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Nature-based Solutions for urban climate resilience in South Asia:

Cases from Bangladesh, India and Nepal

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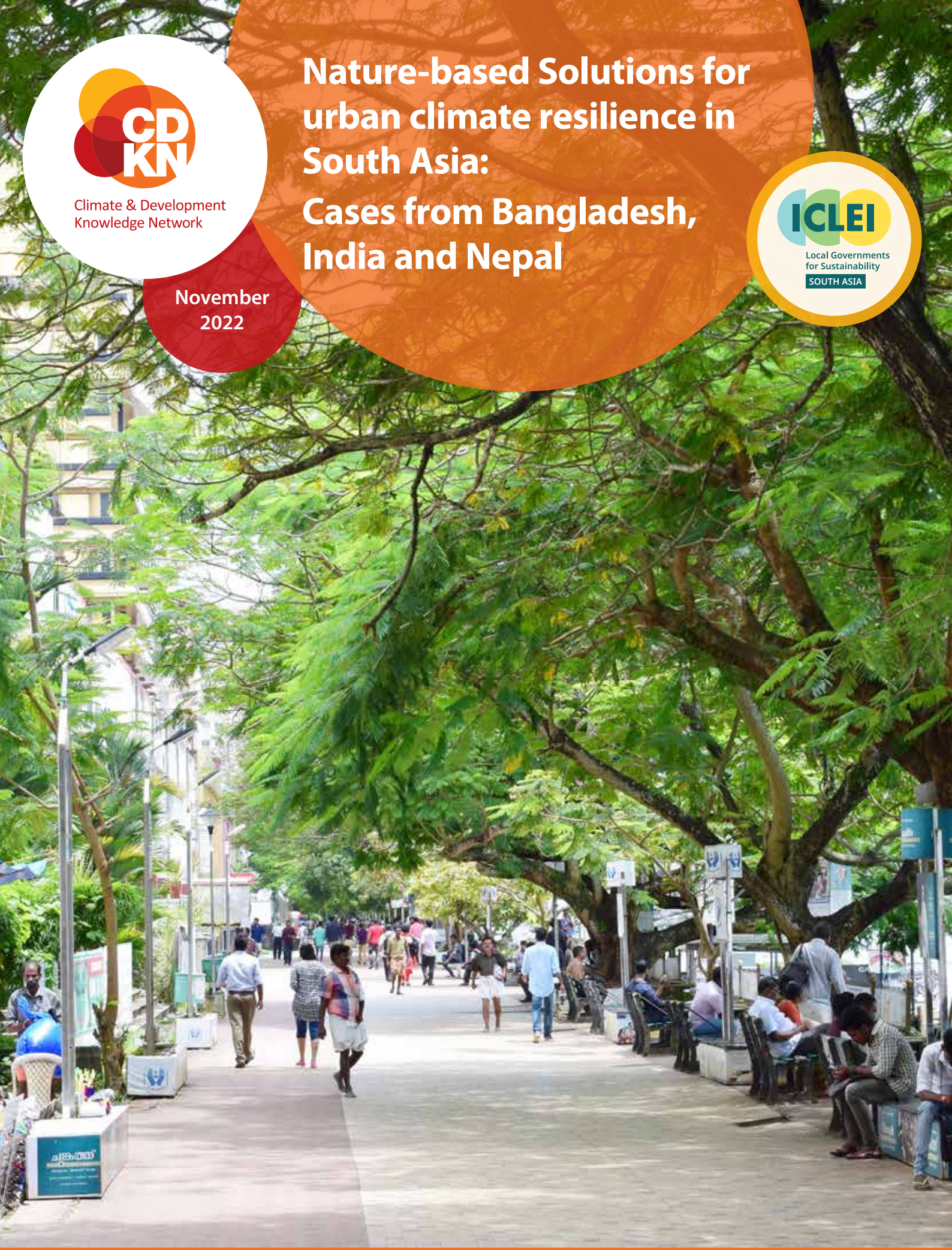

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Front cover image: A street in Kochi, India with ample green cover © ICLEI South Asia

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List of abbreviations

ABP	Aravalli Biodiversity Park
ACCCRN	Asian Cities Climate Change Resilience Network
AFA	A for Architecture
AIA	Ashraf Islam Associates Limited
AWD	Alternate Drying and Wetting
AYUSH	Ministry of Ayurveda, Yoga, Naturopathy, Unani, Siddha, Sowa-Rigpa and Homeopathy
BAPA	Bangladesh Poribesh Andolon
BBMP	Bruhat Bangalore Mahanagara Palike
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BDP	Bangladesh Delta Plan
BNHS	Bombay Natural History Society
BOD	Biological Oxygen Demand
BUET	Bangladesh University of Engineering & Technology
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CBD	Convention on Biological Diversity
CBO	Community Based Organization
CEMDE	Centre for Environmental and Management of Degraded Ecosystems
CFUGs	Community Forests User Groups
CHAL	Chitwan-Annapurna Landscape
CII	Confederation of Indian Industry
CNRS	Center for Natural Resource Studies
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CPR	Common Property Resource
CPRs	Common Pool Resources
CRZ	Coastal Regulatory Zones
CSR	Corporate Social Responsibility
CZMP	Coastal Zone Management Plan
DCC	Dhaka City Corporation
DDA	Delhi Development Authority
DDWSUC	Dhulikhel Drinking Water and Sanitation User Committee
DEWATS	Decentralized Wastewater Treatment Systems
DMDP	Dhaka Metropolitan Development Plan
DNCC	Dhaka North City Corporation
DoLIDAR	Department of Local Infrastructure Development and Agriculture Roads
DPM	Design, Planning and Management Consultants Limited
DRP	Displaced Rohingya Population
DSCC	Dhaka South City Corporation
DTWs	Deep Tube Wells
DWASA	Dhaka Water Supply and Sewerage Authority
EbA	Ecosystem-based Adaptation
EbM	Ecosystem-based Mitigation
EC	European Commission
ECNEC	Executive Committee of the National Economic Council
Eco DRR	Ecosystem-based Disaster Risk Reduction
EES	Environmental Engineering Services
EIA	Environmental Impact Assessment
EMS	Environmental Management Systems
FTW	Floating Treatment Wetlands
G&B	Godrej & Boyce Manufacturing Company Limited
GBH	Girth at Breast Height
GCF	Garden City Farmers
GDA	Gorakhpur Development Authority
GDP	Gross Domestic Product
GEAG	Gorakhpur Environmental Action Group
GHG	Greenhouse Gas
GHMC	Greater Hyderabad Municipal Corporation
GI	Green Infrastructure
GLA	Greater Lumbini Area
GPS	Global Positioning System
GTI	Global Tiger Initiative
GYL	Green Youth of Lumbini
ha	Hectare
HMDA	Hyderabad Metropolitan Development Authority

HMS	Horticulture Management Services
IBA	Important Bird Area
ICF	International Crane Foundation
ICLEI South Asia	ICLEI-Local Governments for Sustainability, South Asia
ICZM	Integrated Coastal Zone Management
IIHS	IOE- Indian Institute of Human Settlements Institution of Eminence
ILO	International Labour Organization
INDC	Intended Nationally Determined Contributions
IPM	Integrated Pest Management
IOM	International Organization for Migration
ISO	International Organization for Standardization
IT	Information Technology
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resource Management
JFM	Joint Forest Management
JNR	Jaberkhet Nature Reserve
KMC	Kutupalong Mega Camp
km^2	Square Kilometre
LAPA	National Framework on Local Adaptation Plan for Action
LCF	Lumbini Crane Foundation
LCS	Lumbini Crane Sanctuary
LDT	Lumbini Development Trust
LEISA	Low External Input and Sustainable Agriculture
LGED	Local Government Engineering Department
LLP	Limited Liability Partnership
LPZ	Lumbini Protected Zone
LSKM	Laghu Seemant Krishak Morcha
LSSF	Lumbini Social Service Foundation
Lt. Governor	Lieutenant Governor
MDDA	Mussoorie Dehradun Development Authority
MEA	Millennium Ecosystem Assessment
MoEFCC	Ministry of Environment, Forest & Climate Change
MoU	Memorandum of Understanding

m^2	Square Metre
NABARD	National Bank for Agriculture and Rural Development
NAPA	National Adaptation Programme of Action
NAPCC	National Action Plan on Climate Change
NBAP	National Biodiversity Action Plan
NbS	Nature based Solutions
NBSAP	National Biodiversity Strategy and Action Plan
NBTs	National Biodiversity Targets
NCT	National Capital Territory of Delhi
NDC	Nationally Determined Contributions
NDMP	National Disaster Management Plan
NDUAT	Acharya Narendra Deva University of Agriculture and Technology
NFSM	National Food Security Mission
NGO	Non-Governmental Organization
NGT	National Green Tribunal
NI	Natural Infrastructure
NIDM	National Institute of Disaster Management
NLCP	National Lake Conservation Plan
NPCA	National Plan for Conservation of Aquatic Ecosystems
NPPM	Nagar Palika Parishad Mussoorie
NPWC	National Parks and Wildlife Conservation Act
NRCP	National River Conservation Plan
NUPF	National Urban Policy Framework
NWCP	National Wetlands Conservation Programme
NWP	National Water Plan
OECM	Other Effective Area-based Conservation Measure
OFYT	Oota From Your Thota
O&M	Observations and Measurements
ORRRC	Office of the Refugee Relief and Repatriation Commissioner
PES	Payment for Ecosystem Services
POC	Persons of Concern
PRI	Panchayati Raj Institutions
RAJUK	Rajdhani Unnayan Kartripakkha
REDD+	Reduced Emissions from Deforestation and forest Degradation

SCS	Special Conservation Sites
SDG	Sustainable Development Goal
SIAS	Southasia Institute of Advanced Studies
SMA	Sustainable Mountain Architecture
SMEP	Site Maintenance and Engineering Project
SMS	Short Message Service
SSDS	Special Sewerage Diversion Structure
SWO	Special Works Organization
TAL	Terai Arc Landscape
TSPCB	Telangana State Pollution Control Board
ULB	Urban Local Body
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN Habitat	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees
USD	United States Dollar
UT	Union Territory
WFP	World Food Programme
WHO	World Health Organization
WMS	Wetland Management Services
WPA	Wildlife (Protection) Act
WWF	World Wide Fund for Nature
YBP	Yamuna Biodiversity Park

Executive summary

Climate change and anthropogenic activities have exacerbated biodiversity loss and severely affected the overall health of the world's ecosystems. Technological solutions, which are often lauded as multi-purpose remedies, are limited in their efficacy and often do not offer sustainable outcomes. Nature-based Solutions (NbS) are fast receiving recognition as holistic and integrated alternatives, which can account for the dynamic complexity of socio-ecological systems[i] and use nature to minimise damage and increase resilience.

Initially put forward by the International Union for Conservation of Nature (IUCN) in the late 2000s, in response to the negative consequences of climate change on natural ecosystems, the term NbS was defined as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". In addition to protecting the natural environment, NbS are meant to provide sustainable solutions for communities and help reduce vulnerability to the effects of climate change and other environmental threats.

As awareness of the interrelationship between nature, society and the economy spreads, NbS have begun to occupy a central place in the global conversation. The NbS concept encapsulates a number of implementation measures that can be taken up at all landscape levels, from cities to forests to individual wetlands. For implementation purposes, NbS encompass a range of approaches across ecosystem services, biodiversity conservation, nature-based development, ecosystem-based adaptation and restoration.

The objective of NbS implementation is to help contribute to the Sustainable Development Goals (SDGs), Aichi Biodiversity Targets and Post-2020 Global Biodiversity Framework, while ensuring long-term environmental security. Recognising the need to address the negative impacts of rapid and unplanned urbanisation, many cities around the world have started implementing NbS to ensure long-term sustainable urban development and resilience to extreme climate events.

In South Asia, although the concept is gaining ground, it is still relatively unexplored, especially in urban areas. Several hurdles exist when it comes to mainstreaming NbS, the most significant being limited policy and legal mechanisms that integrate NbS into governance.

Despite the lack of specific frameworks for implementing NbS in India, Bangladesh and Nepal, there are an extensive set of national policies, guidelines and laws that have the potential to contribute to their mainstreaming. Several medium and short-term plans along with long-term visions for development planning, addressing climate change, protecting the environment and conserving biodiversity are also relevant to enabling NbS. Protection of the environment is enshrined in the Constitution of all three countries, instructing both the government and citizens to take appropriate steps in this direction. A summary of the relevant legislation in India, Bangladesh and Nepal with regard to NbS is provided in Annexure 1.

NbS are an 'umbrella concept' that can be implemented under the scope of a range of approaches which have been defined by the IUCN to ensure effective implementation. To provide guidance and cohesion, the IUCN has five categories of NbS approaches (see Figure 1). These are further broken down into sub-categories.

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i. The concept of socio-ecological systems highlights the role of human action on ecological systems. Simply put, it means that human beings are not separate from nature, but rather part of it. Human actions have consequences on ecological dynamics, which, in turn, impact social systems because they are inextricably linked through complex feedback mechanisms.

FIGURE 1: Defining Nature-based Solutions © IUCN (2020)[1]

This compendium follows the IUCN-based categorisation of NbS approaches and their definitions, and the case studies in this publication have been classified accordingly. Since the IUCN classification falls under the ambit of ecosystem-related approaches, they share commonalities in terms of the interventions they involve or the ecosystem services they tackle. The five approaches and their related case studies covered in this compendium are:

1. **Ecosystem-restoration approaches:** Approaches that deal with ecological recovery from various states of degradation and include ecological-restoration approaches, ecological-engineering approaches and forest-landscape restoration.

   Case studies: Yamuna Biodiversity Park (India), Aravalli Biodiversity Park (India) and the restoration of the Rohingya Refugee Camp (Bangladesh).

2. **Issue-specific ecosystem-related approaches:** Approaches using nature, whether through its biodiversity or ecosystem services, to deal with the impacts of climate change. They cover ecosystem-based adaptation, ecosystem-based mitigation, ecosystem-based disaster risk reduction and climate adaptation services.

   Case studies: Enhancing climate resilience in peri-urban areas (India), integrated development of the Hatirjheel and Begunbari Canal (Bangladesh) and Oota From Your Thota (India).

3. **Infrastructure-related approaches:** Natural or semi-natural, green, or environmental assets that provide, conserve or enhance ecosystem services that yield societal benefits.

   Case studies: Greening and conserving Pirojshanagar's mangroves (India) and Pocket Parks (Nepal).

4. **Ecosystem-based management approaches:** Integrated management approaches of natural resources that in turn improve ecosystem health, thereby sustaining stocks and the flow of services.

