the risk of soil erosion and landslides.

The existing canal network built within Nainital serves as a vital infrastructural network to direct and manage stormwater flows. This network needs to be maintained, refurbished and extended to ensure resilience to the increasing intensity of rain events induced by climate change. Additionally, retrofitting existing stepped drains along hill walls with gabion walls will ensure that the flow of water is slowed down and rainwater infiltrates along the slopes. Locally managed rainwater harvesting initiatives should be used to reduce runoff while generating water for non-portable uses.

3. Resilient urban expansion around Nainital
Bhimtal and Khurpatal, which surround Nainital, have been designated for urban development. These urban expansions are opportunities to establish climate-resilient districts. The urban planning of these districts should be guided by the understanding of existing landslide and potential susceptibility zones as well as a comprehensive water management strategy. Appropriate mitigation and adaptation measures should lead the development process. Water channels and flows should be planned to distribute, slow down, channelize and infiltrate rainwater reducing erosion of topsoil. Currently, barren

plots should be developed with tree planting and deep-rooted ground planned appropriately with other urban infrastructure. Existing forested lands should be protected, and deforestation should be minimized in the process of urban expansion. Pathways and small and big roads should be planned and constructed sensitively considering existing topography and vegetation.

Building plots and heights should be planned to ensure that the load of new buildings on the sloping topography is distributed. This could be included in an update of the building code. Open spaces should be planned in a way that runoff is contained, and water balance is managed within neighbourhoods, creating space for detention, infiltration, re-use and recharge in a distributed manner. Public awareness programs should be proactively planned to disseminate best practices related to sustainable ways of human-mountain interaction for new residents.

4. Valuing water
Water flows including rainwater, domestic water and wastewater should be comprehensively managed within each watershed. Valuing water initiatives that create most societal value out of the available water should be implanted across all scales of water management. Existing water infrastructure should be documented and checked to ensure optimal performance. For example, sewer flows should all be redirected to STPs. Currently certain sewage flows within the city are not planned appropriately and intercept stormwater flows contaminating freshwater and groundwater sources. Faulty connections should be disconnected and re-designed. Rainwater and wastewater flows should be gradually decoupled, starting upstream and gradually decoupling municipal flows. This will boost climate resilience in the event of more intense rainfall.

Awareness-building campaigns should be used to ensure that water consumers limit their daily usage. This will also ensure that existing resources can be distributed equitably and continuously across the city. The repair of water supply line and appropriate metering is important to reduce the losses related to non-revenue water.

10.2 Opportunities and way forward

The following steps outline how this work can be developed and used further within Nainital.

- Identify a local high-level champion for further development of this work including planning, design and implementation of NbS interventions.
- Develop a “Urban Planning workshop week” between the project team and the local counterpart, where the assessment, framework plan can be used as a basis to further develop concept designs with a wider spectrum of government officials than were engaged in the Assessment and Conceptualization workshop. This step is essential for local ownership, uptake and follow up.
- Use the results of the assessment and the framework plan to prepare zoning maps identifying where which developments can take place and where not.
- Use the framework plan and the concept designs as the departure point for further integrated planning and design of NbS interventions to increase climate resilience.
- Inter-departmental coordination before planning and implementation of major projects including road infrastructures, city expansion plans and landslide remediation projects.
- Involve all relevant actors and beneficiaries, from the start, in urban planning and design processes to develop interventions.
- Create new opportunities for collaborative working. The successful implementation of integrated Nature-Based Solutions (NBS) requires collaboration across various departments, sectors, and stakeholders. A survey conducted during the training workshops revealed that participants prefer to work in isolation rather than in an integrated manner (see table 7-1, #4). To address this, working groups and projects with a multidisciplinary and multi-stakeholder setup can facilitate collaborative efforts, enabling the proper analysis, design, and implementation of NBS. This process should be supported by a "champion" within the government to provide high-level backing.

- Develop example projects or ‘pilots’ to demonstrate key interventions, raise awareness among stakeholders and streamline construction and maintenance protocols across governmental departments or asset managers.
- Use the framework plan, concept designs, and future pilots to prototyping NbS strategies for similar cities and towns. Dehradun and Nainital can serve as examples for other tier-1 and tier-3 cities respectively within Uttarakhand, north India and other cities within comparable challenges across India.
- In Nainital, the Climate Resilient Framework Plan and the concept designs should be developed by combining soil engineering with bioengineering. Soil assessment is necessary for measuring the status of landslide. Bioengineering is required to prototype and test the capacities of the nature-based measures proposed (like organic soil nailing, broom grass plantation etc.)

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Annexes

A Cost estimation for the concept designs

Cost estimate based on quantities and unit costs separately for each measure in each case study.

A.1 Case study 1 - Ayarpatha

A. Road drainage

The list of items commonly involved in the construction of roadside drainage is provided below including details of unit costs as referred in Ministry of Road Transport & Highways (MoRTH) Technical Specification for Roads and Bridge Works (5Th Revision).

Sno	Item	Unit	Length	Width	Height	No	Quantity	Rate	Amount	Remarks
1	ROAD SIDE Drain Excavation									
1.1	Road side drain 1	Cum	1000	1.5	0.5	1	750	1258	943500	
1.2	Road side drain 2	Cum	330	1.5	0.5	1	247.5	1258	311355	
1.3	Road side drain 3	Cum	670	1.5	0.5	1	502.5	1258	632145	
1.4	Road side drain 4	Cum	1360	1.5	0.5	1	1020	1258	1283160	
2	ROAD SIDE Drain									
2.1	Road side drain 1	Cum	1000	1.5	1	1	1500	4827	7240500	
2.2	Road side drain 2	Cum	330	1.5	1	1	495	4827	2389365	
2.3	Road side drain 3	Cum	670	1.5	1	1	1005	4827	4851135	
2.4	Road side drain 4	Cum	1360	1.5	1	1	2040	4827	9847080	
3	ROAD SIDE Drain									
3.1	Road side drain 1	Cum	1000	2	0.1	1	200	4827	965400	
3.2	Road side drain 2	Cum	330	2	0.1	1	66	4827	318582	
3.3	Road side drain 3	Cum	670	2	0.1	1	134	4827	646818	
3.4	Road side drain 4	Cum	1360	2	0.1	1	272	4827	1312944	
	Total Cost								**30,741,984.00**	
	Add 5 % miscellaneous like transportation and other expenses								1,537,099.20	
	Add 15 % Contractor profit								4,611,297.60	
	Total estimated amount as per rate taken from the report published on 2021								**36,890,380.80**	

B. Stepped Drain

Stepped drains are used in areas with sloped terrain to control water flow and prevent erosion by creating a series of steps. Each step in the drain helps dissipate water energy, reducing the speed and force of water runoff. Below is a list of items commonly involved in the construction of stepped drains considering the costs mentioned in CPWD, Delhi Schedule of Rates Vol 1.

Sno	Item	Unit	Length	Width	Height	No	Quantity	Rate	Amount	Remarks
1	Excavation work by mechanical means (Hydraulic excavator)/ manual means in foundation trenches or drains (not exceeding 1.5m in width or 10 sqm on plan), including dressing of sides and ramming of bottoms, lift upto 1.5 m, including getting out the excavated soil and disposal of surplus excavated soils as directed, within a lead of 50 m.									Refer CPWD Vol 1
	drain 1	Cum	41	2	0.5	1	41	1258	51578	prohibited
	drain 2	Cum	95	2	0.5	1	95	1258	119510	
	drain 3	Cum	103	2	0.5	1	103	1258	129574	
	drain 4	Cum	63	2	0.5	1	63	1258	79254	
	drain 5	Cum	37	2	0.5	1	37	1258	46546	
	drain 6	Cum	20	2	0.5	1	20	1258	25160	
2	Geotxtitle in Gabion wall's base									
	drain 1	SqM	41	2		1	82	250	20500	
	drain 2	SqM	95	2		1	190	250	47500	
	drain 3	SqM	103	2		1	206	250	51500	
	drain 4	SqM	63	2		1	126	250	31500	
	drain 5	SqM	37	2		1	74	250	18500	
	drain 6	SqM	20	2		1	40	250	10000	
3	Gabion wall 5 m Center / Center in the stepped draiin									
	drain 1	Cum	2.5	3	1	4	30	3727.7	111831	
	drain 2	Cum	2.5	3	1	9	67.5	3727.7	251619.75	
	drain 3	Cum	2.5	3	1	10	75	3727.7	279577.5	
	drain 4	Cum	2.5	3	1	6	45	3727.7	167746.5	
	drain 5	Cum	2.5	3	1	3	22.5	3727.7	83873.25	
	drain 6	Cum	2.5	3	1	2	15	3727.7	55915.5	
4	Channel bottom with 40 mm size boulder 1:4 cement mortor									
	drain 1	Cum	41	2.5	0.2	1	20.5	4820	98810	
	drain 2	Cum	95	2.5	0.2	1	47.5	4820	228950	
	drain 3	Cum	103	2.5	0.2	1	51.5	4820	248230	
	drain 4	Cum	63	2.5	0.2	1	31.5	4820	151830	
	drain 5	Cum	37	2.5	0.2	1	18.5	4820	89170	
	drain 6	Cum	20	2.5	0.2	1	10	4820	48200	
5	Additional for stepped drain									
	drain 1	Cum	41	5	4	1	820	4820	3952400	
	drain 2	Cum	95	5	4	1	1900	4820	9158000	
	drain 3	Cum	103	5	4	1	2060	4820	9929200	
	drain 4	Cum	63	5	4	1	1260	4820	6073200	
	drain 5	Cum	37	5	4	1	740	4820	3566800	
	drain 6	Cum	20	5	4	1	400	4820	1928000	
6	Construction of of side wall of steppeped drain - with stone masonry of 40 mm size gravel									
	drain 1	Cum	41	0.5	2	1	41	4820	197620	
	drain 2	Cum	95	0.5	2	1	95	4820	457900	
	drain 3	Cum	103	0.5	2	1	103	4820	496460	
	drain 4	Cum	63	0.5	2	1	63	4820	303660	
	drain 5	Cum	37	0.5	2	1	37	4820	178340	
	drain 6	Cum	20	0.5	2	1	20	4820	96400	
	Total Cost								**38,784,855.50**	
	Add 5 % miscellaneous like transportation and other expenses								1,939,242.78	
	Add 15 % Contractor profit								5,817,728.33	
	Total estimated amount as per rate taken from the report published on 2021								**46,541,826.60**	

C. Gabion retaining wall

Gabion Wall is nothing, but Boulder filled box type cage formed by Standard nets made of steel wire or polymer ropes. The netting is from mechanically double twisted hexagonal wire mesh made of Heavily Galvanized steel wire. The boxes are properly wired and laced together to form flexible, monolithic, confined building blocks, which are called as Gabion walls. The information provided in this section is based on Chikute et al. (2019).

Gabions in conjunction with boulders act as wall which retains water or soil as waterfront structures, as bridge abutment retaining structures and as slope stabilizing, erosion controlling systems, aprons and revetment construction etc.

These walls are porous gravity walls, which stand by self-weight, and it does not require any foundation or anchorage. Gabions can be used effectively and economically in its all applications.
Major components of gabion wall are the gabion box and the boulders.

Gabion box

The steel wire gabion boxes and mattresses are factory fabricated boxes manufactured using Mechanically Woven Double Twisted Hexagonal shaped wire meshes. Mechanically woven Double twisted wire meshes are non-ravelling; manufactured by twisting continuous pairs of wires through three one-half turns (commonly called double twisted) to form hexagonal shaped mesh openings which are then interconnected to adjacent wires to form hexagonal meshes. The edges of the mesh are toughened with a thicker wire called the selvedge/edge wire.

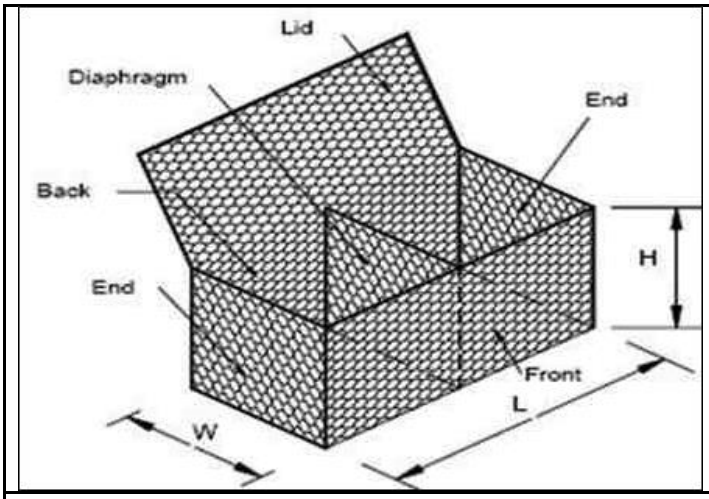


Figure 1: Metallic Gabion box

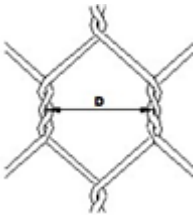


Figure 2: Double twisted Hexagonal Wire Mesh

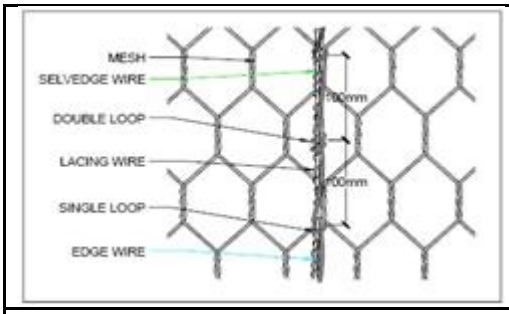


Figure 3: Gabion box connection details

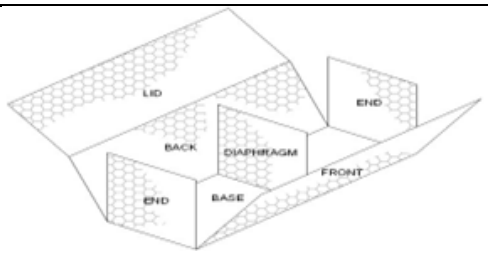


Figure 4: Gabion box assembly details

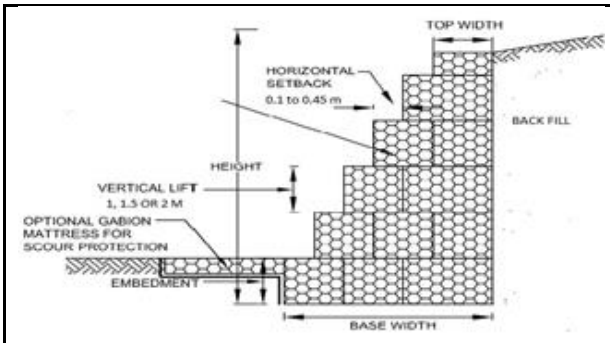


Figure 5`: Typical Gabion wall cross section

Figure 6: Example – Gabion wall

As per CPWD Vol2, Gabion structure with Mechanically Woven Double Twisted Hexagonal Shaped Wire Mesh Gabion Boxes as per IS 16014:2012, MORTH Clause 2500, of required size, Mesh Type 10x12 (D=100 mm with tolerance of ± 2%) Zinc coated, Mesh wire diameter 3.0 mm, mechanically edged/selvedge with partitions at every 1m interval and shall have minimum 10 numbers of openings per meter of mesh perpendicular to twist, tying with lacing wire of diameter 2.2mm, supplied @ 3% by weight of Gabion boxes, filled with boulders with least dimension of 200 mm, as per drawing, all complete as per direction of Engineer-in-charge.

Sno	Item	Unit	Length	Width	Height	No	Quantity	Rate	Amount	Remarks
7	Gabion retaining wall on the side of the road drain									
71	Earth work in excavation of soil	Cum	1000	2	0.5	1	1000	1258	1258000	
7.2	Gabion box(Mesh type 10X12) filling with boulders	Cum	1000	2	0.5	1	1000	1258	1258000	
7.3	Gabion box(Mesh type 10X12) filling with boulders	Cum	1000	1.5	0.5	1	750	1258	943500	
7.4	Gabion box(Mesh type 10X12) filling with boulders	Cum	1000	1	0.5	1	500	1258	629000	
7.5	Geotextile 120 grams per sqm membrane	Cum	1000		2.5	1	2500	250	625000	
7.6	Back filling behind the retaining wall with granular material as per the drawing and specifications	Cum	1000	1	2.5	1	2500	1058	2645000	
7.7	Drainage Fill coarse sand as filter media	Cum	1000	1	2.5	1	2500	1250	3125000	
7.8	100 mm dia PVC C pipe @ 2 meter C/c	m	2			500	1000	200	200000	
7.9	Providing and Laying plum concrete in 1:2:4 c.c. (1 Cement, 2 Coarse sand , 4 clean hard graded stone chips of 20 mm down nominal gauge) with 50 % clean hard stone of size not excceding 15 cm including shuttering, compacting and curing complete. - AS base course	Cum	1000	2.5	0.1	1	250	4827	1206750	
	Total Cost								**11,890,250.00**	
	Add 5 % miscellaneous like transportation and other expenses								594,512.50	
	Add 15 % Contractor profit								1,783,537.50	
	Total estimated amount as per rate taken from the report published on 2021								**14,268,300.00**	

Total estimate project cost in INR is given in table below

Sno	Item	Amount in INR
1	Stepped drain	46,541,826.60
2	Road side drain	36,890,380.80
3	gabion retaining wall	14,268,300.00
	Total	**97,700,507.40**

A.2 Case study 2 – Sri Khrisnapur

A. Gabion in st5epped drain

The Bill of Quantities for the gabion in stepped drain is presented below.

Sno	Item	Unit	Length	Width	Height	No	Quantity	Rate	Amount	Remarks
1	Excavation work by mechanical means (Hydraulic excavator)/ manual means in foundation trenches or drains (not exceeding									Refer CPWD Vol 1
	drain 1	Cum	45	2	0.5	1	45	1258	56610	prohibited
	drain 2	Cum	75	2	0.5	1	75	1258	94350	
	drain 3	Cum	81	2	0.5	1	81	1258	101898	
2	Construction of Gabion structure (Gabion box(Mesh type 10X12) filling with boulders)									
	drain 1	Cum	2.5	1	4	4	40	6200	248000	
	drain 2	Cum	2.5	1	4	7	70	6200	434000	
	drain 3	Cum	2.5	1	4	8	80	6200	496000	
3	Geotxtitle in Gabion wall's base									
	drain 1	SqM	2.5	2		4	20	250	5000	
	drain 2	SqM	2.5	2		7	35	250	8750	
	drain 3	SqM	2.5	2		8	40	250	10000	
4	Laying of boulders, of 40 mm size using cement mortar 1:2:4	cum								section 2.8 and 2.9
	drain 1	Cum	45	2	0.2	1	18	4820	86760	
	drain 2	Cum	75	2	0.2	1	30	4820	144600	
	drain 3	Cum	81	2	0.2	1	32.4	4820	156168	
5	Additional for stepped drain									
	drain 1	Cum	45	5	4	1	900	4820	4338000	
	drain 2	Cum	75	5	4	1	1500	4820	7230000	
	drain 3	Cum	81	5	4	1	1620	4820	7808400	
6	drain - with stone masonry of 40 mm size gravel									
	drain 1	Cum	45	0.5	2	2	90	4820	433800	
	drain 2	Cum	75	0.5	2	2	150	4820	723000	
	drain 3	Cum	81	0.5	2	2	162	4820	780840	
	Total Cost								1,842,136.00	
	Add 5 % miscellaneous like transportation and other expenses								92,106.80	
	Add 15 % Contractor profit								276,320.40	
	Total estimated amount as per rate taken from the report published on 2021								**2,210,563.20**	

B. Bamboo Soil Nailing

The list of items commonly involved in the construction of bamboo soil nailing is provided below including details of unit costs as referred in Ministry of Road Transport & Highways (MoRTH) Technical Specification for Roads and Bridge Works (5Th Revision). Based on the assumption of bamboo spacing at 7.5 cm, bamboo soil nailing cost per sqm is estimated.