   Case studies: The integrated wetland management system of Nekhnampur Lake (India), Kyalasanahalli Lake Rejuvenation (India) and Water Security in Dhulikhel (Nepal).

5. **Ecosystem-protection approaches:** Area-based conservation approaches including protected area management and 'Other Effective area-based Conservation Measures' (OECMs).

   Case studies: The Jabarkhet Nature Reserve (India), the Urban Sacred Groves of Gangtok (India), and the Green Lumbini Initiative (Nepal).

As Covid-19 has devastated societies and economies across the world, adding to the global challenges of climate change and socio-economic issues, the importance of conserving nature has been increasingly recognised. The need to employ NbS as a means to reinstate the relationship between humans and nature is becoming more imperative. NbS hold immense potential for building green and resilient economies, and their implementation should be promoted.

While the use of NbS in rural areas, encompassing forests and coastal areas, is well documented, the same is not the case in urban areas. This compendium showcases the use of NbS in three countries in South Asia. Apart from the 15 case studies, an exhaustive list of NbS initiatives in cities in India, Bangladesh and Nepal has also been provided in Annexure 2.

This compendium will be useful for governments at all levels and is intended to support key actors and institutions to plan, implement, replicate and upscale NbS. The learnings from each case study detailed in the compendium will also be helpful for practitioners, NGOs, civil society and academics to better understand how to implement NbS projects and programmes.

Integrating Nature-based Solutions with urban planning © ICLEI South Asia

Chapter 1: Nature-based Solutions

Since the advent of the industrial revolution, human activities have disrupted the planet's natural functioning, leading to an environmental crisis. Global phenomena, such as industrialisation and urbanisation, have led to the exploitation of natural resources, resulting in adverse environmental conditions and human-induced climate change. Climate change is arguably one of the biggest threats facing humankind in the 21st century. This, in turn, has further exacerbated biodiversity loss and severely affected the overall health of ecosystems worldwide.

According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) released in 2021, human-induced warming has reached approximately 1.09°C above pre-industrial levels.[2] At this present rate, global average surface temperatures are expected to reach or surpass 1.5°C around the year 2040.[3] While technological solutions are being worked on, these alone cannot help address climate change.[4] More integrated and holistic solutions to combat climate change are gaining ground that recognise the dynamic complexity of socio-ecological systems[3] and utilise nature to minimise damage and increase resilience.

Using nature for climate mitigation and adaptation serves two purposes: (i) conservation and proliferation of ecologically significant ecosystems, and (ii) protection of human health, wellbeing and infrastructure. As countries battle the global pandemic of Covid-19 and recovery from its economic aftershocks, it is vital for governments, organisations and society to take the necessary steps to incorporate nature into recovery strategies.

Origin of the term Nature-based Solutions

In recent decades, there has been a shift in perspective related to the management of natural ecosystems and resources.[5,6] The formation of the United Nations Framework Convention on Climate Change (UNFCCC) and adoption of the Convention on Biological Diversity (CBD) at the United Nations Conference on Environment and Development (UNCED), also known as the Earth Summit held in Rio de Janeiro in 1992, emphasised integrating the concept of sustainability into the management of natural resources and into the global economy.[7] Additionally, with the findings of the scientific assessments, such as the Millennium Ecosystem Assessment (MEA)[8] in the early 2000s, it became evident that human actions have altered the functioning of natural ecosystems in order to derive net economic gains, and significant changes in policy and relevant actions are needed to reverse the damage.

Besides promoting the term 'ecosystem services', the MEA report also highlighted the adverse impacts of increased human use of these services, thus focusing on the necessity to take appropriate steps against these harmful trends.[9] According to Article 4(I) of the Paris Agreement, the parties have been advised to achieve "a balance between anthropogenic emissions from sources and removals by sinks of greenhouse gases in the second half of this century",[10] advancing the need for using nature to mitigate the effects of climate change and counter socio-environmental challenges, such as food security, water scarcity, and the rise in sea level and temperature.

The IUCN and other international organisations such as the World Bank and the European Commission formulated the concept of NbS.[11,12] The term 'Nature-based Solutions' was initially adopted by the IUCN in the late 2000s.[13,14] Emphasising the urgency to combat the negative consequences of climate change and the threats posed to natural ecosystems,[15] the IUCN referred to the term NbS in its position paper on the UNFCCC.[16] The term's emergence forms the basis of conservation actions mapped out to serve the main objective of the UNFCCC,[17] i.e. "to stabilise greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human

interference with the climate system, in a time frame which allows ecosystems to adapt naturally and enables sustainable development".[18] With the establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2012,[19] 94 governments reaffirmed their commitment to integrate "diverse conceptualisations of the values of nature, nature's contributions to people"[20] and good "quality of life into policy decisions"[21] as well as to support relevant capacity building. The Global Assessment Report released by IPBES in 2019 builds on the Millennial Ecosystem Assessment by offering a comprehensive assessment of the state of nature and ecosystems, viewed from the lens of indigenous and local scientific knowledge and scales, while endorsing the adoption of NbS as tools to conserve biodiversity.

BOX 1: NBS: DEFINING THE TERM

NbS encompass a large group of practices that harness the potential of nature to protect the Earth's ecosystems. IUCN defines NbS as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits".[22] In addition to protecting the natural environment, NbS are meant to provide sustainable solutions to communities and help reduce vulnerability to the extreme effects of climate change and other environmental threats.

The European Commission understands NbS as "solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions".[23] In 2020 the European Commission updated this definition, highlighting that implementing NbS must aim to enhance the flow of ecosystem services and support biodiversity.[24]

Given that NbS research is still in its nascent stages,[25] various organisations have differing opinions on NbS.[26] For example, the IUCN, taking a more eco-centric perspective (seeing nature as valuable in its own right, not just in terms of what it offers to humans), considers the provision of biodiversity benefits and human well-being as fundamental to NbS. The European Commission, on the other hand, holds the idea of using nature to derive economic, social as well as environmental benefits as more important.[27]

The concept of NbS

Understanding the complexities of a range of challenges being faced by societies across the globe, such as climate change, food and water scarcity, poverty and depletion of natural resources, there is a growing awareness among scientists, researchers and policymakers to look for solutions at the convergence of nature, society and the economy.[28]

Research led by the European Commission shows the concept of NbS holds the potential to address the socio-environmental threats in the 21st century. These solutions involve the use of nature to conserve, restore and sustainably manage the earth's ecosystems, while simultaneously paying attention to human welfare.[29] The very heart of these solutions is to benefit society and enhance the environment that enables organic and sustainable responses to environmental change and risks in the long-term. In bringing back the spotlight on human action and systems, and incorporating societal factors (governance, human wellbeing, poverty alleviation, socio-economic development),[30] NbS takes the focus beyond traditional biodiversity conservation and management principles.

For example, avenue plantations (planting trees) along roads and growing a forest in a city is a simple NbS to combat the urban heat island effect. In addition, the concept of NbS seeks to enhance the flow of 'ecosystem services'[31] and encourage conservation of natural ecosystems and biodiversity.[32]

The NbS concept encapsulates a number of implementation measures that can be taken up at landscape levels (i.e. at a large scale encompassing a forest, estuary, city, etc.) across ecosystems, ranging from cities to forests to wetlands and more.[33] For implementation purposes, NbS includes a list of approaches under a range of keywords such as ecosystem services, biodiversity conservation, nature-based development, ecosystem-based adaptation and sustainability.[34] Additionally, the objective of NbS implementation is to help achieve sustainable development goals (SDGs)[35] and ensure long-term environmental security of communities.[36,37,38]

Urban green (comprising vegetation) and blue infrastructure (comprising water bodies, rivers, etc.) provides amenities, recreational opportunities and health benefits, carbon sequestration and air quality improvement. It has a crucial role in increasing the adaptive capacity to cope with climate change.[39] Investing in urban green and blue infrastructure constitutes a tangible contribution that cities can make to the SDGs and the Post 2020 Global Biodiversity Framework.

The conceptual framework of NbS[40] considers the linkage between biodiversity and human well-being as key to producing synergistic results that benefit both communities and nature.[41] To provide a basis for clear understanding of the concept of NbS, IUCN has established a set of NbS principles,[42] which:

1. embrace nature conservation norms (and principles);
2. can be implemented alone or in an integrated manner with other solutions to address societal challenges (e.g., technological and engineering solutions);
3. are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
4. produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
5. maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
6. are applied at a landscape scale;
7. recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystem services; and
8. are an integral part of the overall design of policies, and measures or actions, to address a specific challenge.

The growing momentum of the NbS concept

The concept of NbS has gained immense momentum, especially since 2015.[43] Although the NbS concept is still being refined by IUCN and other organisations,[44] it is being widely encouraged in the scientific community, in national and international policies and by civil society.[45] For example, the European Commission set up an agenda on NbS under its Horizon 2020 Framework Programme.[46] IUCN[47] and international organisations such as the World Wide Fund for Nature (WWF)[48] and The Nature Conservancy[49] have largely advocated the importance of NbS as effective climate change mitigation and adaptation strategies.[50]

Reports published by the IUCN and University of Oxford[51] and the United Nations Development Programme (UNDP)[52] have increasingly emphasised strengthening the use of NbS in Nationally Determined Contributions (NDCs), which form the basis of the Paris Agreement.[53] In the past, reports published by the IUCN, University of Oxford and the United Nations Development Programme (UNDP) emphasised strengthening the use of NbS in Nationally Determined Contributions (NDCs), which form the basis of the Paris Agreement. This was reflected in the 2021 *NDC Synthesis Report*[54] where adaptation actions and economic diversification plans with mitigation co-benefits included NbS among countries' new or updated NDCs. Taking it further, the Standing Committee on Finance (SCF), which provides a platform for climate finance stakeholders, organised a two-part forum across 2021 and 2022 focusing on NbS, with the objective to enhance communication and information exchange around financing the same.[55]

NbS were amongst the major topics of discussion in the 2019 UN Climate Action Summit held in New York City.[56] To harness the potential of nature in the fight against climate change, a "Nature based Solution Coalition" led by China and New Zealand was formed during the course of the Summit.[57] In addition, to raise awareness and promote research on NbS through dialogue and stakeholder engagement, the 'Nature-based Solutions Initiative' was founded at the University of Oxford in 2017.[58]

NbS approaches

NbS are an 'umbrella concept' that can be implemented under the scope of a range of approaches.[59] To ensure effective NbS implementation, approaches have been defined by the IUCN. To refine the overall concept of NbS and its application, NbS approaches, also referred to as ecosystem-related approaches, are divided into five categories, which further comprise specific sub-categories that are meant to refine the overall concept of NbS and its application. This compendium follows the IUCN-based categorisation of NbS approaches and their definitions.

BOX 2: NbS APPROACHES

1. Ecosystem-restoration approaches (e.g., ecological restoration, ecological engineering and forest-landscape restoration)
2. Issue-specific ecosystem-related approaches (e.g., ecosystem-based adaptation, ecosystem-based mitigation, and ecosystem-based disaster risk reduction)
3. Infrastructure-related approaches (e.g., natural infrastructure and green infrastructure approaches)
4. Ecosystem-based management approaches (e.g., integrated coastal zone management and integrated water resources management)
5. Ecosystem-protection approaches (e.g., area-based conservation approaches, including protected-area management).

The different NbS approaches and their definitions as considered by the IUCN are described in Table 1.

TABLE 1: IUCN NbS approaches and definitions

Additional details on the South Asia examples are provided in Annexure 2.

SUB CATEGORY	DEFINITION	SOUTH ASIA EXAMPLES
IUCN NbS Approach: Ecosystem-restoration approaches		
Ecological restoration	Defined as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed"[60] and "the attempt to repair or otherwise enhance the structure and function of an ecosystem that has been impacted by disturbance or environmental change."[61] The objective of this approach is to restore the ability of a disturbed ecosystem to function properly. In addition, effective implementation of this approach aims to render the restored ecosystem suitable to provide a habitat for a range of species and, simultaneously, provide ecosystem services for the well-being of society. Examples of NbS implementation that restores lost ecosystems due to factors such as fragmentation, deforestation and land-use conversion are covered under the ecological-restoration approach. In addition, projects involving natural site reclamation, land rehabilitation and ecosystem mitigation are grouped under the ecological-restoration approach. Wetland restoration, watershed management, lake rejuvenation and re-wilding programmes also constitute a few examples under this approach.	• Restoration of morrum mined pits in Asola Bhatti Wildlife Sanctuary in New Delhi, India • Restoration of native Aravalli vegetation in Aravalli Biodiversity Park • Native vegetation of Yamuna floodplains in New Delhi, India • Restoration of fly ash mounds in Dadri, India • Ecological rehabilitation of the Korean Export Processing Zone in Chittagong, Bangladesh • Ancient pond restoration in Manthali Municipality, Nepal
Ecological engineering	Described as a restoration approach that involves the "management of systems of human and environmental self-design or light management that joins human design and environmental self-design, so that they are mutually symbiotic".[62] Another accepted definition refers to ecological engineering as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both". The objectives of this approach include restoration and sustainable development of ecosystems that benefit both humans and nature.[63]	• Constructed wetlands in Madhyapur Thimi, Nepal • Oyster breakwater reefs at Kutubdia Island, Bangladesh • Constructed wetlands in Neela Hauz, New Delhi, India

SUB CATEGORY	DEFINITION	SOUTH ASIA EXAMPLES
Forest-landscape restoration	Defined as "a planned process that aims to regain ecological integrity and enhance human well-being in deforested or degraded landscapes".[64] It also refers to "the long-term process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes". The objective of forest-landscape restoration approach aims to enhance the functioning of a disturbed forest ecosystem.[65]	• Tropical forest restoration in the Auroville Township, Tamil Nadu, India • Community-based forest landscape restoration around Lake Phewa, Pokhara, Nepal • Ecological restoration of degraded forest ecosystems in Bandipur, India • Terai forest restoration project in Rautahat and Jhapa region of Nepal
IUCN NbS Approach: Issue-specific ecosystem-related approaches		
Ecosystem-based adaptation (EbA)	Referred to by the Convention on Biological Diversity (CBD) as "the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change".[66] The objective of this approach is to manage natural ecosystems based on the principle of sustainability as well as to help develop resilient communities against climate change.	• Urban farming in Bengaluru, India • Rooftop farming practices in Kathmandu, Nepal, and Dhaka, Bangladesh • The adoption of innovative agricultural practices such as floating agriculture in the Gopalganj, Barisal, Madaripur and Pirojpur districts in Bangladesh
Ecosystem-based mitigation (EbM)	Considered by the CBD as an ecosystem approach that aims to "enhance the benefits for, and avoid negative impacts on biodiversity by reducing emissions, taking into account the need to ensure the full and effective participation of indigenous and local communities in relevant policy-making and implementation processes, where appropriate".[67] In addition, NbS implementation under the ecosystem-based mitigation approach intends to "enhance the conservation, sustainable use and restoration of marine and coastal habitats that are vulnerable to the effects of climate change or which contribute to climate-change mitigation".[68] Efficient management of ecosystems such as forest, mangroves and oceans to ensure increase in carbon sequestration levels and maintenance of carbon stocks forms the main objective of this approach.	• Development of an oxyzone in Raipur, India • Community-based Pichavaram mangrove restoration in Cuddalore, India • Creation of an urban jungle on terraces in Bengaluru, India