	Item	Unit	Length	Width	Height	No	g	Rate	Amount	ks
	Laying and fixing Bamboos including labour work (Bamboo (25 mm dia 2.5 metre long))									Refer CPWD Vol 1
		SqM					77800	400	31,120,000.00	Area taken from plan

C. Rainwater Tank

As per Indian Standard (IS) Roof Top Harvesting Guidelines (IS 15797:2008 (https://www.nwm.gov.in/sites/default/files/IS-15797-Rainwater_Haresting_Roof_Top.pdf)

The size of storage water tank should be sufficient to store water during rainy season and supply during dry season. Assuming full tank at the beginning of the dry season (and knowing the average length of dry season and average water use) the volume of tank can be calculated as

$$V = t \times n \times q$$

Where V = Volume of tank in litres
t = length of dry season in days
n = number of people using the tank
q = consumption litres in per capita per day

For example, 20 lpcd (q), is agreed upon and a dry period of 100 days (t), is not exceeded a storage of 10 cum is required for a family of 05 members (n)

V = 100 (t) x 5 (n) x 20 (q) = 10000 litres =10 Cum

As per Schedule of Rates vol 2, CPWD 2021, Polyethylene water storage tank with cover and suitable locking arrangements is INR 6.10 per litres. So estimated amount for 10000 litres tank

= 6.10 x 10000 = INR 61,000/-

The required catchment area i.e., area of the roof, can be determined by dividing the volume of the tank by the accumulated average rainfall volume (in litres) per unit area (in sqm) over the preceding wet months and multiplying this with the runoff coefficient, which varies from 0.8 to 0.95 depending upon type of roof.

Item	Unit	Length	Width	Height	No	Quantity	Rate	Amount	Remarks
RWH capacity for the catchment area/roof top area									Refer CPWD Vol 1
	Cum	135	65	1.2	1	10530	61000	642,330,000.00	Area taken from plan

Total estimate cost of the project is given below:

Sno	Item	Amount in INR
1	Stepped drain	2,210,563.20
2	Rainwater tank	64,233,000.00
3	Bamboo soil nailing	31,120,000.00
	Total	**97,563,563.20**

B Program of the conceptualization workshop

Agenda day 1 – 27th June 2024, Nainital

Nr.	Time	Description
1	10:00-10:30	Registration (with coffee/tea)
2	10:30-11:30	**Opening session: Welcome and introductions** Opening by chairman Pratul Shrivastava, RMSI Round of introductions Welcoming words by Pedro Almeida (ADB) Welcoming words by Er. Neeraj Upadhyay (UUSDA) Pre-assessment of perspectives and opinions
3	11:30-12:30	Presentations, questions, and discussion: **Project introduction** by Marnix van der Vat (Deltares) **Landslide risk assessment** by Shafique Ahmed (RMSI) **Water system assessment** by Marnix van der Vat (Deltares) Reflection on the findings of the situation assessment by Dr. Santosh Joshi from Kumaon University, Nainital and Dr. Surjeet Singh, NIH Roorkee
4	12:30-13:30	**Group sessions: Challenges and opportunities** Introduction of the SWOT analysis by Nanco Dolman (Deltares) Work in two groups, one led by Pratul Shrivastava with Shafique Ahmed (RMSI) and the other by Saurav Sen with Dr. K.J. Anandha Kumar (RMSI) Brief plenary feedback from group session
-	13:30-14:30	Lunch
5	14:30-15:00	**Plenary session: Introduction pilot sites and geo-visualization tool** Shafique Ahmad (RMSI) and Nanco Dolman (Deltares)
6	15:00-15:30	**Plenary session: Introduction landslide and water measures** Water measures with emphasis on NbS interventions by Nanco Dolman (Deltares) Land slide measures by Shafique Ahmad (RMSI)
6	15:30-17:00	**Design session 1: Local scale interventions and urban NbS** Introduction of session with emphasis on NbS interventions by Nanco Dolman (Deltares) Work in two groups, one led by Pratul Shrivastava with Shafique Ahmed (RMSI) and the other by Saurav Sen with Dr. K.J. Anandha Kumar (RMSI)

Agenda day 2 – 28th June 2024, Nainital

Nr.	Time	Description
1	10:00-10:30	Welcome (with coffee/tea)
2	10:30-11:30	**Opening session: Welcome and reflection on first day** Opening by chairman Pratul Shrivastava, RMSI Recapitulation of and reflection on results of the first day by Nanco Dolman (Deltares) Presentation of results design session 1
3	11:30-12:30	**Plenary session: Water and landslide sensitive planning** Landslide and water strategies including discussion of governance and socio-economic aspects, Nanco Dolman (Deltares)

4	12:30-13:30	**Design session 2: Integrated solutions on a catchment scale: towards a framework plan** Introduction of session by Nanco Dolman (Deltares) Work in two groups, one led by Pratul Shrivastava with Shafique Ahmed (RMSI) and the other by Saurav Sen with Dr. K.J. Anandha Kumar (RMSI)
-	13:30-14:30	Lunch
5	14:30-15:30	**Design session 2: Continuation**
5	15:30-16:30	**Plenary session: Prioritizing interventions (with coffee/tea)** Plenary feedback from group session on framework plan Session led by Nanco Dolman (Deltares)
7	16:30-17:00	**Wrap-up, feedback and next steps** Next steps by Marnix van der Vat (Deltares) Post-assessment of perspectives and opinions (with discussion) Workshop evaluation Closing words

C Participants in the conceptualization workshop

No.	Name	Designation	Organisation
1	Mr. Neeraj Updhyay	Project Manager	Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
2	Mr. Kushank Nautiyal	Project Manager	TCP
3	Dr. Surjeet Singh	Scientist G	National Institute of Hydrology (NIH), Roorkee
4	Mr. Dinesh Chandra Arya	Asst Eng.	Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
5	Mr. Dinesh Singh	Asst Eng.	State Irrigation Deptt.
6	Mr. Shailesh Kumar		District Disaster Management Authority (DDMA), Nainital
7	Mr. Anil Parihar	Asst Eng.	Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
8	Mr. Shafique Ahmad	Senior Manager	RMSI
9	Mr. Marnix van der Vat	Project Manager	Deltares
10	Mr. Nanco Dolman	Expert	Deltares
11	Mr. Pratul Srivastava	Deputy Team Lead	RMSI
12	Mr. Sunil		Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
13	Dr. K. J. Anandha Kumar	Consultant	RMSI
14	Mr. Trivendra Joshi		Uttarakhand Jal Sansthan (Water Resource)
15	Mr. Ravindra Singh Chilwal		Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
16	Mr. Kailash Chandra Kapil		Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
17	Mr. Prawal Pratap Singh		Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
18	Mr. Mukesh Joshi		Project Implementation Unit (PIU), Uttarakhand Urban Sector Development Agency (UUSDA)
19	Mr. Saurav Sen	Consultant	RMSI
20	Mr. Sunil Joshi	Asst. Consultant	District Disaster Management Authority (DDMA), Nainital
21	Mr. Govind Sastri	Asst Eng.	Public Works Department (PWD) Nainitalz

D Finalization workshop: Documentation and Feedback

D.1 Overview

Within the last phase of the assignment, a final workshop was conducted to share outcomes and receive feedback for the finalization of the report. One-day workshops were conducted in Nainital and Dehradun on 18th October 2024 and 21st October 2024 respectively. The goal of the workshops was to present the outcomes of the Draft Final report and review in detail the main project deliverables, namely:
note
The workshops in both cities were attended by over 20 participants from various departments and were marked by lively interaction and exchange by all participants. The day schedule and attendance sheet, per city, can be found in the annex 1.

The feedback received during the workshops is documented, per city, in the following formats

- Speeches
- Feedback for Climate Resilient Framework Plan & Concept designs
- Feedback for the workshops

D.2 City specific themes

The workshop in each city emphasized city-specific themes developed through the assignment. These themes informed the presentation of the outcomes (by Mr. Nanco Dolman) alongside the interactive feedback sessions.

Nainital: Reduction of landslide risk and depletion of the lake

- Landslide susceptibility in urban development
- Synergy with storm water, sewage and road drainage, irrigation, and construction of housing and infrastructure, such as roads and STPs

Dehradun: Rejuvenation of the rivers Rispana and Bindal

- Improve flood resilience of Dehradun
- Make rivers flow with clean water all the way through the city for the whole year
- Synergy with drinking water supply, storm drains, sewer drains, STPs, groundwater, solid waste, and pollution.

D.3 Interactive Feedback Sessions

Following a presentation of the project overview and key outcomes by Mr. Nanco Dolman, the participants provided their feedback through interactive feedback sessions. Two feedback sessions were conducted one for the Climate Resilience Framework Plan and the second for the Concept Designs. Each session was 1-hour long and was conducted in two groups of 6-9 participants along with facilitators from the project team. Participants provided individual feedback by posting notes, and drawings on large format printouts. Group work was followed by group presentations.
The first session focused on integrating the Climate Resilient Framework Plan within spatial planning practices in the city. The second focused on identifying roadblocks and opportunities to implement the concept designs the following questions were used as prompts to gather feedback

Climate Resilient Framework Plan
In the Climate Resilience Framework Plan what aspects are…
1. Recognizable? (already used or being used)
2. New? Are these desirable or undesirable?
3. Missing and need to be included?

4. Identify links to ongoing master planning/ development agenda/development priority/ projects etc.? Do any links exist?
5. Identify top 3 steps to incorporate key elements into ongoing or new work regarding spatial planning in Uttarakhand (who, what, where, how?)

Concept Designs
In the concept design what aspects are…
1. Recognizable? (already used or being used)
2. New? Are these desirable or undesirable?
3. Missing and need to be included?
4. Identify specific stakeholders and identify roles for implementation
(leading, participating & supporting)
5. Identify roadblocks and opportunities to implement such a project
(Legislation/ Financing/ Community outreach/ Design ideas/ engagement ideas/ another location that has much more momentum.)

Figure 10-1: Group Photo, Nainital.

1 2: Handing over Report to UUSDA, Nainital.

1 3: Group presentations, Nainital.

1 4: Group presentations, Nainital.

1 5: Group presentations, Dehradun.

1 6: Group presentations, Dehradun.

1 6: Group photo, Dehradun.

1 6: Handing over Report to UUSDA, Dehradun.

D.4 Speeches

The following speeches document the opening and closing remarks made during the final workshops in Nainital and Dehradun. These speeches are paraphrased from shorthand notes and translated from Hindi in certain instances.

1. Nainital

Opening remarks, Mr. Neeraj Upadhyay, Project Manager, UUSDA.

Our current practices include primarily conventional methods.
The project demonstrated how to apply these measures.
We need “Jaldi Vikas” (fast progress). We realized that there was something missing.
Through the project we learnt a model to connect to NBS.

Closing remarks, Mr. Surjeet Singh, Scientist 'G', National Institute of Hydrology, Roorkee.

Usually, studies are done at a very high level. This project also focused on implementation. This workshop has been able to facilitate information sharing from various line departments. I appreciate the wholistic approach.

2. Dehradun

Opening remarks, Mr. Rajesh Bahuguna, IEC Officer, UUSDA.

The environment is the key place where the negative impacts of development take place. We need to work towards a balance between development and climate. NBS is a key component and has been studied in this project.

Remarks, Mr. Neerjah Kumar DFO (Divisional Forest Officer), Department of Forest, Dehradun.

We would like to invite you to conduct detailed analysis and measurements in the forests in Dehradun, under the preview of the Department of Forests. Forests play a key role upstream in ensuring climate resilience for the city. We are in the process of creating vegetative check dams. However, we require resource persons to provide input on how these measures can be implemented in correct locations.

We have teams that can conduct monitoring and implement measures to create check dams and rainwater harvesting measures in the forest areas.

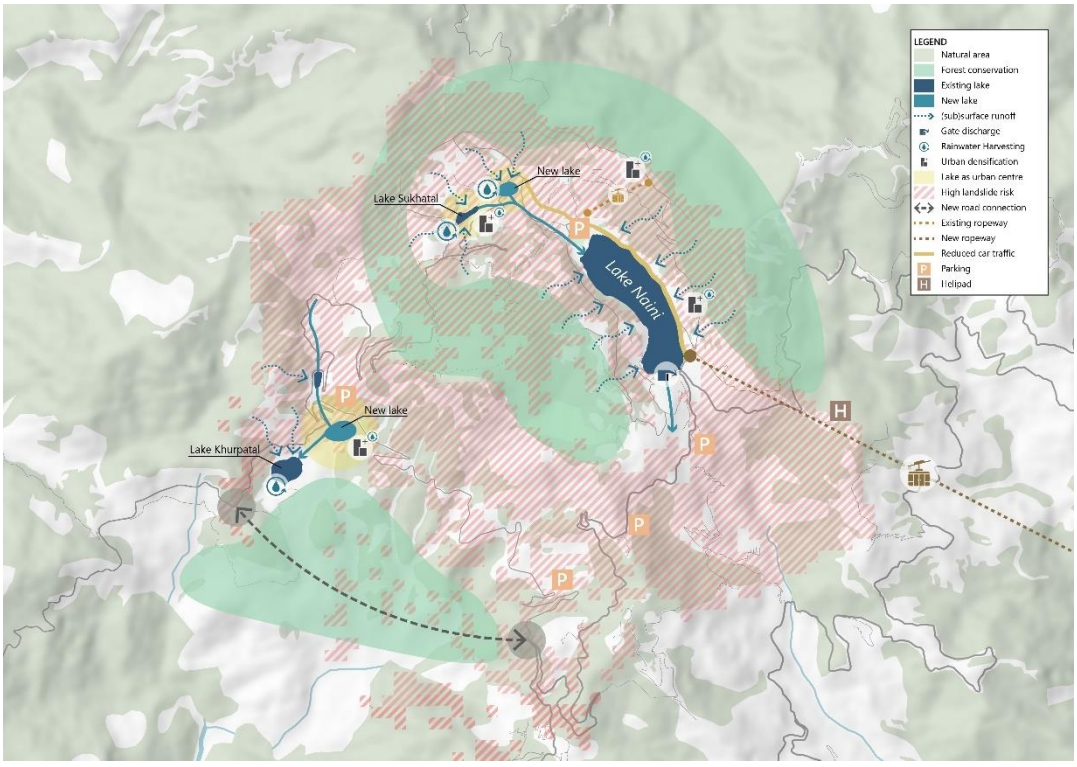
Closing remarks, Mr. Ankit Ayra, Project Manager, UUSDA.
I extend my heartfelt gratitude to the project team and the attendees. The reports shared with UUSDA were received positively. The project has achieved a good problem and solution definition. We will incorporate the findings in our processes. Funds are necessary. Stakeholder participation is necessary. Data Sharing is necessary. Interdepartmental participation is necessary.

D.5 Feedback on Climate Resilient Framework Plan & Concept designs

The responses gathered during the interactive feedback sessions have been documented per question.

3. Nainital

Climate Resilience Framework Plan



3- 1: Climate Resilience Framework Plan, Nainital.

1. In the Climate Resilience Framework Plan what aspects are recognizable?
Group 1:
- Cable Car is an acknowledged mode of public transport, currently used for access to the snow view at (enter location). Currently the cost to use the cable car is INR300 per person, this would not be affordable for the current tourists as car transport is cheaper.

Group 2
- The surface parking at Metropol (NW of Naini Lake)
- Water collection tank provided as for government schemes for every household
- When we speak about “zoning” we expect this applicable for new built-up areas only
- Existing versus new development

- Retaining wall at D.S.B. college, and Raj Braheem Road and Pangot road
- New sewage treatment location – on the map?
- Slope stability measurement – like at Balia Nala
- Learn from Shimla (hill station)

2. In the Climate Resilience Framework Plan what aspects are new? Are these desirable or undesirable?
Group 1:
- Rainwater Harvesting to tank for non-portable use is not currently being practiced and is suitable for campuses.
- Current practice is based on short term solutions. The framework plan provides a long-term perspective.
- Additional bypass route from Baldiya Khan to Khurptal, is new and would be beneficial to reduce traffic load through Nainital.

Group 2:
- Subsidy for fitting RWH in every house like already provided for solar panels
- Water collection is compulsory for each house for the annul. requirements
- Lighter building materials to be promoted, such as local wood for construction and plants for isolation

3. In the Climate Resilience Framework Plan what aspects are missing and need to be included?
Group 1:
- It is suggested that there be real time monitoring of slope movement (or slope creeping) using scientific installation especially above existing mall road.
- Framework Plan drawing to include land use information.
- Sewage management to be considered in the framework plan
- Sewage or wastewater is incorrectly released in drains results in eutrophication of lake
- Along metro road, tree roots enter sewer lines. Currently robotic survey is being used to mitigate this issue.
- Wastewater flows to be separated from stormwater flows.
- Awareness building is necessary among hotels and tourism related businesses to reduce such illegal connections to stepped drains.
- NGOs should be engaged to enable solid waste management
- Lakes to be reviewed within wider region.
- There is a communication gap between this ADB project and ongoing work.
- Widening of highways to reduce traffic congestion.

Group 2:
- Not stronger legislation – Nainital needs stronger enforcement.
- Benching provision for slope stability
- Gabion walls
- Stepped slopes instead of retaining walls
- Rainwater harvesting (RWH) for every house

4. Identify links to ongoing master planning/ development agenda/development priority/ projects etc.? Do any links exist?
Group 1:
- A DPR has been prepared for the parking at Metropol, Nainital.
- DPR by DLDA in 2024 has been prepared for Saita Tal. This includes Water Supply, sewage and planning.
- Comprehensive view is missing. Ask District Administration Authority
- Balia Nala stabilization, by the Irrigation department is ongoing in the last 3-4 months. This includes landscape mitigation measures such as deep drilling, slope stepping. It also includes the use of spring water.
- Connect to 2040 plan for Uttarakhand state, CM Uttarakhand.
- A parking a bus shuttle service has been planned. This involves parking 10 kilometres before the city. This has been planned by Nagar Palika, Zilla Parishad. This service is operated during peak season. The status of effectiveness of this measure is to be confirmed by the Urban Local Bodies (ULBs)
- DPR for proposed cable car has not yet been created.

Group 2:
- Introducing lighter construction materials (in centralisation/ coordination with government)
- New/ alternative route identification
- Underground/ below level parking facilities (cantilever parking)
- Integrated infrastructure, such as: transport, recreational facility, parking, water supply, public utilities.
- Government in centralisation of RWH.
- Separate provision of FSTP's

5. Identify top 3 steps to incorporate key elements into ongoing or new work regarding spatial planning in Uttarakhand (who, what, where, how?)

Group 1:
1. Lake development authority (DLDA) to be involved
2. Participation of communities is poor. Incentives and awareness campaigns should be used.
3. Slope creeping measurements should inform the prioritization of locations, phases and types of measures related to landslide prevention measures are implemented. Currently data is missing on slope creeping measurements and needs to be collected.
4. Restrict growth. This can be done by distributing the tourism load to several locations.
5. Kaichi Dham area can learn from Nainital to prevent overtourism and unsustainable growth.
6. Decentralization of tourism load.
7. Discourage or regulate homestays.
8. Taxi-bikes operational in the city (on option for alternate mobility) are currently unregulated. Total number is unknown.
9. Tourist footfall data unclear
10. Who to involve Lead: District Administration (DA) Nainital; with PWD, Nagar Palika, Tourism department, DA of Kaichi
11. Funds: DA Nainital, State gov. Of Uttarakhand, ADB, Central funds

Group 2: Top 3: (1+2), (3+4+5), (8).
1. Stricter implementation of regulations
2. Awareness campaign -> community
3. Public utilities -> RWH administration
4. Compact EV's -> Public/ private players
5. Shuttle service for tourists -> private players.
6. Move recreational centres to periphery of the town.
7. Registration system for tourist influx -> administration.
8. Strengthening of existing drainage system (regular maintenance and cleaning).
9. Improving camber (lateral slope) of the road.

Concept Designs

Group 1: Ayarpatta, Nainital.

3- 2: Concept Design, Ayarpatta, Nainital.

1. In the concept design what aspects are recognizable?
- No Responses

2. In the concept design what aspects are new? Are these desirable or undesirable?
- No responses.

3. In the concept design what aspects are missing and need to be included?
- The trees in the green belt reduce landslide risk and protect roads.