SUB CATEGORY	DEFINITION	SOUTH ASIA EXAMPLES
Ecosystem-based disaster risk reduction (Eco-DRR)	"The sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience".[69] The objective of this approach is to reduce the risk of natural hazards by proper management and disaster mitigation strategies and at the same time, provide societal benefits.	• Nature-based landslide risk management in the districts of Nuwara Eliya, Ratnapura, Galle and Matale, Sri Lanka • Enhancing climate resilience by buffering floods through climate resilient peri-urban agriculture in Gorakhpur, India • Hatirjheel integrated development project in Dhaka, Bangladesh • Urban flood protection through wetlands in Colombo, Sri Lanka
Climate adaptation services	"Benefits to people from increased social ability to respond to change, provided by the capacity of ecosystems to moderate and adapt to climate change and variability".[70] As illustrated by IUCN, this approach is synonymously used with the ecosystem-based adaptation approach. However, climate adaptation services, in a broader spectrum, tends to be in close alignment with the concept of ecosystem services in its objective to provide ecological benefits to society as well as enhance the potential of ecosystems to adapt to climate change.	• Identification of climate change hotspots such as the Indus basin in Pakistan and India • Capacity building programme on adaptive Delta management to assist the implementation of the Bangladesh Delta Plan 2100
IUCN NbS Approach: Infrastructure-related approaches		
Natural Infrastructure (NI)	Defined as an ecosystem approach that is "strategically planned and managed network of natural lands, such as forests and wetlands, working landscapes, and other open spaces that conserves or enhances ecosystem values and functions and provides associated benefits to human populations".[71] The objectives of this approach are to conserve biodiversity, promote ecosystem health and enhance the flow of ecosystem services for deriving social benefits. NbS implementation in the form of NI is considered a cost-effective approach to tackle environmental issues.	• Urban forests developed using the Miyawaki technique in Mumbai, India • Greening and conserving mangroves in Pirojshanagar, India • Development of biodiversity parks like Tughlaqabad Biodiversity Park in New Delhi, India

SUB CATEGORY	DEFINITION	SOUTH ASIA EXAMPLES
Green Infrastructure (GI)	The IUCN highlights this is conversely used with the term natural infrastructure and is defined by the European Commission as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings".[72] IUCN also considers green infrastructure as an approach which "comprises of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales. The green infrastructure concept emphasises on the quality as well as quantity of urban and peri-urban green spaces, their multifunctional role, and the importance of interconnections between habitats".[73]	• Development of Sabarmati River Front project in Ahmedabad, India • Construction of pocket parks in Lalitpur, Nepal • Ekrukh Lake constructed wetlands in Solapur, India • Development of Bagmati River Nature Park in Kathmandu, Nepal • Adoption of smart green infrastructure development for the Global Tiger Initiative (GTI) in Bhutan
IUCN NbS Approach: Ecosystem-based management approaches		
	Defined as the "integrated, science-based approach to the management of natural resources that aims to sustain the health, resilience and diversity of ecosystems while allowing for sustainable use by humans of the goods and services they provide".[74] The objective of this approach is development of climate-resilient and high-yielding ecosystems so that the flow of services is sustained for a long-time. As per the guidelines of IUCN, this approach widely constitutes a number of similar approaches i.e., ecosystem-based fisheries management, integrated marine and coastal zone management and integrated water resource management.	
Integrated coastal zone management (ICZM)	"A dynamic, continuous and iterative process designed to promote sustainable management of coastal zones".	• Thane Creek mangrove restoration project in Navi Mumbai, India • Community-based sustainable management of Tanguar Haor in Sunamganj, Bangladesh • Coastal embankment improvement in Bagerhat and Barguna districts, Bangladesh

SUB CATEGORY	DEFINITION	SOUTH ASIA EXAMPLES
Integrated water resources management (IWRM)	"The coordinated development and management of water, land, and related resources to maximize the resulting economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".[75]	• East Kolkata wetlands in Kolkata, India • Chauganpur pond restoration in Greater Noida, India • Restoration of Neknampur Lake in Hyderabad, India • Spring revival and building water security in Dhulikhel, Nepal • Adoption of spring-shed approach for long- term water security in the Himalayas in Mahakali Basin, Nepal
IUCN NbS Approach: Ecosystem- protection approaches		
	The common use of this approach comprising of area-based conservation approaches including protected area management, is not explicitly described under the guidelines laid out by the IUCN.[76] However, in general, this refers to an ecosystem approach that promotes conservation in protected areas as well as in 'Other Effective area-based Conservation Measures' (OECMs).[77]	• Jabarkhet Nature Reserve in Mussoorie, India • Community conservation reserve in Arunachal Pradesh, India • Development of Lumbini Crane Sanctuary in Lumbini, Nepal • Community-based Special Conservation Sites (SCS) such as Golchha House in Biratnagar, Nepal

The IUCN has classified the various approaches to bring cohesion and provide guidance. Because the approaches all fall under the ambit of ecosystem-related approaches, they share commonalities in terms of the interventions they involve or the ecosystem services they tackle. Chapter 3 of this compendium presents a collection of 15 urban-based case studies from South Asia. Each case study is classified into each NbS category, based on the overarching objective of that intervention. However, each intervention also demonstrates similarities with or employs more than one type of NbS approach. Annex 2 provides a matrix with more examples from cities in India, Bangladesh and Nepal, classified based on the NbS categories.

Significance of NbS in the wake of the Covid-19 pandemic

The global Covid-19 pandemic has illustrated the consequences of ignoring and over-exploiting nature. These consequences have had drastic effects on societies and economies across the world.[78] It is now clear that human actions have led to massive ecological degradation and Covid-19 is a direct result of disconnect between humans and the natural environment.[79] Given that the world is already battling the environmental issues of climate change, and socio-economic issues, such as poverty and unemployment, the need to use NbS to revitalise the relationship between humans and nature in the wake of the pandemic becomes imperative.[80] NbS can be used for creating new green jobs, and this could even – in some contexts – regulate or reverse the trend of migration for work.

NbS hold immense potential in building green and resilient economies and their implementation should be promoted at all landscape levels.[81] In a 2020 report titled Nature hires: How Nature-based Solutions can power a green jobs recovery by the WWF and the International Labour Organization (ILO),[82] successful examples of how NbS are helping to build economies, provide employment and increase community resilience around the world are showcased. In addition, the global call to recognise the importance of conserving nature has been gaining stronger acceptance worldwide.[83]

Chapter 2: Mainstreaming Nature-based Solutions: Existing laws, policies and missions

NbS have, at their core, the use of nature and natural assets to result in outcomes that benefit the environment, biodiversity and people. Eggermont et al. (2015)[84] specifically state that NbS should "refocus the debate from traditional biodiversity conservation and management principles onto humans, integrating societal factors such as human wellbeing and poverty alleviation, socio-economic development, and governance principles".

While there is already a global consensus building on the far-reaching positive impacts of adopting NbS,[85,86] there are several hurdles, especially in regions like South Asia and Southeast Asia, when it comes to their mainstreaming.[87] The integration of NbS into government policy processes would provide a legal framework and incentives for undertaking them at a larger scale, thus improving mainstreaming.[88] Although governance mechanisms alone are not enough, they still provide a critical starting point that can amplify actions by communities and the private sector.

The need for mainstreaming NbS is not limited to South Asia. A comprehensive review conducted in Europe[89] found that although the policy instruments mention NbS, on most occasions there is an absence of quantitative and measurable targets relating to NbS deployment and quality. The review also highlighted that the application of NbS in urban settings is narrow, and often confined to already existing blue-green spaces, rather than focused on the creation of new blue-green infrastructure.

NbS have come to encompass diverse and dynamic categories of interventions, as discussed in the previous chapter.

Within South Asia, specifically India, Bangladesh and Nepal, although specific frameworks for the NbS implementation do not currently exist, there is an extensive set of national policies, guidelines and laws that have the potential to contribute to their mainstreaming. This chapter provides an overview of relevant national-level policies and guidelines.

India is supported by a well-developed environmental legislative and policy framework encompassing aspects of conservation, protection, sustainable use, access and benefit sharing of its natural resources. Under Articles 48A and 51(A)g, the Constitution of India (1950) cherishes the protection of the environment, and instructs its government and citizens to take appropriate steps in this direction.

Similarly, Bangladesh, under Article 18.A of its Constitution (1972), enshrines the protection, conservation and improvement of the environment and biodiversity for present and future generations. Development plans, climate change strategies, environmental protection and biodiversity conservation offer a framework for NbS.

The Constitution of Nepal (2015) guarantees Nepali citizens the right to live in a healthy and clean environment while instructing the state to take necessary actions related to environmental and biodiversity protection, natural resource use and conservation. Since the Ninth Five Year Plan (1997–2002), the country has established sustainable development at the core of its economic growth developing various enabling plans, policies, strategies and legislation.

The tables below outline the national-level policies, strategies and legislation that support NbS implementation in these three countries.

TABLE 2: National-level legislation that supports NbS implementation in India

LEGISLATION	DESCRIPTION
The Indian Forest Act, 1927	Relates to forests, the transit of forest-produce and the duty leviable on timber and other forest-produce within reserve forest, village forest, protected forest and private forests not under the control of the Government.[90]
The Wildlife (Protection) Act (WPA), 1972	Protects listed species of flora and fauna, through a network of ecologically-important protected areas.[91]
The Water (Prevention and Control of Pollution) Act, 1974	Falling under the umbrella of the Environment (Protection) Act, 1986,[92] it prohibits the discharge of pollutants into water bodies beyond a given standard, and lays down penalties for non-compliance.
The Forest (Conservation) Act, 1980	Protects and conserves forests with a focus on prevention of deforestation that will lead to land degradation and the loss of forest biodiversity.[93]
The Air (Prevention and Control of Pollution) Act, 1981	Enacted to control and reduce air pollution.[94]
The Environment (Protection) Act, 1986	Allows for actions to protect and improve the quality of the environment through emissions and various types of discharge standards, regulation and management of the same and public health protection.[95] The Act also mandates an Environmental Impact Assessment (EIA) for some development projects and regulates , and certain activities in the coastal zone through a Coastal Zone Management Plan (detailed below).
The Joint Forest Management (JFM) Circular, 1990	Mandates forest preservation and regeneration through co-management with local communities.[96]
Coastal Regulation Zone Notification, 1991	Protection of beaches from unplanned development and delineation of ecologically fragile areas for conservation. The notification binds states to prepare a Coastal Zone Management Plan (CZMP) classifying various beach areas in terms of four Coastal Regulatory Zones (CRZ I, II, III and IV).[97]
Panchayati Raj Act, 1992	Devolves power to urban local bodies (ULBs) for subjects under the Eleventh Schedule such as minor irrigation, water management, watershed development (as per State approval), and subjects under the Twelfth Schedule, such as water supply, public health, sanitation, and solid waste management.[98]
Biological Diversity Act, 2002 and Biological Diversity Rules, 2004	Conservation of biological resources, their associated knowledge and facilitating access to them in a sustainable manner is dealt with here[99] through integrated national, state and local strategies and plans, EIAs.
Disaster Management Act, 2005	Sets directives for disaster management in terms of institutional, legal, financial and coordination mechanisms at the National, State, District and Local levels.[100]
The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006	Recognises rights and devolves power to forest-dwelling communities over the forest lands inhabited.[101]

LEGISLATION	DESCRIPTION
Wetlands (Conservation and Management) Rules, 2010	Conservation, management and prevention of degradation of existing wetlands in India[102] through an Integrated Management Plan for notified wetlands.
Compensatory Afforestation Fund Act (CAMPA), 2016	Compensates the loss of forest area through a mitigation fund managed by a well-defined institutional mechanism and maintains accordance with the Forest (Conservation) Act,1980.[103]

TABLE 3: National-level policies and strategies that support NbS implementation in India

POLICIES/STRATEGIES	DESCRIPTION
National Forest Policy, 1988	Deals with protection, conservation and development of forests through an ecology-centric approach. It underlines that a third of the country's land area in the plains and two thirds of the area in the hills should be under forest cover. It also calls for local community participation through joint management programmes such as social forestry, farm forestry and agroforestry whilst promoting afforestation. Modifications to the 1988 policy were proposed in 2018[104] such as improvement of green cover through urban greens, public private partnership models for afforestation, strengthening forest fire prevention measures and carrying out tree planting in catchment areas to rejuvenate water bodies. The 2018 draft focusses more on timber and forest-based industries.[105] It also pushes for economic valuation of ecosystem services, forest certification, national forest ecosystem management information system and incorporation of climate change concerns in all forest and wildlife areas working/management plans and Community Ecosystem Management Plans. The draft policy also recognises urban forests.
National Conservation Strategy and Policy Statement on Environment and Development, 1992	Expresses India's commitment in aligning its various policies and action with the environmental perspective.[106] It describes the various problems present, actions taken in response as well as future priorities and actions.
National River Conservation Plan (NRCP), 1995	Lists out strategies to prevent the pollution of over 39 rivers.[107]
National Ecotourism Policy and Guidelines, 1998	Details the preservation, retention and enrichment of natural resources through seven cardinal principles in order to regulate ecotourism within an environmental and community development perspective.
National Forestry Action Programme, 1999	Details the various actions to sustainably develop forests over a period of 20 years, keeping in mind the goal laid out in the National Forest Policy (1988) of 33% geographic area of the country under the forest and tree cover.[108]
National Agriculture Policy, 2000	Targeting equitable inclusive growth and sustainability in terms of efficient use of resources, the policy seeks to promote technically sound, economically viable, environmentally non-degrading, and socially acceptable use of natural resources for the sustainable development of agriculture. The conservation of bio-resources through their ex-situ preservation in Gene Banks and in-situ preservation in their natural habitat through Biodiversity Parks is emphasised. It also aims at promoting special measures for conserving and enriching soils, using watershed approaches, promotion of balanced and optimum use of fertilisers together with organic manures.[109]

POLICIES/STRATEGIES	DESCRIPTION
National Environment Policy, 2006	The policy's[110] main theme is the sustainable use of natural resources, and it sets out to achieve "balance and harmony between economic, social and environmental needs of the country" through seven main objectives.
National Policy for Farmers, 2007	In order to support farmers and improve their quality of life, this policy[111] explores the themes that will lead to improved productivity, appropriate price policies and risk management measures. It also recognises that natural resources must be protected and enhanced by views this through an economic lens. Biodiversity too is highlighted as an important aspect of biosecurity.
National Action Plan on Climate Change (NAPCC), 2008	The NAPCC[112] identifies eight core 'national missions' to further India's development and climate change-related objectives. The plan itself contributes to climate mitigation by reducing or avoiding GHG emissions. The missions through which NbS can be implemented include the National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, Green India Mission, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change.
National Biodiversity Action Plan (NBAP), 2008 and Addendum, 2014	Drawing on the framework laid by the National Environmental Policy of 2006, the NBAP[113] and its addendum were developed to align with the CBD Strategic Plan for Biodiversity 2011–2020. The document lists actions that can be taken to protect and enhance biodiversity. The addendum[114] itself reflects the Aichi Biodiversity Targets through the formulation of 12 National Biodiversity Targets (NBTs).
National Policy on Disaster Management, 2009	Adopts a proactive stance towards prevention, mitigation and preparedness underlining that adequate mitigation and disaster risk reduction measures can prevent hazards from turning into major disasters.[115]
The National Water Policy, 2012	Adopts an integrated perspective in the planning and management of water resources.[116] Declaring that water is a common pool community resource, the policy proposes management along these lines to allow equitable and sustainable development. It also deals with climate change adaptation especially in the context of extreme events, river corridor and water body conservation, available infrastructure alternatives, water supply and sanitation.
National Plan for Conservation of Aquatic Ecosystems (NPCA), 2013	Encompasses two centrally-funded schemes i.e., the National Lake Conservation Plan (NLCP) and National Wetlands Conservation Programme (NWCP). These schemes deal with the restoration and conservation of waterbodies and wetlands degraded by pollution[117] and attempt to follow an integrated ecosystem approach.
National Land Utilisation Policy (Draft), 2013	Concerns itself with improving livelihood, food and water security, and the achievement of various developmental targets to ensure India's sustainable development. Some relevant objectives of the policy that fit with the NbS approach include: the preservation and conservation of lands under important environmental functions such as those declared as, for example, national parks, wildlife sanctuaries, reserve forests, eco-sensitive zones), and regulating land use for the aforementioned areas to reduce land-use conflicts or negative environmental impacts.[118]

POLICIES/STRATEGIES	DESCRIPTION
National Agroforestry Policy, 2014	The policy, which was the first of its kind in the world, deals with the practice of integrating trees, crops and livestock on the same plot of land. Discusses agroforestry as a tool to mitigate the impact of climate change while bringing about sustainability in agriculture and improving productivity. Views agroforestry through the lens of agriculture and brings together various agroforestry elements dispersed across various existing missions, programme and schemes under different ministries.[119]
Intended Nationally Determined Contribution (INDC), 2015	With the aim of reducing the emissions intensity of its GDP by 33–35% by 2030 from 2005 levels, India's INDC includes considerations of adaptation, mitigation, and requirements for finance, technology transfer and capacity building. As part of its commitment, India aims to enhance its forest cover to a level that will absorb 2.5 to 3 billion tonnes of carbon dioxide by 2030.
National Disaster Management Plan (NDMP), 2016	With the release of the first National Plan in 2016,[120] a critical gap in the country's disaster management system was addressed. The plan is based on the four priority themes of the Sendai Framework.
Guidelines for Integrated Water Resources Development and Management, 2016	Deals with implementing Integrated Water Resources Management principles at the river basin level in line with the National Water Policy (2012). The overall aim is "to create sustainable water security within the present constraints and through improving conditions incrementally" in each river basin in the country.[121]
Policy on Promotion of City Compost, 2016	Aims to address the processing and use of a city's organic waste as compost through market development assistance of US$ 18.85 per tonne of city compost. The policy is a step in the right direction towards managing uncontrolled decomposition of organic waste in dumpsites, which leads to GHG emissions.
National Wildlife Action Plan (2017–2031)	Acts as a road map for wildlife conservation and is the first in the series that recognises the impacts that climate change will have on wildlife; thereby incorporating actions that encompass adaptation and mitigation perspectives.[122]
National Mission on Biodiversity and Human Well-Being, 2018	Aims to address the dire issues of biodiversity loss and environmental degradation facing India, through advanced research in the field of biodiversity sciences as well as encouraging citizen's participation in protecting the natural heritage of the country.[123]
National Urban Policy Framework (NUPF), 2020	An integrated and clear approach towards the future of urban planning in India, which is based on 10 principles that correspond to 10 functional areas of urban space and management. The policy emphasises environmental sustainability as a means to achieve sustainable urbanisation. It calls for mainstreaming of the same at all levels of the government through an "integrated approach across urban sectors to plan proactive measures to prevent, avoid and minimise adverse impacts from the natural systems upon which our communities, businesses and infrastructure systems depend".[124]
Guidelines for Setting up of Biodiversity Parks in Floodplains of Rivers of India, including River Ganga, 2020	Provide theoretical knowledge and practical information on the Ganges and its network of tributaries, their ecosystems and the process of setting up of biodiversity parks in order to rejuvenate rivers.[125] It deals with the planning, design, development, implementation, management, financing and institutional mechanisms associated with biodiversity parks.

TABLE 4: National-level legislation that supports NbS implementation in Bangladesh

LEGISLATION	DESCRIPTION
The Forest Act, 1927	Introduces the practice of social forestry and facilitates the formation of village forests.[126] The Act seeks to promote community participation through afforestation and other plantation activities. Ecosystem-based adaptation, mitigation and forest restoration programmes fall under the ambit of this Act.
Bangladesh Environment Conservation Act, 1995	The Environment Conservation Act, 1995, amended in 2010, is the chief environmental law in Bangladesh.[127] The Act serves to include the protection of wetlands, Ecologically Critical Areas under its scope, in conjunction with the conservation of environment. It also prohibits deforestation activities in hills, thus aiming to reduce GHG emissions. The Law seeks to promote the implementation of ecosystem restoration and conservation activities under its jurisdiction.
Playgrounds, Open Spaces, Parks and Natural Reservoirs in all Municipal Areas of the Country, including Municipalities in Metropolitan, Divisional Cities and Districts Act, 2000	Ensures protection of urban green spaces such as parks, playground, open green spaces, gardens and natural water reservoirs such as lakes and wetlands.[128] It is primarily enacted to promote and conserve green spaces in cities, towns and other municipal areas. The law further encourages NbS implementation under infrastructure-related approaches. Any action concerned with interfering the ecological balance of green spaces without approval is strictly prohibited, under the provisions of this Act.
The Wildlife (Conservation and Security) Act, 2012	Originally known as the Bangladesh Wildlife (Preservation) Order, 1973, the Wildlife (Conservation and Security) Act, 2012 aims to conserve and protect wildlife, forest and biodiversity of the country.[129] According to the Act, the Government of Bangladesh holds special provision for declaration of any area as national park, sanctuary, eco-park, buffer zone and core zone which is in direct relation to area-based conservation approaches including protected area management under the formally described NbS approaches. The Government is also authorised to proclaim wetland, river, sea, canal or pond meant for special purpose, as special biodiversity conservation area.
National River Conservation Commission Act, 2013	Provides for the set-up of a commission that oversees the health of the rivers and makes recommendations to the government to take appropriate actions towards addressing the river pollution, encroachment, maintaining ecological balance of the river systems and sustainable management of rivers.[130]
Bangladesh Water Act, 2013	Provides citizens with a sense of entitlement over water for services, such as drinking and sanitation as well as encourage water conservation.[131] The Act also illustrates the formation of water governing bodies i.e. the National Water Resources Council and the Water Executive Committee. These governing bodies at large aim to promote integrated management of water resources, facilitate the implementation of the National Water Policy, 1999 and ensure proper water supply.
Ecologically Critical Area Management Rules, 2016	The Ecologically Critical Area Management Rules, 2016 were framed under the Bangladesh Environment Protection Act, 1995.[132] The Rules provide provisions for establishment of committees at various levels such as national, district, upazilla and village. A list of prohibited and banned activities in the ecologically-critical areas including restriction on modification in land use types, is provided under the Rules.

LEGISLATION	DESCRIPTION
Bangladesh Biodiversity Act, 2017	The Act facilitates the protection of environment and conservation of biodiversity, forests, wildlife and wetlands.[133] It pledges to safeguard and manage the country's natural resources in line with the objectives of the Convention on Biological Diversity, including sustainable use of its resources, biodiversity conservation and equitable sharing of benefits derived from its land.
Protected Area Management Rules, 2017	These rules are especially relevant for effective implementation of coastal afforestation projects and conduct community engagement programmes to ensure benefits to all.[134] They also comprise of the first co-management model of the country highlighting the role of local communities in the protected area management process.[135]

TABLE 5: National-level policies and strategies that support NbS implementation in Bangladesh

POLICIES/STRATEGIES	DESCRIPTION
Environment Policy, 1992	Following the Earth Summit held in Rio de Janeiro, Brazil in 1992, the Government of Bangladesh drafted its first Environment Policy.[136] The policy recognises the importance of sustainable management of natural resources in order to ensure social and environmental well-being. The policy also explicitly identifies the threats to environment and aims to mitigate the ill-effects of climate change by promoting national development based on the principle of sustainability.
National Water Policy, 1999	The National Water Policy, 1999 was declared by the Ministry of Water Resources "to manage, water resources in the country in a comprehensive, integrated and equitable manner".[137] It includes measures for planning and management of water resources, water supply and sanitation, water and agriculture, fisheries and wildlife and water for environment. Additional measures comprise water for preservation of haors, boars and beels and river-basin management are important conservation-related component that fall under the ecosystem-based management NbS approaches. The policy also encourages private sector intervention in the development of groundwater for irrigation and emphasises surface water augmentation.
Coastal Zone Policy, 2005	Focusses on the development of the coastal zones in a way that provides both economic and ecological benefits to the local communities.[138] It also encourages the use of integrated coastal zone management practices. In addition, the policy framework aims to ensure reduction of vulnerabilities due to disaster risk, sustainable management of natural resources, livelihood generation, gender equity and conservation of critical ecosystems.
Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009	An action plan of programmes that is structured based on the pillars of food security, disaster management, infrastructure, mitigation and low carbon development.[139] The plan is a cross-sectoral policy document aimed at building a climate-resilient country by strengthening institutional capacity for environmental management. It envisages a series of actions which address climate change related issues facing communities at all levels and provides scope for adopting NbS interventions to combat the same.

POLICIES/STRATEGIES	DESCRIPTION
National Agriculture Policy, 2013	This policy is a revision to the National Agriculture Policy drafted earlier in 1999.[140] It was formulated by the Ministry of Agriculture and focusses on higher crop production and productivity by increasing the crop intensity and use of fallow land for cultivation. It also aims to ensure food and nutrition security for all sections of people through diversification of crops. In addition, the policy encourages the development of a sustainable agricultural system to facilitate long-term livelihood generation for farmers in the sector.
National Strategy for Water Supply & Sanitation, 2014	Aims to provide a safe and sustainable water supply, and sanitation and hygiene access on the basis of equitable sharing, for better health and well-being.[141] The strategy seeks to manage solid waste efficiently, mitigate the effects of disaster, climate change and move ahead on the sanitation ladder. Furthermore, it also includes provisions for adopting and mainstreaming integrated water resource management thereby holding scope for NbS implementation.
Nationally Determined Contributions (NDC), 2021	The NDC encompass a number of mitigation measures to help reduce the country's GHG emissions in three sectors i.e. power, transport and industry.[142] It comprises of different elements linked to mitigation contribution, adaptation component and implementation of the NDC. The aims and targets of a few mitigation actions such as composting of organic waste, waste biomass-based thermal energy generation, installation of solar panels under the solar roof-top programme and provision of off-grid electricity access under the solar homes programme run parallel to the outcomes of NbS interventions.
National Forest Policy, 2016	Supports the sustainable management of forest, wildlife including restoration of degraded land areas and forest cover, to ensure efficient flow of ecosystem services and goods to the people of Bangladesh.[143] The policy emphasises on increased ecosystem services and includes payment for ecosystem services in the planning and management of forests. It holds potential of incorporating NbS in its larger theme of actions by encouraging climate-compatible development.
National Biodiversity Strategy and Action Plan (NBSAP) of Bangladesh (2016–2021)	Identifies conservation and restoration of ecosystems, recovery of endangered species, and linking biodiversity conservation actions to mitigating climate change effects as some of the major priority areas.[144] The objectives of the NBSAP include formulating strategies for sustainable use of country's biological diversity and building capacity to help initiate NbS implementation at various community levels. The action plan focuses on a number of conservation-related components, in direct compliance with the goals of the Convention on Biological Diversity that can further help the country achieve its targets.

POLICIES/STRATEGIES	DESCRIPTION
Bangladesh 8th Five Year Plan (2020–2025)	Amidst the global crisis of Covid-19, Bangladesh put forward its 8th Five Year Plan.[145] The plan focusses on six main subjects with the aim of ensuring reduction in poverty and low carbon development pathway for the country and achieving SDGs to develop a climate resilience economy. The plan also emphasises the country's adherence to Rio Convention, Paris Agreement and Sendai Framework on Disaster Risk Reduction. With the objective of growing with nature, it highlights the need to conserve biodiversity and increase the overall forest cover in the coming decades. In close alignment with the environmental agendas listed out in Perspective Plan 2021–2041, the plan stresses on the importance of NbS implementation in cities to provide better living conditions, proper drainage facilities, waste management system and clean air to its dwellers.
The Bangladesh Delta Plan (BDP), 2100	Encompasses an integrated and holistic plan for achieving environmental sustainability in Bangladesh. The core of the Bangladesh Delta Plan focusses on sustainable use of water resources and protection from water-related natural disasters, such as cyclones, drought etc.[146] The BDP aims to ensure long-term flood protection, water and food security, climate change resilience and overall economic growth, in line with promoting NbS implementation. It envisages an analytical framework with a defined set of management strategies for development of integrated river and estuary systems, restoration of wetlands and conservation of coastal ecosystems. It also considers the challenges facing urban areas and formulates effective strategies to combat water pollution caused by industry and improve urban services such as water supply, sanitation, wastewater and solid waste management.