4. Identify specific stakeholders and identify roles for implementation
(leading, participating & supporting)
- Landowners:
1. University
2. Forest Department
3. Influential residents (Padma Shree awardees)

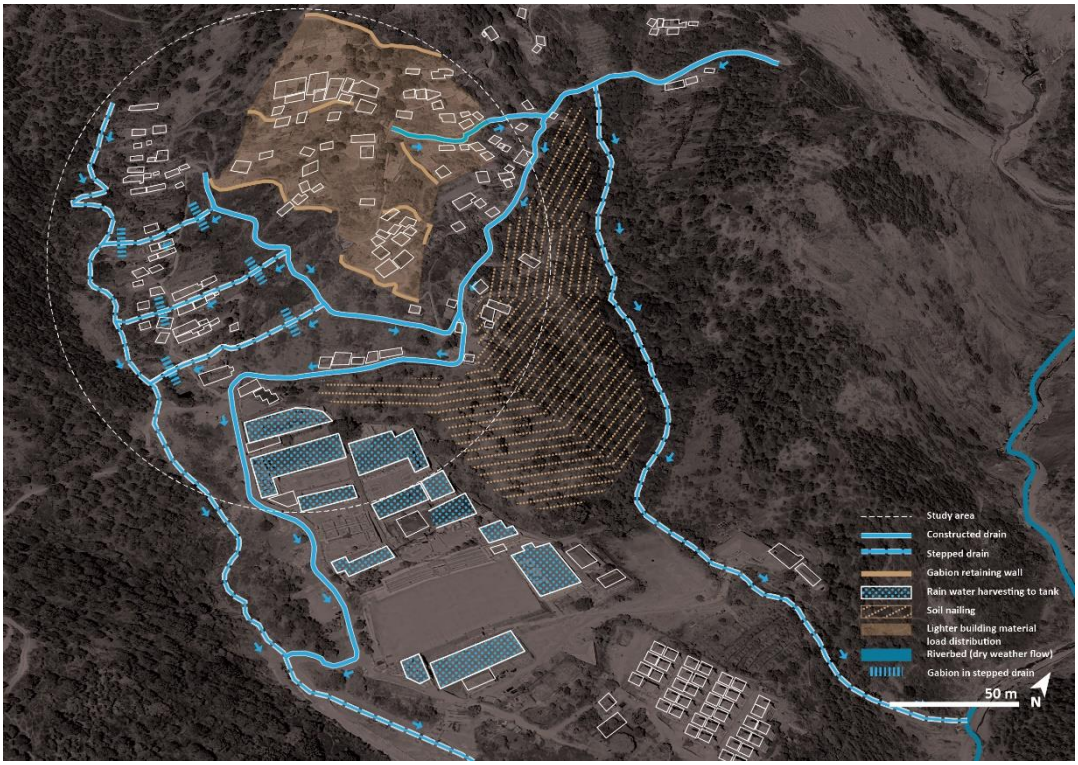
- Other important actors: District Level Development Authority (DLDA)

5. Identify roadblocks and opportunities to implement such a project
(Legislation/ Financing/ Community outreach/ Design ideas/ engagement ideas/ another location that has much more momentum.)
- Tree planting is an opportunity.

Baaj (local oak species) is an indigenous species. It retains water and releases it slowly. It has fire resistance and is the source of springs. It is forbidden to cut this tree.
Pine trees in comparison are a foreign species, they release water quickly and result in forest fires.

- The project should be developed by combining soil engineering with bioengineering.
- Soil assessment is necessary for measuring the status of landslide.
- Bioengineering is required to prototype and test the capacities of the nature-based measures proposed (like organic soil nailing, broom grass plantation etc.)

Group 2: Shri Krishnapur, Nainital.



3- 2: Concept Design, Shri krishnapur, Nainital.

1. In the concept design what aspects are recognizable?
- Road drainage; -> make distinction on the map in roads and drainage!
- Bamboo soil nailing
- Stepwise water drains like a waterfall
- Community/ school STP – decentralized
- RWH channelization -> school
- Two new “natural drain” connections suggested to make the system more redundant

2. In the concept design what aspects are new? Are these desirable or undesirable?
- Gabions in drains
- Soil nailing
- Stepped drain
- Water drain block for waterfall in multiple stage
- Stone pitching in stepped drains (to pitch the slope)

3. In the concept design what aspects are missing and need to be included?
- RWH coverage to be increased on more buildings

4. Identify specific stakeholders and identify roles for implementation
(leading, participating & supporting)

- Champion: Local politicians
- Leading:

1. Administrative Department
2. Forest and Revenue Department (natural drains)
3. Irrigation Department + consultants (constructed drainage)
4. PWD (a.o. roads and its drains)

- Participating

1. Subject experts (e.g. geologist,)
2. Development authority

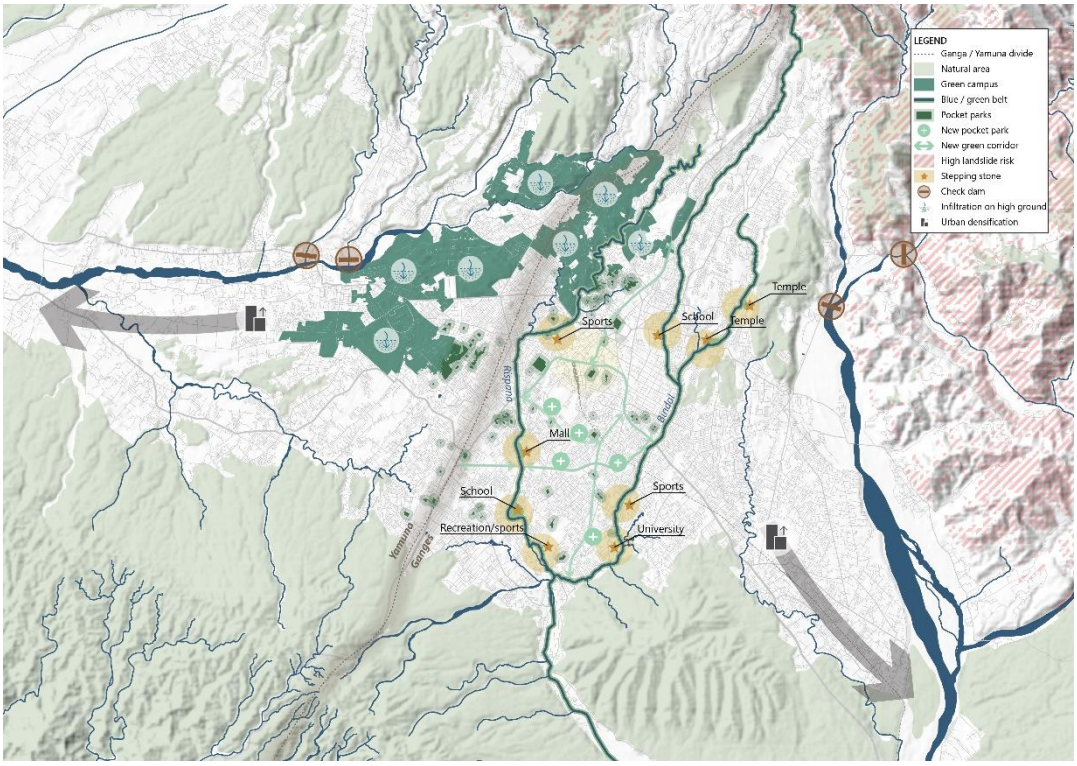
- Supporting: Funding agencies
- Beneficiaries:

1. School/ institution -> beneficiary
2. Individual households -> beneficiary

5. Identify roadblocks and opportunities to implement such a project
(Legislation/ Financing/ Community outreach/ Design ideas/ engagement ideas/ another location that has much more momentum.)

- No Objection Certificate (NOC) from various departments.
- Funding: skill development funds, differentiation of funds, new business model.
- Terrain/ topography: new innovative idea.
- Technical expertise: training/ talent development.
- Lack of integrated management
- Space constraints
- Lack of support from community

Climate Resilience Framework Plan



3- 4: Climate Resilience Framework Plan, Dehradun

1. In the Climate Resilience Framework Plan what aspects are recognizable?
Group 1:
- Ongoing initiatives by the Forest department in Malsi to be incorporated in the study
- The forest department is implementing the following measures further upstream: check dams, check valves, water holes, contour areas and Gabions

Group 2:
- Switch names of Rispana and Bindal rivers on the Framework Plan map!

2. In the Climate Resilience Framework Plan what aspects are new? Are these desirable or undesirable?
Group 1:
- Ground water recharge into green campus areas
- Cleaning and restructuring of waterways and open drains to full capacity

Group 2:
- Phytoremediation.
- Specified species (of trees, vegetation for treatment) should be planted.
- Riparian zone should be enhanced.

3. In the Climate Resilience Framework Plan what aspects are missing and need to be included?
Group 1:
- Existing plan by NIH & NN Dehradun for Rispana rejuvenation reference missing
- Strategy to address slums located around the river
- Forest Department is a key stakeholder
- Elevated roads are proposed on the rivers Rispana and Bindal, this needs to be included in the drawing.
- Mark landmarks in the drawing.

Group 2:
- The map is missing land use, especially industrial and other polluting bodies.
- Floodplain zoning is missing which may be useful for urban planning and infrastructure development.
- STP's are not marked on the map.
- Industrial and habitable areas (zones to be marked on the map) to property implement.
- RWH/ AR as per the water table of that area.
- We need footpaths along many more roads.
- Utility ducts for avoiding road excavation (also in streets).

4. Identify links to ongoing master planning/ development agenda/development priority/ projects etc.? Do any links exist?

Group 1:
- 2041 Masterplan, Development plan by Town and country Planning Authority
- Uttarakhand Integrated River Urban Development Plan by UUSDA. Status: Ongoing project. The scope of the project includes 24/7 water supply, storm water planning and wastewater management.
- Vedh Van (van-forest) by UUSDA. Status: ongoing DPR, funding awaited. The project is a water sponge area, connected to an 18 MLD STP. The project infiltrate reuse treated wastewater through the sponge area enabling ground water security. This is a flagship project.
- Amrit Sarovar Mission, 24 sites including 2 in Dehradun and one in Mussoorie. Status: Implemented. This project also includes the Forest, fisheries and Horticulture department. The project components include water hole structures, rejuvenation of urban ponds, creation of jobs for local communities through fishing and boating.
- Amrut 2.0 project that include water body rejuvenation
- Urban water body rejuvenation by Finance commission.

Group 2:
- Need for central database on urban developments
- Green city concept
- RWH <-> recharge (where possible?)
- Pocket parks
- Footpaths with recharge pits
- Utility ducts in roads
- City wide water management strategy re. urban flood and climate change adaptation
- Street profile with integrated functions
- "Save water" communication
- Also, grey water system (non-potable water use) in construction of new buildings
- Public <-> private
- Gap between Masterplan 2041 and Town planning (reality)

5. Identify top 3 steps to incorporate key elements into ongoing or new work regarding spatial planning in Uttarakhand (who, what, where, how?)