TABLE 6: National-level legislation that supports NbS implementation in Nepal

LEGISLATION	DESCRIPTION
Soil and Watershed Conservation Act, 1982	Defines soil and watershed conservation as actions to prevent or save any area from being destroyed from natural calamities such as flood, landslide and soil erosion and maintain a normal flow of water.[147] The Act authorises a conservation officer to check soil fertility and maintain cleanliness of water and environment in a balanced manner. It encourages farming practices in regulation with a prescribed land use system. It also prohibits throwing away of solid wastes into the open and prevents contamination of the environment. In line with NbS implementation, it facilitates ecosystem-based management approaches, for example, projects related to integrated water resources management.
Water Resource Act, 1992	An umbrella act that governs water resources management in Nepal.[148] It declares the order of priority of water use and seeks to prohibit water pollution. River projects such as Bagmati River Basin Improvement Project in the Kathmandu valley, which is an example of ecosystem-based management approaches, comes under the ambit of this Act.

LEGISLATION	DESCRIPTION
Forest Act, 1993	The most important Act for the governance and management of forests.[149] It has undergone two amendments. After the latest amendment in 2016, the Act includes the concept of environmental services and carbon storage. The Act also emphasises the "management, utilization and benefit sharing of the environmental services obtained from forest". This is especially instrumental in NbS implementation across the spectrum.
National Parks and Wildlife Conservation Act, 2017	Originally put forward in 1973, this Act was amended five times.[150] It provides for the establishment and management of protected areas, protection of wildlife and their habitat, regulation of hunting and conservation, and promotion and development of places of special importance from the point of view of natural beauty.
Environment Protection Act, 2019	Addresses many issues and challenges not covered under the earlier Environment Protection Act, 2053 (1997).[151] This includes climate change GHG emissions and provisions regarding the protection of mountains, hills and waste management. Through the framing of this Act, the Government of Nepal is also encouraged to actively engage in carbon trading with other governments. Such engagement facilitates an incentive mechanism i.e., Reduced Emissions from Deforestation and Forest Degradation (REDD+), for conservation and sustainable management of forests. This will further help in achieving climate change mitigation through community forestry in Nepal.

TABLE 7: National-level policies and strategies that support NbS implementation in Nepal

POLICIES/STRATEGIES	DESCRIPTION
Nepal Environmental Policy and Action Plan, 1993	Aims to sustainably manage natural and physical resources, including agricultural land, rangeland, forest and water resource management, balance development with environmental considerations for its citizen's welfare, safeguard national heritage, mitigate adverse environmental impacts and support the development of related legislation, education, institutions and public resources.[152]
Water Resource Strategy, 2002	One of the outputs within the strategy is the sustainable management of watersheds and aquatic ecosystems.[153]
National Agriculture Policy, 2004	Focuses on enhancing commercial agriculture system to achieve sustainable economic growth through food security and poverty alleviation.[154] The policy also encourages conservation, promotion and proper utilisation of natural resources, environment and biodiversity through various strategies such as in-situ conservation, establishment of gene banks, participatory biodiversity parks and agroforestry.
Science and Technology Policy, 2005	Endorses sustainable use of natural resources using science and technology.[155] It also outlines strategies for education, research, training, and development in various sectors including agriculture, forests, water resources, environment, and biotechnology.

POLICIES/STRATEGIES	DESCRIPTION
National Water Plan (NWP), 2005	Developed for the purpose of "integration, coordination, decentralisation, participation and implementation" of water-related programmes operational within the principles of good governance, equitable distribution and sustainable development.[156] A key highlight of the NWP is the inclusion of environmental action plan concerned with the management of watershed and aquatic ecosystem, water supply, sanitation and hygiene, irrigation for agriculture, fisheries and water-related information systems.
Agrobiodiversity Policy, 2007	Emphasises conservation, promotion and sustainable use of agro-biodiversity.[157] It safeguards and promotes the rights, interests, traditional knowledge, skill, innovation, technology, and practices of the farmers.
National Adaptation Programme of Action (NAPA), 2010	Aims to address the climate change adaptation needs of the country.[158] Identification of thematic areas such as forest and biodiversity are included under the aim of listing immediate adaptation actions. In addition, the NAPA also identifies the importance of forest ecosystems in reducing the impacts of climate-induced hazards. Furthermore, recognising the need of community-based climate change adaptation activities, it facilitates the implementation of EbA projects.
Climate Change Policy, 2011	The main objective of the Policy is to "enhance the climate adaptation and resilience capacity of local communities for optimum utilisation of natural resources and their efficient management".[159] The policy emphasises on the need of sustainable management of REDD+. It also has provisions for climate-friendly natural resources management, such as the development and implementation of a scientific land-use system, and the conservation and proper use of forest resources, soil and water through measures like rain water harvesting and encouraging carbon sequestration.
National Framework on Local Adaptation Plan for Action (LAPA), 2011	Sets out the guidelines for the development of local adaptation plans of action.[160] It also provides the basis for the preparation and implementation of adaptation plans set out for community forest user groups. The LAPA also formulates the steps for its development, such as climate change sensitisation, prioritisation of adaptation options, climate vulnerability and adaptation assessment.
National Wetland Policy, 2012	Aims to ensure conservation and sustainable management of wetlands including restoration with local community participation.[161] It envisages the identification and development of management plans to prevent long-term degradation and exploitation of wetlands and the use of scientific knowledge for better management.
Environment Friendly Local Governance Framework, 2013	Mainstreams environmental, climate change, and disaster management considerations in the local planning process while making the local governance system environment-friendly, encouraging coordination and collaboration in environment and development; and increasing local ownership.[162]

POLICIES/STRATEGIES	DESCRIPTION
Nepal Biodiversity Strategy and Action Plan (NBSAP) (2014–2020)	Formulated to pave way for conservation and sustainable management of biodiversity in Nepal.[163] The action plan envisions climate change adaptation and mitigation as one of its main cross sectoral themes. In addition, it emphasises building climate change resilience. Major priority actions for adaptation and mitigation include long-term environmental monitoring, climate change risk/vulnerability assessment of ecosystems, and promotion of climate-friendly farming systems. It also identifies the implementation of payment for ecosystem services (PES) and REDD+ as an important priority action. Thus, the aims and objectives of NBSAP incorporate measures to implement NbS at a national level.
Community Forestry Development Guidelines, 2014	Developed to encourage the formation of Community Forests User Groups (CFUGs) through facilitating the process of community forestry.[164] The guidelines also hold the provisions on climate change adaptation. Under the guidelines, CFUGs are authorised to prepare the community adaptation plans. To promote the forest management activities, the guidelines aim to encourage community participation.
Forest Policy, 2015	Formulated to address major sustainability and climate change related issues.[165] It seeks to integrate forest and watershed management with food security, increase carbon stocks, promote local innovation and encourage community participation. The policy envisages both the mitigation and adaptation strategies to reduce climate-induced hazards, especially through community-based forest management. It provides for formulating and implementing programmes in accordance with REDD+ for resource generation. In addition, it seeks to incorporate NbS implementation through programmes to reduce climate change vulnerability in various areas.
Terai Arc Landscape (TAL) Strategy and Action Plan (2015-2025)	The second plan in the TAL programme series[166] builds on the first, which tackled immediate threats within the landscape. The current plan addresses persisting and emerging threats with a vision to secure the socio-ecological integrity of the landscape.
Forestry Sector Strategy (2016–2025)	Aims to make the ecosystems and natural resources such as forest, wildlife and watersheds climate resilient and promote the sustainable management of the same.[167] It expects to achieve "climate resilient capacity of society and forest ecosystems enhanced". In addition, the strategy addresses climate change mitigation and aims to mainstream the EbA approach.
Chitwan-Annapurna Landscape (CHAL) Strategy and Action Plan 2016–2025	Deals with the conservation and management of biodiversity and natural resources at landscape scale (CHAL) in a sustainable and equitable manner.[168] The action plan specifically adopts a river basin approach, incorporating the principles of climate-smart conservation and sustainable development practices.
Nationally Determined Contribution (INDC), 2020	Nepal's NDC[169] encompasses several mitigation measures to help reduce the country's GHG emissions in three main sectors, energy, forestry and transport through 10 targets. The NDC also aims to promote economic development through low carbon emission focusing on: (i) energy; (ii) agriculture and livestock; (iii) forests; (iv) industry; (v) human settlements and wastes; (vi) transport; and vii) commercial sectors.

POLICIES/STRATEGIES	DESCRIPTION
National Ramsar Strategy and Action Plan, Nepal (2018–2024)	This is the first strategy and action plan for conservation of Ramsar sites in Nepal and dovetails the Sustainable Development Goals and the Aichi Biodiversity Targets.[170] It aims to strengthen the sustainable development of ecosystems i.e. Ramsar site network, and communities, biodiversity and to fight climate change.
Fifteenth Three Year Plan, 2019–2024	Identifies that agriculture, forest, land, and other natural resources are important sectors for the country's economic development and prosperity.[171] It promotes sustainable forest management and ecological balance, highlighting the benefits to societal wellbeing and the economy, and endorses community-based management of forests.
National Agriculture Forestry Policy, 2019	Promotes comprehensive use of agroforestry by smallholders, strengthens the capacity of policymakers, researchers and extension workers to promote more resilient farming systems, support tree-planting initiatives, and ensure ecological stability by reducing pressure on natural forests from over-collection of fuelwood and fodder. It also aims to facilitate investment in agroforestry and promote connections between agroforestry farmers and markets, industries, banks and insurance providers.[172]

Healthy urban open green spaces provide several ecosystem services © ICLEI South Asia

Chapter 3: Case studies on Nature-based Solutions

This chapter showcases some examples of Nature-based Solutions implemented in urban areas in India, Bangladesh and Nepal. The case studies are arranged according to the IUCN NbS approaches. The 15 case studies have been chosen so that there is at least one in-depth case study and one smaller one (in a box) for each of the IUCN defined NbS approaches. In each case study, the following is highlighted:

- how the initiative was implemented;
- the factors that led to success; and
- essential elements for replication and upscaling of the initiative.

Figure 2 and Table 8 summarise the cases studies documented in this chapter. Annex 2 presents a more exhaustive list of NbS initiatives in urban areas in these three countries.

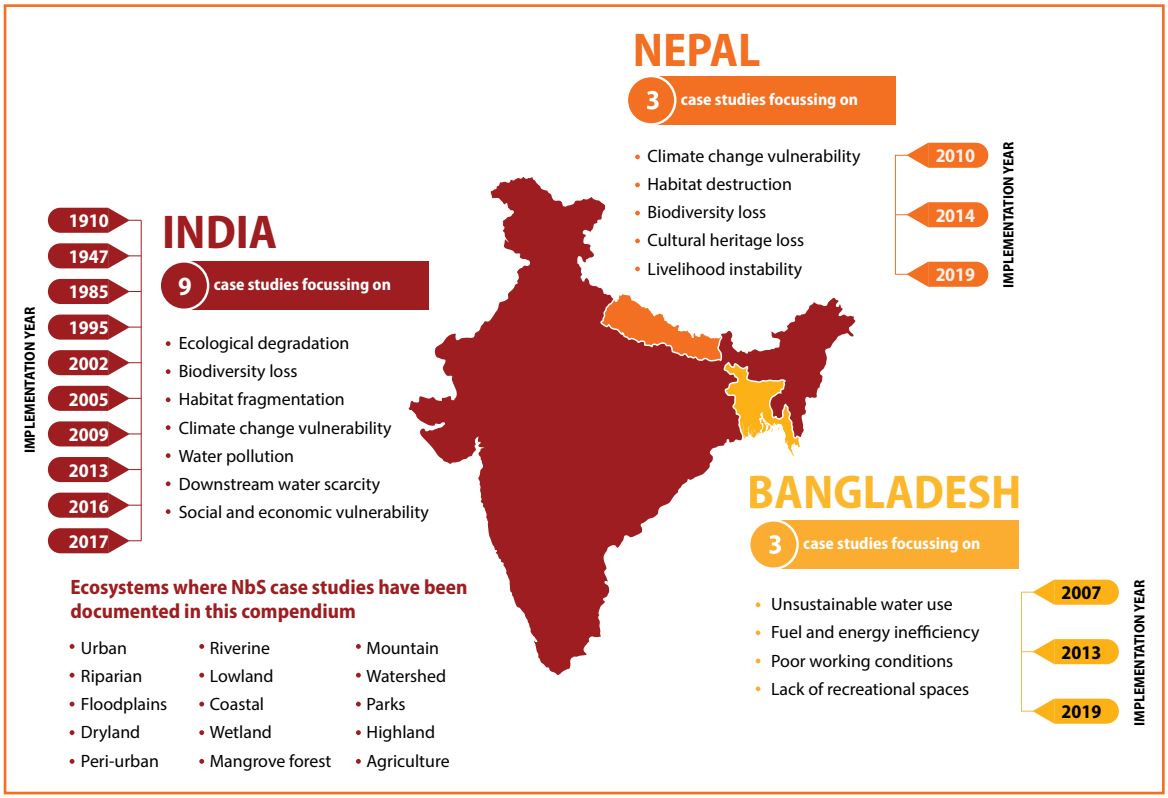


FIGURE 2: Documented case studies at a glance

TABLE 8: Overview of case studies from India, Bangladesh and Nepal

NO.	COUNTRY	NAME OF THE CASE STUDY	NBS APPROACHES USED (PRIMARY IN BOLD, SECONDARY)	LOCATION (CITY)	IMPLEMENTERS	START DATE	TYPE OF ECOSYSTEM	ISSUES ADDRESSED
1	India	Yamuna Biodiversity Park: A model for environmental sustainability and resilience	Ecosystem- restoration approaches, Issue-specific ecosystem-related approaches, Infrastructure-related approaches, Ecosystem- based management approaches, Ecosystem- protection approaches	New Delhi	Delhi Development Authority and Centre for Environmental Management of Degraded Ecosystems (University of Delhi)	2002	Urban, riparian, floodplains	Ecosystem degradation, habitat and biodiversity loss, water pollution
2	India	Aravalli Biodiversity Park	Ecosystem- restoration approaches, Infrastructure-related approaches, Ecosystem-protection approaches	New Delhi	Delhi Development Authority and Centre for Environmental Management of Degraded Ecosystems (University of Delhi)	2005	Urban, dryland	Ecosystem degradation, habitat and biodiversity loss
3	India	Enhancing climate resilience of Gorakhpur City by buffering floods through climate resilient peri-urban agriculture	Issue-specific ecosystem-related approaches	Gorakhpur	Gorakhpur Environmental Action Group	2009	Peri-urban, riverine, lowland	Climate change, vulnerability, food insecurity, disaster risk (floods), human health, social and economic vulnerability
4	India	Oota From Your Thota (Food from your garden)	Issue-specific ecosystem-related approaches	Bengaluru	Dr. B.N. Viswanath, Garden City Farmers	1995	Urban, lowland	Food insecurity, water scarcity, climate change vulnerability