Group 1:
Identification of stakeholders to be included
- Lead: UDD > UUSDA (planning), Nagar Nigam (Implementation)
- Landowners: Revenue Department, Forest Department
- Support entities: Irrigation, Jal Sansthan (wastewater and water supply), CGWB, Town and city Planning, Mussoorie Development Authority
- CSR: Indian Association of Petroleum
- Project review: SARRA (for river rejuvenation integrated development)
- Implementation: Basis land ownership e.g. FRI (Forest Research Institute, SOI, CSWCRTI, ONGC, IAP etc.

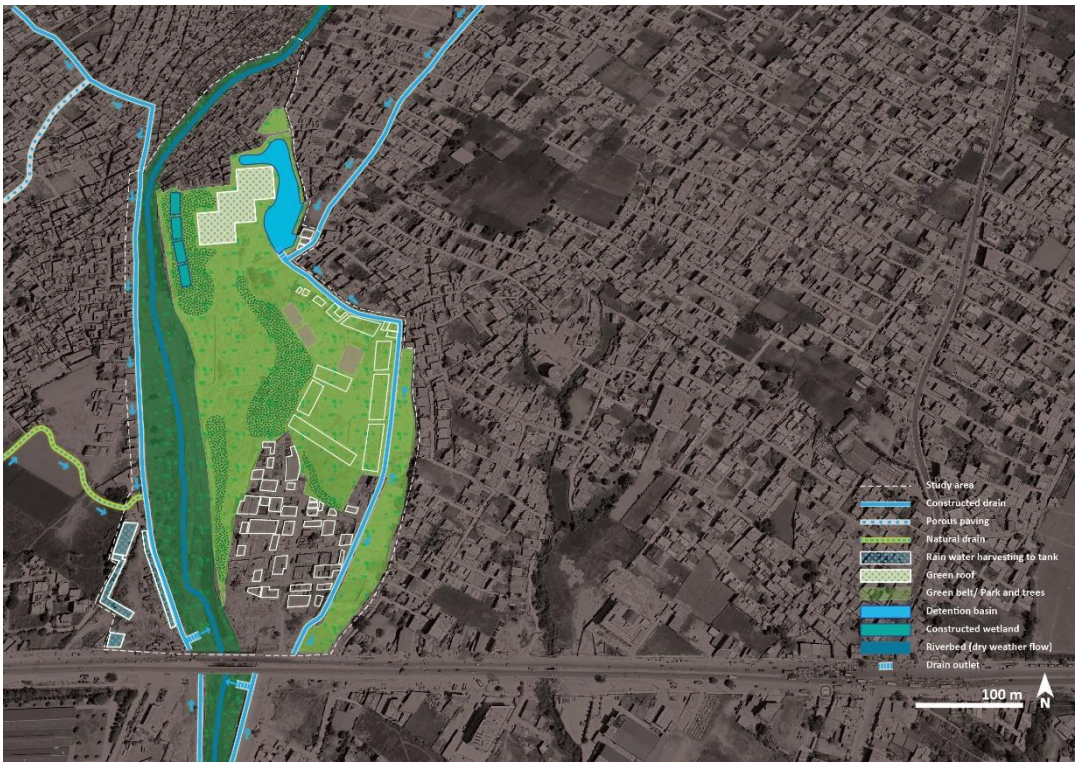
Group 2:
- State level:

1. Smart city Dehradun
2. SARRA – Watershed Department

3. State specific schemes under irrigation, minor irrigation
4. UUSDA water and sewerage projects
• Central level:
1. Jal Shakti Abhiyan along with state
2. Jal Sanchay Jal Bhagidari
3. Swachh Bharat Mission 2.0
4. Flood control management CWC (FHP project under Uttarakhand OZ Nos)

Concept Designs

Group 1: Bindal



3- 5: Concept Design, Bindal, Dehradun.

1. In the concept design what aspects are recognizable?
• Solid waste management already in place. Both in collection in dwelling area as well as removal in river – every 2 or 3 months
• Also, drainage already separated from wastewater system

2. In the concept design what aspects are new? Are these desirable or undesirable?
• No responses

3. In the concept design what aspects are missing and need to be included?
• An additional detention basin should be in south as per natural slope.
• Additional solid waste processing measures during rainfall runoff.
• Relocate informal encroachments.

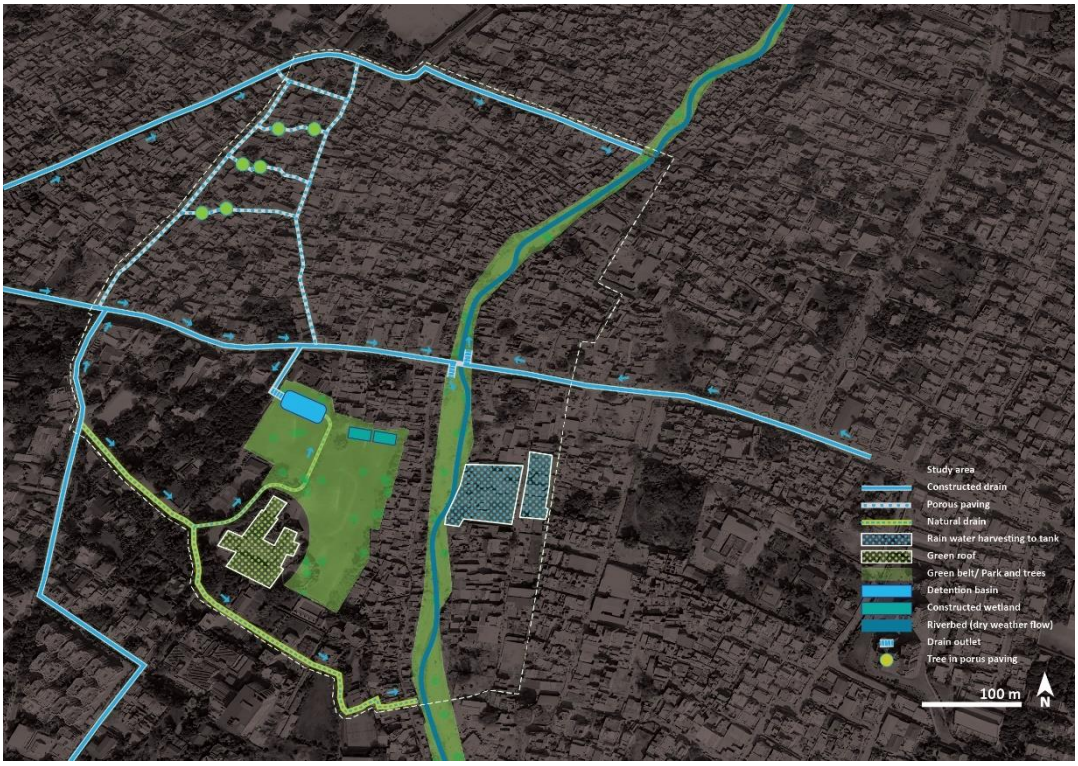
4. Identify specific stakeholders and identify roles for implementation (leading, participating & supporting)
• SARRA – led by Watershed Department -> leading?
• Who is the champion? Or: who is leading? A strong committee must be formed.
• Municipal Cooperation.
• District Administration (DDA).
• MDDA: Mussoorie Dehradun Department Authority.

- Irrigation Department.
- Urban Development Directorate.
- UKPCCB/ NGT.
- Concerned land/ assets owning department.
- Forest Department: watershed, check dams, pits -> e.g. trees advice etc.
- NIH, CWC, CGWB, IIT, TCPD.

5. Identify roadblocks and opportunities to implement such a project
(Legislation/ Financing/ Community outreach/ Design ideas/ engagement ideas/ another location that has much more momentum.)

- Residents + RWA's -> champion?
- Unauthorized enclosures/ settlements
- Funding
- NOCs for various departments
- Upscaling to district level

Group 2: Rispana



3- 5: Concept Design, Rispana, Dehradun.

1. In the concept design what aspects are recognizable?
- No responses

2. In the concept design what aspects are new? Are these desirable or undesirable?
- Green Roof
- Strom water treated and discharged to replenish rivers

3. In the concept design what aspects are missing and need to be included?
- Green Facades, vertical gardens to provide urban cooling. E.g. Project in Lalpur, Bindal.
- Inclusion of underground recharge structures
- Awareness Campaign components
- Green belt to include species like Arjuna Tamalia, along rivers. E.g. Rudraksh Plant was used as a cash crop in a CSR project by HCL and Infosys.

4. Identify specific stakeholders and identify roles for implementation
(leading, participating & supporting)

- UDD > UUSDA (planning), Nagar Nigam (Implementation) Landowners > National Livelihood Mission (NLM) > Mission Manager (In NLM) for sites in Nagar Nigam, for community led projects
- Women and Children as brand ambassadors and to increase acceptability. Self Help Groups (SHGs)
- Participating: Department of Education, Nagar Nigam, MMDA

5. Identify roadblocks and opportunities to implement such a project
(Legislation/ Financing/ Community outreach/ Design ideas/ engagement ideas/ another location that has much more momentum.)

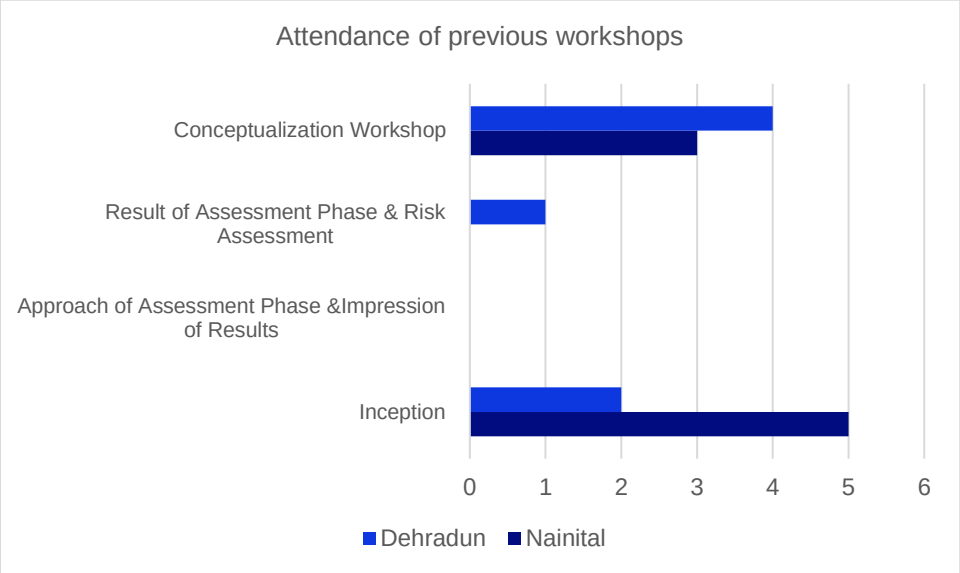
- Use of existing septic tanks in sewered areas UUSDA + 2 RWH tanks
- Effective Gender Mainstreaming. Women involvement and empowerment should be included as a cross-cutting issue. "Women as stakeholder" & "Women at every level"
- Work with existing CBOs, self-help groups, RWAs, Mahila Mandals
- We need to build on existing community capacities
- Funding: CSR, for private properties and small projects
- Porous paving > lack of quality material > Building by laws. In an existing project a strip of tiles was added. To retrofit existing roads.
- Role of enforcement agency to enable climate resilience projects. Using the power of approvals.
- Willingness to implement is a huge hurdle. Enforcement agencies (by planning dept) to step in here to ensure open spaces are preserved and Climate resilience measures incorporated.
- Incentives (by planning department) e.g. Rebate in property tax can also be used in combination with regulatory measures.

D.6 Assessment of outcomes and workshop

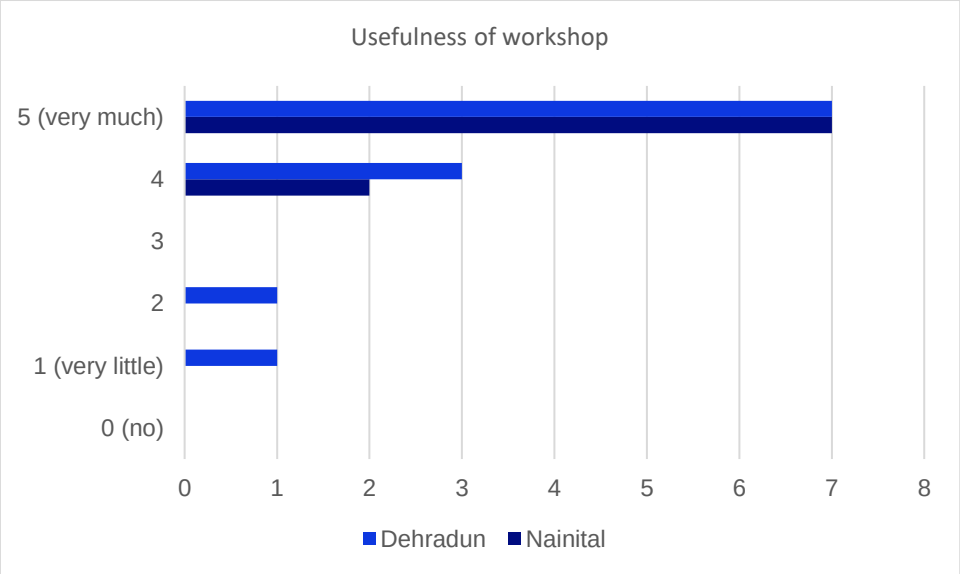
Evaluation forms

Participants filled out evaluations forms to assess the outcomes of the study and the workshop. Results are presented below.

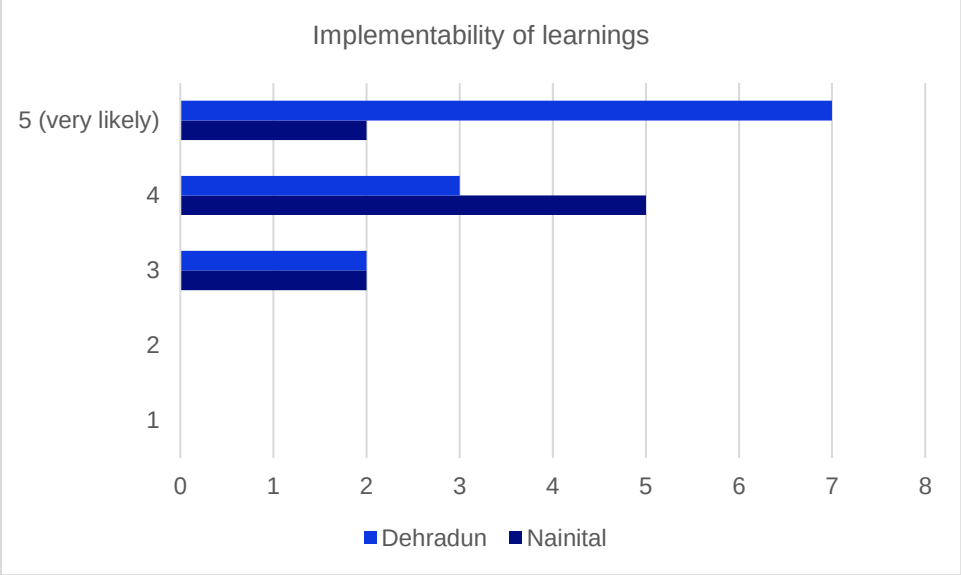
1. Which previous workshops related to this project have you attended?



2. How useful have you found this finalization workshops?



3. How likely is it that you will apply insights from the workshop in your work?



4. Share your thoughts on the material produced (1) Climate resilience Framework Plan (2) Concept Desings?

Dehradun:
- Great as it was a holistic framework - Forest Department
- You should include a lot of type of a similar type of awareness programs. Provide mass data in workshops (such as) population, area, measurements, available link to departments, etc. – UUSDA
- The material produced for both strategy framework and study concept design are at par with the required aspects of the concept plan- UUSDA
- Local initiatives need to be connected with this project like URUDP, AMRUT- 20, SBM-2.0, SARA. Planning is done properly concept designs seem relevant - PMDSC UUSDA
- Material good and informative, case studies should be elaborated further and carried out in very well manner - PMDSC UUSDA
- This is a very useful and helpful concept to include all stakeholder form various organisation to discuss and come out with framework and concept design in synergy that will be helpful in planning in the way forward in a systematic approach - Central ground water board
- Identify residential land, separate road network from the river and identify water logging area water quality in the city - Town security plan Department
- Material produced were good and presented well - PWD Uttarakhand
- The material produced and presented during the workshop was excellent and useful for making a resilient Dehradun city - Nainital Institute of Hydrology
- This is a very good study and required for the sustainable development and making resilient city - IMD Dehradun
- Very well explained – AMDSCCTCE

Nainital:
- (1) strategy framework is fruitful it should be mandatory before planning or any development activities. (2) case study concept design must be applied with stakeholder for its implementation - PIU. UUSDA
- Promote the local people for environment and use the green source of energy, government should instruct the people against the use of single use plastics product - UUSDA- PIU
- The material process is very good and help easily to find solution of particular problem - Nagar Palika
- Discussion based approach/ Brainstorming session resulted in various important points/ solutions so that was very interesting moreover the inputs from different fields were used to build on the interesting solution - Uttarakhand Jal-Sansthan
- The Framework concept design etc are found (to be) excellent, all structed and importantly very focussed - Nainital Institute of Hydrology
- Both strategy framework & case study design are useful & effective - Kumaon University Nainital

- Parallel new road cutting in hills with connect new village instead to existing road widening - UPCL
- Renewable energy source should be adopted in government office/colleges/other public area (2) new construction should restricted in Nainital - TCE Nainital

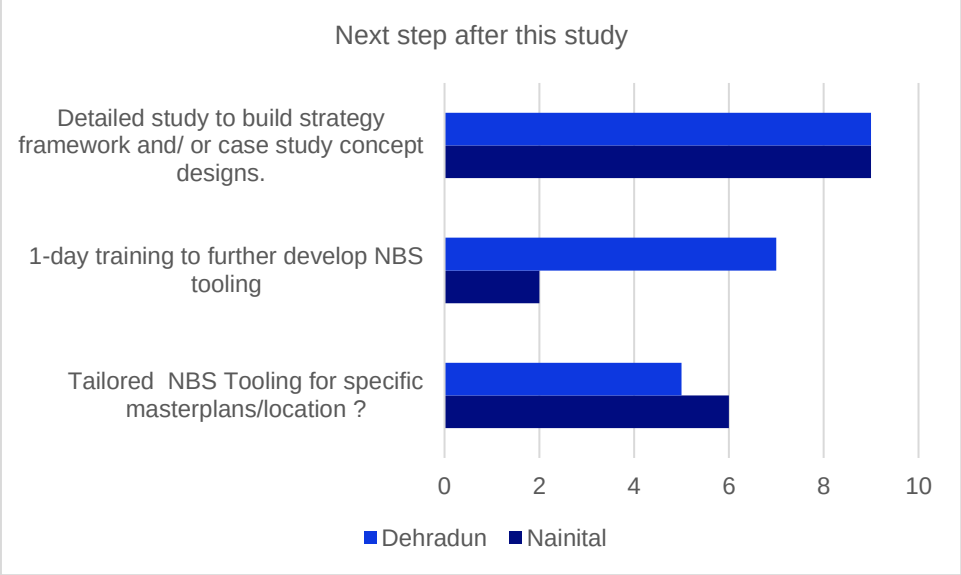
5. In what ways can the insights from this study contribute to your work?