NO.	COUNTRY	NAME OF THE CASE STUDY	NBS APPROACHES USED (PRIMARY IN BOLD, SECONDARY)	LOCATION (CITY)	IMPLEMENTERS	START DATE	TYPE OF ECOSYSTEM	ISSUES ADDRESSED
5	India	Greening and conserving Pirojshanagar's mangroves	Infrastructure-related approaches, Ecosystem-restoration approaches, Issue-specific ecosystem-related approaches, Ecosystem- based management approaches, Ecosystem- protection approaches	Pirojshanagar	Godrej & Boyce Manufacturing Company Limited	1985	Coastal, wetland, mangrove	Water pollution, climate change vulnerability, habitat and biodiversity loss
6	India	Integrated wetland management system: The case of Neknampur Lake	Ecosystem-based management approaches, Ecosystem-restoration approaches, Issue specific ecosystem-related approaches, Infrastructure-related approaches	Hyderabad	Dhruvansh	2016	Urban, wetland	Water scarcity, water pollution, biodiversity loss, climate change vulnerability
7	India	Kyalasanahalli Lake rejuvenation	Ecosystem- based management approaches, Ecosystem-restoration approaches, Issue-specific ecosystem-related approaches, Infrastructure-related approaches	Bengaluru	Mr. Anand Malligavad	2017	Urban, lowland, wetland	Water Scarcity, Climate Change Vulnerability, Biodiversity Loss
8	India	Protecting private forest patches: Jabarkhet Nature Reserve	Ecosystem- protection approaches, Ecosystem-restoration approaches	Mussoorie	Dr. Sejal Worah and Mr. Vipul Jain	2013	Forest, mountain, watershed	Ecological degradation, habitat fragmentation, climate change vulnerability, downstream water scarcity, social and economic vulnerability.
9	India	Urban sacred groves as carbon sinks	Ecosystem- protection approaches, Issue-specific ecosystem-related approaches	Gangtok	Deorali Chorten Monastery and Enchey Monastery	1947 and 1910	Urban, forest, mountain	Climate change vulnerability, air pollution

NO.	COUNTRY	NAME OF THE CASE STUDY	NBS APPROACHES USED (PRIMARY IN BOLD, SECONDARY)	LOCATION (CITY)	IMPLEMENTERS	START DATE	TYPE OF ECOSYSTEM	ISSUES ADDRESSED
10	Bangladesh	Improving degraded riverine areas in Rohingya Camps of Ukhiya	Ecosystem- restoration approaches	Cox's Bazar	Center for Natural Resource Studies (CNRS) and United Nations High Commissioner for Refugees (UNHCR)	2019	Coastal, highland, watershed	Ecological degradation, habitat and biodiversity loss, water insecurity, water pollution, disaster risk (landslides, drought and floods) and human health
11	Bangladesh	Integrated development of the Hatirjheel Area, including Begun Bari Canal	Issue-specific ecosystem-related approaches, Ecosystem-restoration approaches, Ecosystem- based management approaches	Dhaka	Vitti Sthapati Brindo Limited, BUET, RAJUK, LGED, DWASA, Engineering Construction Battalion of Army and SWO (West)	2007	Urban, wetland, lowland, riverine	Climate change vulnerability, disaster risk, water scarcity
12	Bangladesh	Karupannya Rangpur green factory initiative	Infrastructure-related approaches	Rangpur	Mr. Shafiqul Alam	2013	Lowland	Unsustainable water utilisation, fuel and energy inefficiency, poor working conditions, lack of recreational spaces
13	Nepal	Pocket parks: The greening of degraded public spaces	Infrastructure-related approaches	Lalitpur	Vriksha Foundation	2019	Urban, parks	Air pollution, green and recreational space loss, encroachment, public space degradation
14	Nepal	Building water security in Dhulikhel Municipality	Ecosystem- based management approaches, Issue-specific ecosystem-related approaches	Dhulikhel	Southasia Institute of Advanced Studies (SIAS)	2014	Urban, highland	Water scarcity, climate change vulnerability
15	Nepal	Green Lumbini	Ecosystem- protection approaches, Ecosystem-restoration approaches, Issue-specific ecosystem-related approaches, Infrastructure-related approaches	Lumbini	WWF-Nepal in partnership with Lumbini Development Trust and International Crane Foundation	2010	Urban, agriculture, lowland, wetland	Climate change vulnerability, habitat destruction, biodiversity loss, cultural heritage loss, livelihood instability

NbS approach: Ecosystem restoration

Restoration of degraded riverine areas in Rohingya camps, Ukhiya, Bangladesh © CNRS

Restored wetland © Yamuna Biodiversity Park

NEW DELHI, INDIA: Yamuna Biodiversity Park: A model for environmental sustainability and resilience

A greying capital

NbS approach: Ecosystem-restoration approaches	
FACTS AND FIGURES	
Local government	Delhi Development Authority
Country and state	India, Delhi
Population	16,787,941 (2011)
Total area	1,484 km^2
Main geography type:	Dryland/semi-arid
GDP	US$ 118 billion

The National Capital Territory (NCT) of Delhi is situated on the banks of river Yamuna. It is bordered on its northern, western, and southern sides by the state of Haryana and to the east by the state of Uttar Pradesh. Situated in proximity to ancient human migratory routes of the Himalayas, Delhi was a politically active centre and the capital of many ruling dynasties of the past, and is the present capital of India. Demographically, the city is one of the most populous in the world and is an important commercial, transport and cultural hub, as well as the political centre of India. It is also considered one of the world's worst polluted cities with rampant loss of natural heritage.[173]

The Yamuna River flows about 22 km from Wazirabad barrage to Okhla barrage in Delhi. It is the main source of freshwater in the area and also recharges the groundwater table. The Yamuna River and its floodplains and the rocky tracts of the Ridge (which represent the last spur of the Aravalli hill ranges), are the two major ecosystems on and around which Delhi has developed. The floodplains have not only provided land for housing to the rapidly-growing population of the city, but also protect the city from monsoon floods and enhance the quantity and quality of water used by the city. The floodplains also support agriculture in the peri-urban areas.

Rampant development and urbanisation have made Delhi one of the most populous agglomerations in the country and one of the world's worst polluted cities. Expansion of the city and discharge of sewage and agricultural runoff with toxic pesticides into the Yamuna River has detrimentally affected its ecosystem. The massive encroachment on the floodplains, dumping of solid waste, and habitat conversion has led to loss of the floodplain ecosystem, particularly wetlands. The width of the waterways has been almost reduced to the water channel and its embankments.[174]

Yamuna River: A lifeline turned sewer

The Yamuna River originates from the Yamunotri glacier near Bandar Punch in Uttarakhand and meets the Ganga River in Allahabad, Uttar Pradesh.[175] The river flows through seven states and holds immense ecological, socio-economic and cultural significance. Nearly 57 million people depend on the Yamuna's waters. Seventy percent of Delhi's water supply comes from the Yamuna, which has an annual flow of about 10,000 cubic billion metres.[176] Three types of wetland ecosystems exist in the Yamuna River corridor of the Delhi region. These are floodplains, seasonal pools, and marshy areas, of which the floodplains are the most extensive, notwithstanding the high degree of modification that has already occurred, through development in the city. These wetland ecosystems provide tangible benefits, which include water supply for domestic, industrial and agricultural purposes, fodder, utilisable plant species, fisheries, recreation and tourism.[177] They also provide irreplaceable services, like water recharge, nutrient retention, habitat for wildlife and biological productivity.[178]

Today, the Yamuna is considered to be one of the most severely polluted rivers in the world. The major sources contributing to its pollution include untreated sewage, industrial effluents, dumping of garbage and dead bodies, immersion of idols and pollution due to in-stream uses of water.[179] The most pollution comes from Wazirabad, where the Yamuna River enters Delhi. According to a report by the Delhi Pollution Control Committee and the Central Pollution Control Board (CPCB) submitted to the Yamuna Pollution Control Committee, at least 90% of domestic wastewater in the city flows into the Yamuna.[180] A study[181] of the Yamuna found that the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels of the river are much higher than the recommended concentrations. The heavy metal levels detected in the river are also higher than those that are acceptable.

A successful approach to river rejuvenation and restoration is the establishment of biodiversity parks in the riverscape. This holistic approach involves the restoration of degraded diverse river ecosystems, bioremediation of wastewater (treatment of waste water using biological material like plants) that enters into rivers and use of natural floodplain wetlands for cleaning channel water and storage of floodwaters.

The prime goal of the establishment of the Yamuna Biodiversity Park (YBP) was to recreate Delhi's lost natural riverine heritage and sustainably manage and preserve it. The YBP also seeks to conserve keystone species and other threatened floral and faunal species and communities. By establishing field gene banks for threatened landraces (domesticated, locally-adapted and traditionally used animal or plant species) and wild genetic resources (wild plant and animal species), the Park promotes education, environmental awareness and nature conservation. The development of a mosaic of wetlands includes restoring and protecting the floodplains as well as native Yamuna flood plains' floral communities.

Biodiversity parks: An ecological restoration innovation

The concept of the 'biodiversity park' was evolved and implemented by the Centre for Environmental and Management of Degraded Ecosystems (CEMDE), University of Delhi in joint collaboration with Delhi Development Authority (DDA). DDA is a land-owning and planning authority, created in 1957 under the provisions of the Delhi Development Act to promote and secure the development of Delhi. The decision to create the first biodiversity park was taken in 2002 by the then Lt. Governor of Delhi, Shri Vijai Kapoor, in consultation with Professor C. R. Babu, the then Pro-Vice Chancellor of University of Delhi and Director of CEMDE.

The decision was strongly supported by the then Vice Chairman of DDA, Shri Anil Baijal, who not only earmarked the land for YBP but also created the Delhi Biodiversity Foundation, a committee under section 5 (A) of DDA Act 1957, to oversee the development and management of YBP and the creation of more Biodiversity Parks. Today, there are seven biodiversity parks in Delhi: Yamuna, Aravalli, Neela Hauz, Tilpath valley, Northern Ridge, Tughlaqabad and Kalindi Biodiversity Park; together spread over 1,000 hectares and providing a wide range of ecological services to the city of Delhi and its citizens.

The approach

Biodiversity parks are a conservation approach that both bring back lost natural heritage specific to an area, and also conserve vanishing ecosystems, communities and species (flora and fauna) on marginal/ degraded vacant lands in and around urban centres. This approach is based on the principle of ecosystem restoration, which promotes assisted recovery of degraded, damaged or destroyed ecological assemblages of species into communities/ecosystems. A biodiversity park is the end product of ecosystem restoration. It preserves natural heritage, and has educational, conservation and cultural value.[182] This approach is different from all other forms of ex-situ

conservation in the sense that biodiversity parks conserve ecosystems, communities and species, and serve as a nature reserve.

The underlying principle of the biodiversity parks is to recreate self-sustaining ecosystems with native flora and fauna of the area, for enhancing the quality of the environment. They provide a wide range of ecological services that contribute to human well-being. Some of the ecological services rendered include:

- **Improved public health:** A biodiversity park has diverse natural ecosystems that harbour a rich environmental microbiome which, in turn, are a source for enriching people's microbiomes, can enhance their immunity and thereby reduce health risks and the public health burden.[183]
- **Air pollution mitigation:** The diverse assemblages of tree and other plant species act as effective and efficient filters for both point and non-point sources of air pollution, thereby mitigating air pollution hazards and improving the local air quality.[184]
- **Water recharge and stormwater retention:** The wetlands and associated plant communities of biodiversity parks store millions of cubic metres of floodwater every year and recharge groundwater, which is rapidly depleting due to heavy extraction.[185]
- **Carbon sink:** The biodiversity parks serve as major sinks for carbon dioxide and store huge carbon stocks, both above- and below-ground biomass, contributing to climate change mitigation and adaptation, thus enhancing the city's resilience.[186]
- **Improving micro-climate:** A biodiversity park with diverse forest cover influences local climate conditions particularly ambient temperature. There is scientific evidence that on a large enough scale, forest and vegetation cover can drive local cloud formation, resulting in localised precipitation.[187]
- **Habitat for wildlife:** The diverse ecological niches in biodiversity parks are ideal habitats for certain species of flora and fauna that are otherwise disappearing from the area, and hence serve as nature reserves, harbouring natural heritage.[188]
- **Education and research values:** Biodiversity parks serve as living museums/ laboratories for undertaking research on ecosystem processes and functions. They represent the tools for promoting practical environmental and nature conservation education among students and environment awareness among the public.[189]
- **Recreation value:** Biodiversity parks provide recreation to the public and promote ecotourism.[190]
- **Livelihood value:** Biodiversity parks generate livelihoods for local communities by engaging locals as tourist guides for nature walks and for imparting nature education to visitors.
- **Medicinal value:** The rich plant resources of biodiversity parks provide a myriad of products/ medications that can be used through the Ayurveda, Yoga, Naturopathy, Unani, Siddha, Sowa-Rigpa and Homoeopathy (AYUSH) modalities in treating health disorders, and thereby contributing to the human health care system.
- **Treatment of wastewater:** Biodiversity parks can also contribute to the rejuvenation of rivers and lakes through the use of natural and/or constructed wetlands for the treatment of wastewater before it enters into natural waterbodies.

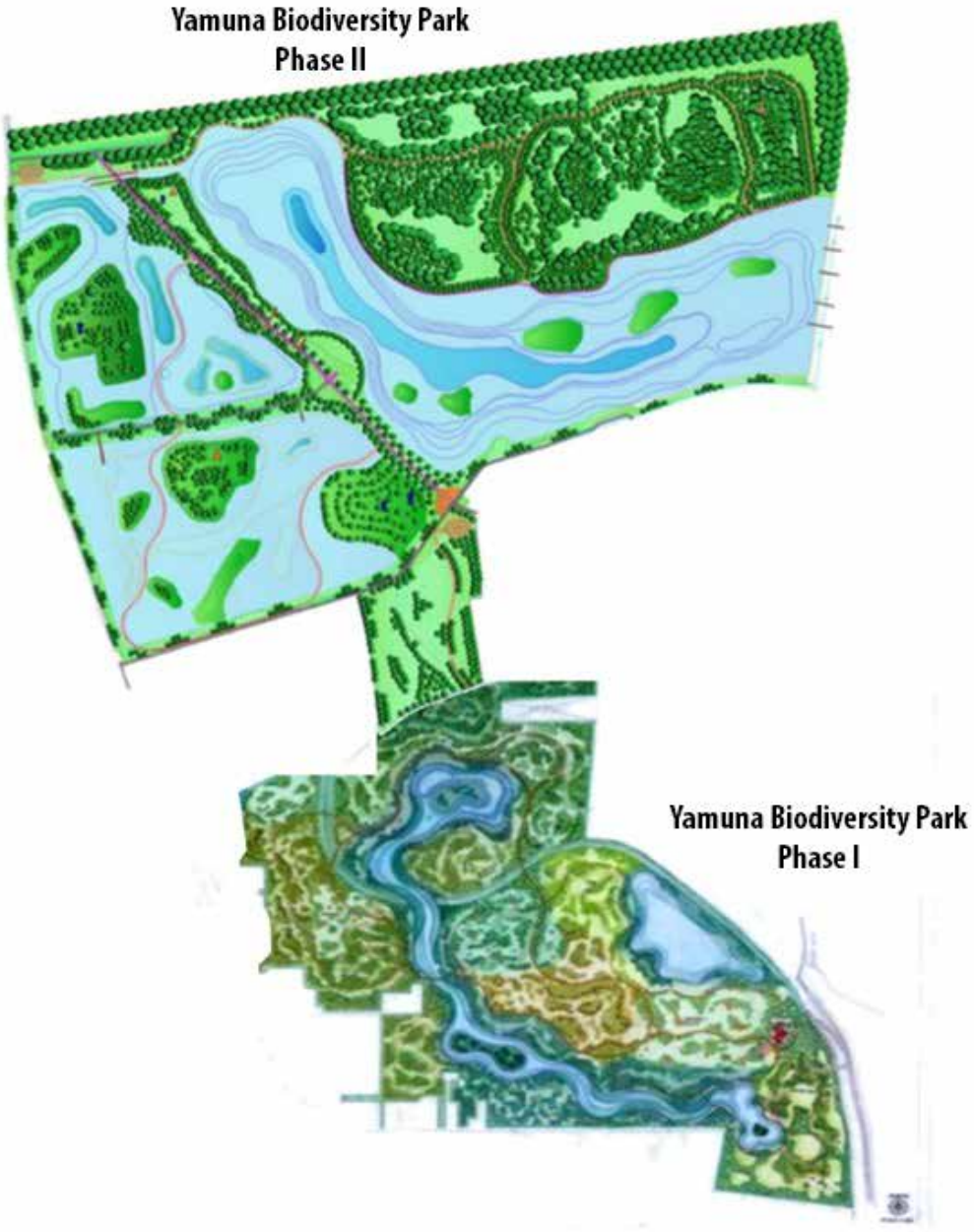
The case of the Yamuna Biodiversity Park

Rejuvenating rivers in biodiversity parks is a proven approach and exemplified by Delhi's YBP. The YBP covers an area of approximately 457 acres (28°43'56.8"N, 77°13'06.6"E) near Wazirabad, on the

flat alluvial plains of the Yamuna. The park was developed in two phases: phase I consisting of 157 acres located on the inactive floodplain (originally this land was part of the Yamuna floodplains about 30-40 years ago, but is now cut off from the existing floodplains due to construction of a permanent bund in 1978), and phase II consisting of 300 acres of active floodplains, which flood every year (see Figure 3). However, both phases of the park are connected by a 200-metre-wide corridor that facilitates the movement of animals.

How the initiative was implemented

With a wide range of landscape elements or structural features, the YBP has two zones: (i) the nature conservation zone, and (ii) the visitors' zone. The nature conservation zone includes the different terrestrial ecosystems of the area and a mosaic of wetlands and marshes interspersed



Source: Yamuna Biodiversity Park

FIGURE 3: Map showing the two phases of the Yamuna Biodiversity Park

with grasslands. This is not open to visitors. The visitors' zone includes (i) a butterfly corner or conservatory, (ii) a herbal garden, (iii) a climbers' grove, (iv) wetlands, marshes, swamps and lakes, (v) a field gene bank, (vi) a conservatory of fruit-yielding plants, (vi) an amphitheatre, (vii) a nature interpretation centre with exhibits of representative ecosystems of the area, and (viii) small recreational parks.

Before the restoration work was initiated, the area was highly alkaline and the underground water was highly saline (electrical conductivity 1,500–5,000 µS cm^{-1}). Existing plant species in the park included a few species of halophytes and weeds. Various restoration strategies were used to develop different forest types, wetlands, grasslands and marshlands.

In order to create wetlands and address the issue of salinity, landscape modification was initially undertaken. Existing silted wetlands were dredged, and the excavated soil was used to develop mounds. These mounds helped in two ways: with increase in height, drainage was facilitated, thereby improving soil fertility; and, the landscape variation positively influenced micro-climatic variables and created niches conducive to plant growth due to reduced salinity.

In order to promote good aeration, and support good mixing of manure to increase the organic content of the soil, ploughing was undertaken. Since the soil comprised high quantities of clay, ploughing also helped to break the hard soil aggregates. This, in turn, helped to promote lateral growth of roots and supported better establishment of the saplings.

The initial planting focused on grass species, keeping the process of ecological succession in mind. Grasses like *Leptochloa fusca, Vetiveria zizanoides* and *Cenchrus ciliaris* along with nitrogen-fixing legumes like *Crotolaria sp., Sesbania sesban, Sesbania aegyptica, Indigofera tinctoria, Trifolium alexandrium, Medicago sativa, Mellilotus sp., Trigonella sp.* and *Rhynchosia sp.* were planted. Saplings of tree species like *Holoptelea integrifolia, Terminalia arjuna, Dendrocalamus strictus* and *Albizia sp.* were planted to develop the three-storeyed vegetation and reduce the noise from the neighbouring human settlements.

In order to simulate the vegetation along the Yamuna floodplains, an extensive survey was conducted of the forest and wetland areas along the Yamuna. In order to initiate the process of succession, 25 species of grasses including *Leptochloa fusca, Bothriochloa sp.,* and *Cenchrus sp.* were planted. Seeds of wild species, collected from natural forests, were germinated in the nursery at YBP. Based on the natural plant communities and species assemblages existing along the Yamuna River basin, large-scale planting was undertaken in YBP. While undertaking the planting, life history traits of species were considered, such as seed size and longevity, germination requirements, growth rate, shade dependence, ability to tolerate moisture stress and successional status.

Two wetlands, which simulate natural water bodies, have also been developed in YBP. One is 1.8 km long and narrow, simulating the river. The other one is wider and deeper and is spread over an area of two hectares. The creation, construction or development of wetlands needs a systematic ecological design in order to ensure that the desired communities of flora and fauna are developed at varying depths in the wetland. The forest communities in YBP represent different ecosystems present across the Yamuna River basin. Various forest communities including tropical dry deciduous, riparian and floodplain forest communities were simulated at YBP. Trees like *Syzygium cumini, Terminalia arjuna, Dalbergia sissoo, Acacia nilotica, Salvadora persica, Hardwikia binata, Mitragyna parviflora* and *Madhuca latifolia* were planted, based on community structure and species assemblage.

Impacts

YBP now has over 900 species of flowering plants. The three-storeyed vegetation of YBP provides the ideal habitat for several faunal species, which thrive, nest and breed there. The forests,

grasslands and wetland communities in YBP comprise diverse ecological niches that harbour a wide range of floral and faunal species, thus forming and supporting the food web.

YBP phase II is made up of a mosaic of wetlands, along with grasslands and floodplain forest communities. These restored wetlands serve as nurseries for zooplankton, phytoplankton, fish, amphibians, snakes, turtles and aquatic plants. They also provide a rich habitat for a large number of resident and migratory birds.

Nature education is a major aspect of YBP. The park has a nature interpretation zone and the visitor zone serves as a live demonstration space to sensitise and educate visitors. It also has an open-air amphitheatre for organising lectures and talks for students and visitors.[191, 192]

View of the site of Yamuna Biodiversity Park before restoration. © Yamuna Biodiversity Park

View of Yamuna Biodiversity Park after restoration. © Yamuna Biodiversity Park

The status of the wetland in the initial stages of development. © Yamuna Biodiversity Park

Initially the project was conceptualised for a period spanning 10 years. However, for the long-term sustainability of the YBP, an institutional mechanism was needed that provides flexibility and greater decision-making autonomy, and regularises staff working in all Delhi's Biodiversity Parks. In consultation with India's Ministry of Housing and Urban Affairs, the DDA formed the Delhi Biodiversity Foundation, registered under the Societies Registration Act, 1860. This Society is not a constituent of DDA, but works through an institutional arrangement with DDA.

Present status of the wetland. © Yamuna Biodiversity Park

Yamuna Biodiversity Park has gained popularity among several sections of the public in India and abroad. Bird watchers, naturalists, students, NGOs, policy makers, planners, forest officials, judges, elected representatives, foreign dignitaries and other stakeholders who visit the park have been impressed by the achievements, highlighting it as a model for environmental sustainability and resilience.

Within 18 years, the total number of plant species has grown from 90 to 915. Most of the forest communities harbour 25 to 50 species characteristic of their natural habitats, with large canopies and GBH (girth at breast height) that range from 15–90 cm, increasing every year at rates that are

comparable to growth in forests in similar agro-climatic zones. Ground cover, too, varies from 15–30%. The gradual increase in species establishment and overall growth of plant species at all the sites indicate the success of ecological restoration undertaken. The amelioration of soil quality has, in turn, increased the soil microfauna. As a consequence, many faunal elements have increased (both in number and species). The change in diversity over 18 years is depicted in Table 8. The photographs provide glimpses of the mammalian species that have been spotted at Yamuna Biodiversity Park.

TABLE 9: Species diversity increase over 18 years

SPECIES GROUPS	NUMBER OF SPECIES	
	2002	2020
Terrestrial plants	90	915
Aquatic plants	0	101
Birds	37	203
Butterflies	11	82
Reptiles and Amphibians	3	18
Mammals	4	22
Fishes	0	18

Wild boars sighted at Yamuna Biodiversity Park. © Yamuna Biodiversity Park

In Delhi itself, the DDA has established six more biodiversity parks at different locations. Based on the successful outcome of the DDA Biodiversity Parks of Delhi, the Ministry of Environment, Forest and Climate Change (MoEFCC) has devised a new scheme – 'Conservation of Natural Heritage and Enhancement of Quality of Urban Environment' – through the establishment of biodiversity parks in States and Union Territories across the country. The Ministry has already issued letters to the Chief Ministers of different states to establish biodiversity parks in State capitals and District headquarters.

In November 2021, orders passed by the National Green Tribunal (a specialised body to enforce environmental protection established under the National Green Tribunal Act, 2010) for actions to be taken by authorities for the rejuvenation of rivers in India, the creation of biodiversity parks has been referenced, and the Yamuna Biodiversity Park has been presented as a model.

Hog deer sighted at Yamuna Biodiversity Park. © Yamuna Biodiversity Park

As per the direction of National Green Tribunal (NGT), the Central Pollution Control Board (CPCB), Government of India has also published guidelines for setting up biodiversity parks in other river floodplains in India, including the River Ganga. Biodiversity Boards of several states and agencies, like the National Bank for Agriculture and Rural Development (NABARD), have already taken the initiative to develop biodiversity parks at different locations. Many universities across India have integrated biodiversity parks into their course curriculum. The staff of various foreign embassies and the United Nations Development Programme, who visited the park expressed that it could become the ideal model for urban resilience and replicated in urban centres across the world.

BOX 3: SUCCESS STORIES OF THE YBP

1. YBP is home to many herbivores, such as the nilgai (*Boselaphus tragocamelus*), Indian hare (*Lepus nigricollis*) and wild boar (*Sus scrofa*). YBP is connected to other protected areas through the Yamuna River corridor. On 7 November 2016, a leopard (*Panthera pardus*) was spotted. The sighting of the same was also confirmed in the following days through pug mark analysis and camera trap photography. The leopard stayed in YBP for two weeks and hunted two nilgai calves. However, to avoid any human-wildlife conflict the leopard was caught by the Forest Department and released into a different natural habitat.[193]

2. Based on the success of the biodiversity park, guidelines for setting up biodiversity parks in floodplains of India's rivers, including River Ganga, have been developed by the CPCB and MoEFCC, Government of India.

3. YBP was featured at the London Design Biennale in June 2021.

Enabling factors

The Yamuna Biodiversity Park initiative was first of its kind in India, where lost biodiversity was brought back to the degraded landscapes and riverscapes in the Delhi metropolis. Today, it serves as a model for urban environmental sustainability and resilience, as well as promoting nature conservation and environmental education. Two organisations – the DDA as a funding and land-owning government agency and the CEMDE from the University of Delhi as the technical and academic partner – came together to address the current environmental issues of the city and enhance the quality of life of its citizens.

Nilgai sighted at Yamuna Biodiversity Park. © Yamuna Biodiversity Park

As a biodiversity park harbours a diversity of flora and fauna and functional ecosystems require ecological integrity for their sustainability, a multidisciplinary approach was adopted that drew upon the expertise of staff with diverse specialisations. A cadre of scientists with expertise in disciplines related to ecology and environmental science have been involved in the development and management of the initiative. Local residents have also been employed in establishing, developing and managing the biodiversity park, thus providing them with social security.

Being a profit-based enterprise, the DDA would previously measure performance of its initiatives using business metrics like profit and revenues. However, under current alarming environmental conditions, the DDA has turned out to be an altruistic enterprise that generates a positive 'return to society' in the form of better environmental quality and sustainability. Through provision of land and funding, the DDA also brought a novel approach of impact investment, i.e., supporting organisations that generate positive environmental and social outcomes and make a positive difference in the world.

> **"Biodiversity Parks are for posterity. These are the only nature reserves/wilderness that would be able to provide the glimpses of natural heritage preserved for future generations. They serve as a replicable model for urban environmental sustainability and resilience."**
>
> – Professor C.R. Babu,
> Professor Emeritus, CEMDE

The elements key to the success of the initiative

The partnership between the DDA and the CEMDE that is the main factor behind the Park's success. Other key elements have been the careful planning and implementation of strategies, a dedicated team with expertise in different facets of biodiversity and community mobilisation, and financial support from the DDA.

The DDA provided full financial support to the CEMDE for the initiative. The services of the DDA engineering staff and landscape architects have been provided free of cost. The DDA also covers expenditure on security staff and infrastructural development and management of the Park. CEMDE on the other hand provides extensive knowledge on the natural history of the site, expertise in soil and water analyses and soil restoration, as well as experts from the fields of taxonomy, ecology, hydrology and wildlife.

The Delhi Biodiversity Foundation, created by the DDA under section 5(a) of Delhi Development Authority Act 1957, also provides a publicly-funded organisation to manage the Park over the long term, critical for sustainability.