Dehradun:
- Forest department is already working on various project and measures on this, so learnings from this workshop will definitely help us in future - Forest Department
- To coordinate and inculcate the aspect of environment conservation and rejuvenation in the conceptualisation of (masterplans) - UUSDA
- Minimization of water pollution, Natural based solution for the problem like global warming will definitely play a key role to minimize the problem – PMDSC UUSDA
- State department like UDO-UUSDA and Nagar Nigam can be sensitised to use the recommendations - PMDSC UUSDA
- Yes, to incorporate your suggestion is our department's work - UUSDA
- Since this work is helpful in creating a masterplan for the city, insights from all departments will be very helpful for inclusion of various idea from different schemes (elaborated in the workshop, into the project) reports - Central Ground Water Board
- Developed understanding of the government intervention in Uttarakhand - AMDSCCTC
- Impact of urbanization on Doon valley. Doon city road network is poor for transport - Town security plan Department
- The insight forms this study will definitely help us to think differently for NBS implementation - Nainital Institute of Hydrology
- This is very good study and required for the sustainable development and making a resilient city - IMD Dehradun

Nainital:
- The case study may be applied / used in further development projects - PIU. UUSDA
- Sustainable Development and controlled pollution - UUSDA- PIU
- Approach to development input of all the shareholder, I learnt that more time should be given to planning phase so that during execution phase we are applied to tackle any problem) - Uttarakhand Jal \-Sansthan
- The workshop helped (provide) implementing idea on the ground- Nagar Palika
- Planned work liability is more than unplanned/ emergency work - UPCL
- (1) Drainage system should be applied in core Nainital area (2) Public awareness is compulsory for drainage separate system - TCE Nainital
- The insights form this study made me to think (about) how focused practical interventions can help in solving real problem, these shall be incorporated in our workplans - Nainital Institute of Hydrology

- This insight from the workshop can be useful to achieve sustainable development across mountain regions - Kumaon University Nainital

6. What next steps do you consider valuable to develop this work further?



Other responses elaborated:

Dehradun:

- Mapping of springs/ rivers sources so that measure to be designed accordingly - Forest Department
- Conceptualisation of project with cost benefit ratio and aspect of implementation as per actual site conditions - UUSDA- PIU
- We can show the pre and post figures of the concerned area - PMDSC UUSDA
- It arranges your training in dual language English and Hindi also for letters clarification - UUSDA
- After the conclusion of such workshops a single portal need to be developed in the order to know about various work done by different department and identify area where collaborate studies can lie taken up - Central Ground Water Board
- Request for detailed study for resilient urban department - Town Security Plan Department

Nainital

- Multiple training program among students in schools and colleges may strengthen team co-learning and awareness about scope of instability, water scarcity etc. - Kumaon University Nainital
- Public transport to be adapted as per requirement (2) public awareness to (enable) neat and clean Nainital - TCE Nainital
- The tailored NBS tools and the application are very useful for the Nainital city and must be incorporated in the Nainital city management plans - Nainital Institute of Hydrology
- Similar work can be implemented in other hilly district of India for making them climate resilient - Nainital Institute of Hydrology

D.7 Reflections on positives and negatives

At the end of the workshop, each participant was invited to candidly share one positive and one negative aspect of the work or workshop. The results are grouped per city

Dehradun

Positives:

- This project, on behalf of ADB has created strategies for both cities. Both Dehradun and Nainital are divisional headquarters of UUSDA. When such projects are implemented, their impact will have a trickle-down impact on various places across Uttarakhand. Through this project a lot of our ongoing studies have come together.
- Urban Development is a multistakeholder challenge. There is a need to create synergy and coordination. This project is able to address this challenge.
- Bringing together multiple stakeholders is rare.
- The workshop has included all stakeholders.
- The topic of Urban Resilience is the need of the hour. This project was well researched and has also incorporated input from local experts.
- Good planning and resilience.
- The hard work is evident.
- The Workshop has created a platform to interact with and learn from each other.
- The project emphasizes Nature Based solutions and Nature is the best.

Negatives:

- We require concrete recommendations. In Nainital the STP was destroyed due to landslide (e.g. Rusi village). We need concrete recommendations to inform ongoing actions.
- Temporal mapping is missing. In this workshop we should have invited Indian Institute of Remote Sensing and SAC. Their input would provide necessary data. All the measures being proposed by the projects are dependent on flow rates.
- Rehabilitation is a big issue. Where do we rehabilitate people. Input is needed on this.
- Currently synergy is missing (within the government) to address Climate Change. Climate Resilience can mitigate climate change. NIH is willing to help with the water treatment components.
- Practical application is missing. I want to be informed on what I can (personally) do to enable climate resilience. I want to be an example. In a ward where we are working, we have made it a zero-waste ward. In another project we planted many trees. How do you maintain these trees.

Response from another participant: Manrega Scheme enables local maintenance of trees along highways, by paying local communities to maintain trees in their vicinity.

- We need to implement projects at scale. We need to directly plan for large-scale implementation. When pilot projects fail, the impact is not tangible. River rejuvenation need to be addressed as a whole.
- How can this project be brought to implementation? This requires data sharing from all departments. Corporation of all departments is vital.
- The community engagement aspect was missing in the project but was elaborated through the workshop.

Nainital

Positives:

- Learnt a lot. I will use it in my work.
- Interactive format of session was new
- Various departments were bought together enabling various viewpoints, backgrounds. We heard and learnt from the perspective of other departments.
- This workshop became a platform for various departments under the Nainital Municipality.

- Bhowali, a legacy project failed. It had a built-up ration of 60:40. This type of workshop would have prevented the project failure.
- PIU participants

Negatives:
- More participants/ stakeholders/ research scholars would have enabled a broader input.
- Road broadening or more roads are required. Parallel roads. There is a need to connect disconnected villages. Tunnels to be considered.
- We should have re-invited old participants.
- I was informed about this workshop, only this morning by the Nagar Palika.

D.8 Workshop program

18 October 2024, Nainital.
10:00-10:30 Registration (with coffee/tea)
10:30-11:00 Opening session: Welcome and speeches
11:00-11:30 Project recap and key outcomes – *Nanco Dolman*
11:30-11:45 Instructions for group session 1
11:45-12:00 Tea break
12:00-13:00 Group session 1: Framework plan [spatial planning]
13:00-13:45 Lunch
13:45-14:00 Instructions for group session 2
14:00-15:00 Group session 2: Concept designs [implementation]
15:00-15:15 Tea break
15:15-15:45 Presentations from groups
15:45-16:00 Feedback

21 October 2024, Dehradun.
10:00-10:30 Registration
10:30-11:00 Opening and speeches
11:00-11:30 Project recap and key outcomes – *Nanco Dolman*
11:30-11:40 Instructions for session 1
11:40-11:50 Tea break
11:50-12:50 Session 1: Framework plan [spatial planning]
12:50-13:05 Feedback
13:05-13:10 Handing over reports & Group photo
13:10-13:45 Lunch
13:45-14:00 Instructions for group session 2
14:00-15:00 Session 2: Concept designs [implementation]
15:00-15:15 Tea break
15:15-15:45 Presentations of group work
15:45-16:15 Reflection and Vote of Thanks
16:00-16:15 Key take-aways and closing

D.9 Attendance

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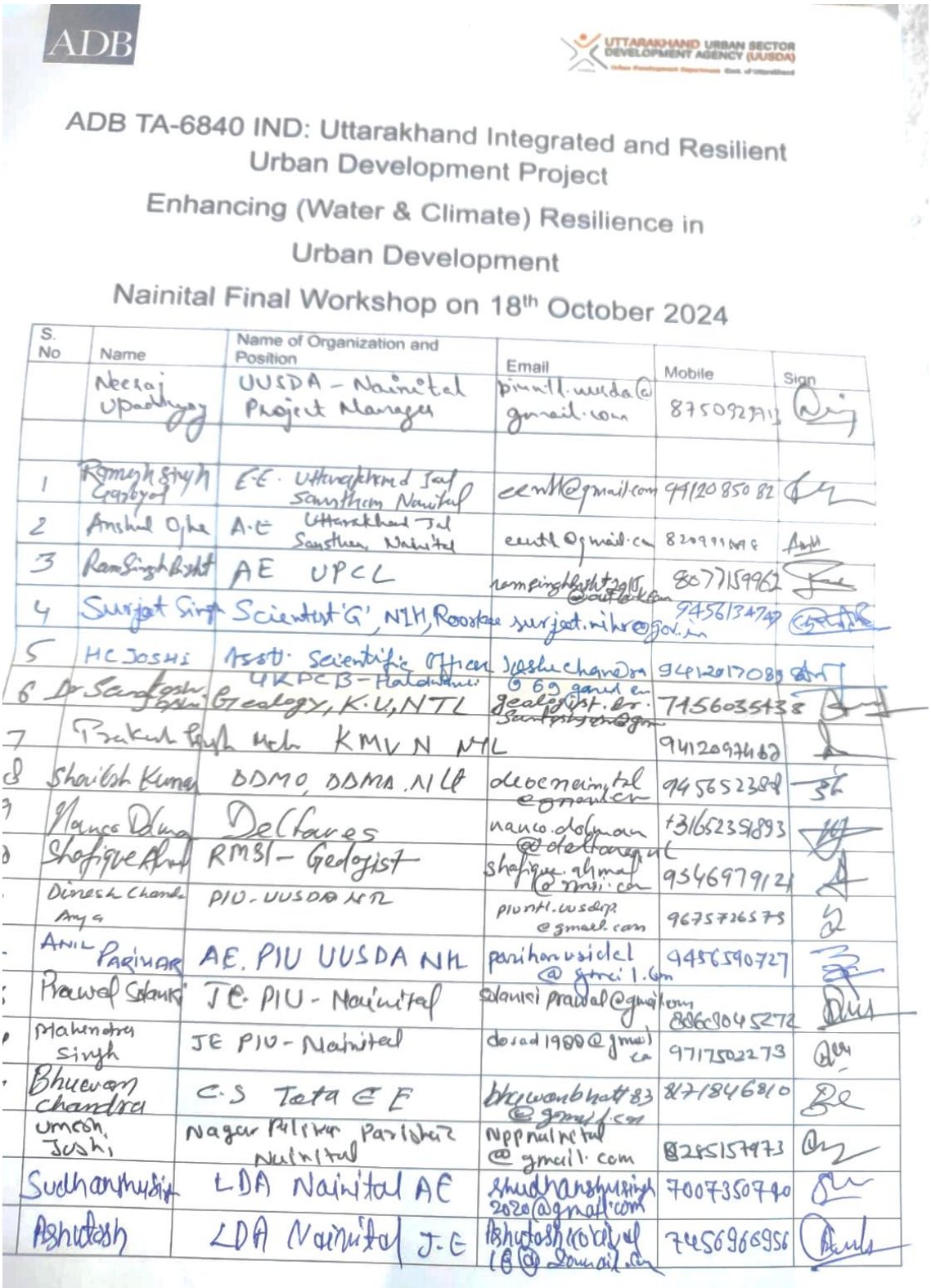

ADB

UTTARAKHAND URBAN SECTOR DEVELOPMENT AGENCY (UUSDA)

ADB TA-6840 IND: Uttarakhand Integrated and Resilient Urban Development Project

Enhancing (Water & Climate) Resilience in Urban Development

Nainital Final Workshop on 18th October 2024

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ADB

UTTARAKHAND URBAN SECTOR DEVELOPMENT AGENCY (UUSDA)

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Dehradun Final Workshop on 21st October 2024

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