Similarly, the guidelines of University of Delhi, allowing for sponsored research projects enabled CEMDE to implement the initiative as one of these projects. Community support for the initiative has also contributed to its success. Since the beginning, the local community supported the initiative and extended full cooperation during its development. Several community members were also employed in YBP as gardeners, thus deepening community support for the initiative.

ENABLING FACTORS: YAMUNA BIODIVERSITY PARK	
Institutional factors	• Political support from the then Lt. Governor of Delhi fast tracked project initiation.
Social factors	• Engagement of the local community from the beginning through livelihood benefits from the initiative.
Knowledge factors	• Expertise in restoration ecology, soil biology and technical expertise on flora and fauna (from CEMDE), landscape architecture and design (from DDA).
Technical factors	• Technical inputs, including restoration ecology, a plantation scheme to replicate succession and develop climax communities, wetland development, identification of natural assemblages of species, phytoremediation, replication of ecosystems present along Yamuna floodplains, etc. from CEMDE.
Economic factors	• Financial support from DDA for the entire initiative.
Social factors	• Nature awareness through Nature Interpretation Centre, a visitor zone, lectures and talks.

Leopard sighted at Yamuna Biodiversity Park. © Yamuna Biodiversity Park

Replication

In order to carry out the development of a biodiversity park, the following resources are critical:

Staff/capacity

Scientists with expertise in disciplines related to environment and ecology are required to design, develop and manage biodiversity parks. The strength of support staff, such as technical assistants, supervisors, nature education officers and other staff, is also critical and their number depends upon the size of the area.

Land

A minimum of 100 acres of land around the city's periphery is a good option. However, in the core city a minimum of 10 acres or more land can be developed as a biodiversity park, given the premium on land within urban centres. The selected site should have considerable ecological diversity at a broad landscape level as well as within the landscape/waterscape. If such a diversity does not exist, it can be created through appropriate landscaping of the area.

Time for planning and implementation

An initial phase of 10 years is non-negotiable to execute the work including planning processes, design and implementation. Within two to five years of project implementation, many landscape elements can be developed and made functional. However, the sustaining ecosystems in a biodiversity park need suitable long-term management.

Stakeholder engagement

As this biodiversity park was a joint collaboration of the DDA and CEMDE, support from the finance, engineering and landscape division of the DDA were significant in achieving success. To sustain biodiversity parks local bodies such as Municipal Corporations/Divisional Forest Departments/ Divisional Irrigation Departments may be entrusted to sustainably manage these initiatives. A society/trust/not-for profit organisation can be created as an alternative management option.

Engaging visitors from among the public, as well as various governmental and non-governmental organisations, also led to their participation in various activities, such as mass plantation drives, and enhanced their understanding and support for the initiative.

Costs and funding

To develop the 457 acres area of Yamuna Biodiversity Park, a cost of approximately US$ 413,890 per annum was incurred. The budget is roughly classified into establishment/non-recurring and recurring costs. The establishment cost is higher initially, and reduced with time. A 100 acres biodiversity park costs about US$206,945, excluding the cost of land and protection such as fencing and security, depending upon the extent of the degradation of the landscape. This is a one-time cost.

Links to Sustainable Development Goals, Aichi Targets and National Biodiversity Targets

SDGs	
Aichi Targets	
National Biodiversity Targets:	

Key contacts	
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Designation	Professor Emeritus
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Yamuna Biodiversity Park

Biodiversity parks are an innovative conservation approach that not only bring back lost natural heritage specific to the area, but also conserve vanishing ecosystems on degraded vacant lands in and around urban centres.

NbS approach: Ecosystem restoration

Local government	Delhi Development Authority
Country and state	India, Delhi
Population	16,787,941 (2011)
Total area	1,484 km^2
Main geography type	Dryland/Semiarid

SDGs: 

Aichi Targets: 

Issues

Degraded flood plains; alkaline soils; highly saline groundwater; sparse vegetation represented by few halophytes; weed infestation; extremely low biodiversity

Actions taken

Solutions

Assisted regeneration; phytoremediation of soil; development of three-storeyed pristine vegetation; two wetlands that simulate natural water bodies

Impact

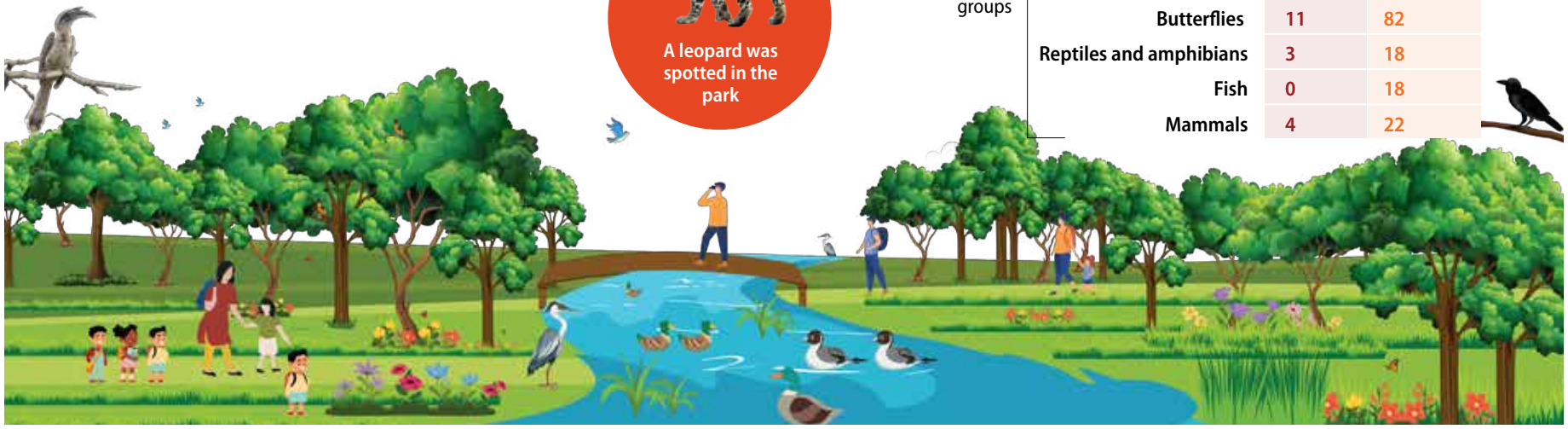
Impacts

Improved public health; air pollution mitigation; water recharge and storm water retention; carbon sink; livelihood value; habitat for wildlife; treatment of wastewater; green jobs; improved urban biodiversity

A leopard was spotted in the park

Number of species recorded in **2002** and in **2020**

Species groups	2002	2020
Terrestrial plants	90	915
Aquatic plants	0	101
Birds	37	203
Butterflies	11	82
Reptiles and amphibians	3	18
Fish	0	18
Mammals	4	22



BOX 4: SHORT CASE STUDY ON ECOSYSTEM-RESTORATION APPROACHES

NEW DELHI, INDIA: Aravalli Biodiversity Park

The why

Deforestation, encroachment of land and illegal mining are some of the major factors contributing to biodiversity loss. Other factors such as the introduction of exotic species, spread of invasive species and lack of environmental awareness also led to the disappearance of native flora and fauna.

NbS approach: Ecosystem-restoration approaches	
FACTS AND FIGURES	
Local government	Delhi Development Authority
Country and state	India, Delhi
Population	16,787,941 (2011)
Total area	1,484 km^2
Main geography type	Lowland

Aravalli Biodiversity Park (ABP), situated within the National Capital Territory (NCT) of Delhi, was developed to fulfil multiple objectives of restoration of natural ecosystems of the Aravalli mountain range in northwest India, sensitising people on biodiversity conservation, and encouraging environmental education in schools.

The what

Prior to restoration, the area was highly degraded due to mining and weed infestation. This degraded, undulating terrain was later transformed into a green haven, now called the ABP.

The ABP covers an area of 280 hectares and is divided into two zones: the nature reserve zone and the visitors' zone. While the nature reserve zone consists of an array of ecosystems, such as forests, wetlands and shrublands, the visitors' zone serves recreational and educational purposes. The Park is home to about 981 plant species, 209 bird species, 113 species of moths and butterflies and around 19 species of mammals. In addition, a range of forest communities including *Adina, Mitragyna, Acacia, Balanites, Grewia, Carissa, Rhus, Lycium,* represent the vegetation of ABP and support in providing habitat to faunal species as well as delivering ecosystem services to the urban dwellers.

The how

The restoration work in the park commenced with a series of surveys conducted in the Aravalli mountains in 2005. To create suitable growing conditions for planting and establishing forest communities, the soil in the area to be developed as a park was initially treated to enhance its fertility. Seeds of native grass species, such as *Cenchrus sp.* and *Heteropogon sp.* were dispersed to enhance soil fertility. In order to facilitate the progress of undergrowth, *Prosopis juliflora* trees were pruned using a canopy opening method and removal of invasive species was carried out using the cut root stock method. As part of the final site preparation, planting along the slopes of water bodies and mulching were done to conserve soil and prevent erosion.

The who

The DDA, with the technical support of CEMDE of the University of Delhi, developed the ABP. Professor C. R. Babu, a noted ecologist and Professor Emeritus, was the backbone behind the successful restoration of the degraded land to develop the Aravalli Biodiversity Park.

Aravalli Biodiversity Park

Aravalli Biodiversity Park, situated within the National Capital Territory of New Delhi, was developed to fulfil the multiple objectives of restoring natural ecosystems of the Aravalli mountain range, raising awareness of the importance of conservation of biodiversity and encouraging environmental education in schools for students.

NbS approach: Ecosystem restoration

Local government	Delhi Development Authority
Country and state	India, Delhi
Population	16,787,941 (2011)
Total area	1484 km²
Main geography type	Lowland

SDGs:

Aichi Targets:

Park zones

Visitor's zone

Recreational and educational purpose

DEGRADATION

- Deforestation
- Mining
- Invasive species

TREATMENT

- Planting of native Aravalli vegetation
- Soil conservation activities
- Weed removal
- Development of wetland in mined pits

Nature conservation zone

An array of ecosystems, such as forests, wetlands, shrub lands, grasslands and an orchidarium

- **981** Plants
- **209** Birds
- **113** Moths and butterflies
- **19** Mammals

The where

The Aravalli Biodiversity Park is located in Vasant Vihar, on the Delhi Ridge in the southern part of the city of Delhi in India.

The when

The process of developing the ABP began in 2005. The Park was opened for visitors in 2015.

Key contacts	
Name	Professor C. R. Babu
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Organisation	Centre for Environmental Management of Degraded Ecosystems, University of Delhi

Purple sunbird sighted at Aravalli Biodiversity Park © Aravalli Biodiversity Park

UKHIYA UPAZILA, BANGLADESH: Improving degraded riverine areas in Rohingya Camps of Ukhiya, Cox's Bazar

A disaster-prone refugee haven

NbS approach: Ecosystem-restoration approaches	
FACTS AND FIGURES	
Local government	Ukhiya Upazila
Country and state/division	Bangladesh, Chittagong
Population	27,317 (2011)
Total area	18.32 km^2 (2020)
Main geography type	Coastal and highland

Located along the Bay of Bengal in south-eastern Bangladesh, the district of Cox's Bazar has always been particularly susceptible to environmental disasters, including floods and landslides.

The district has economic potential and comparative advantages due to its linkages with the Chittagong port and Dhaka. Specifically, owing to planned mega-investments by the government and international actors in the region, Cox's Bazar is poised to become a new centre of economic activity. The construction of a deep-sea port and an associated energy-generation complex, in combination with economic zones and investments in connectivity (road, water and rail) to main urban centres, is expected to catalyse significant economic activity in the district.

Although the average poverty rate in Cox's Bazar (16.6%) is lower than the national average (24.5%),[194] there is large variation in poverty incidence. Poverty rates outside the district capital of Cox's Bazar Sadar are higher than both the national and district averages, with the *upazilas* (sub-districts) of Teknaf and Ukhyia reporting poverty estimates of 30% and 40% respectively.[195, 196, 197]

Ukhyia is one of the eight *upazilas* of Cox's Bazar district[198] and is regarded as one of the poorest in the district.[199] Administratively, Ukhyia was formed as a police station in 1926 and later declared an *upazila* in 1983.[200] The *upazila* is located between 21°08′ N and 21°21′ N latitudes and in between 92°03′ E and 92°12′ E longitudes, covering an area of 261.8 km^2. It is divided into five unions that are further subdivided into 13 mauzas and 54 villages. Geographically, the *upazila* is bordered by the Bay of Bengal on the west, bounded by Ramu *upazila* in the north, Bandarban district in the east and Teknaf *upazila* in the south. Ukhyia *upazila* also shares an international boundary with Myanmar on its eastern side. Ukhyia comprises mostly highlands and is bordered by an elevated coastline. It receives the highest average annual rainfall of about 3,001–3,500 mm in the district. The *upazila* hosts tropical evergreen and semi-evergreen forests dominated by *Dipterocarpus sp.*[201, 202]

According to the Bangladesh Bureau of Statistics (BBS), in 2011 agriculture was the main economic activity of 55% of the population in the *upazila*.[203] Most of the population also derives its income from fishing-related activities and labour where 85% of households in the *upazila* derive their main income from labour.[204]

The office of refugee relief and repatriation, a government wing under Bangladesh's Ministry of Disaster Management, allocated 3,000 hectares of forestland in Ukhiya in 2011 to develop settlements for the Rohingya refugees fleeing Myanmar into Bangladesh.[205] Most of the refugees have been housed in shanties in Balukhali, Kutuplaong, Madhurchhara, Lambarshiar, and other camps in Ukhiya and Teknaf.[206] According to the United Nations High Commissioner for Refugees (UNHCR) the Kutuplaong camp is currently the world's largest refugee camp housing around 600,000 Rohingyas.[207]

An additional layer of vulnerability: Accommodating displaced Rohingya populations

The influx of Rohingyas since August 2017, has added to the vulnerability of Cox's Bazar District. An estimated 840,000 people[208] are currently residing in 34 camps designated by the Government of Bangladesh in Ukhyia and Teknaf *upazilas* of Cox's Bazar district. These two sub-districts were already vulnerable and poverty-ridden before the influx. In Ukhyia, the influx has further exacerbated the problems of food insecurity, unemployment and poverty.[209] Large-scale deforestation for material to build shelters for the refugees has caused environmental degradation and increased the risk of landslides and slope instability in the hilly areas of the *upazila*.[210, 211] Ukhyia is also prone to frequent occurrences of cyclones, further increasing the vulnerability of the existing and newly-arrived population to monsoon rains, flooding, landslides and disasters.[212]

Surrounding Ukhyia is an ecologically critical area called the Teknaf Peninsula.[213] The peninsula has a collection of diverse ecosystems: mixed evergreen hill-forests, networks of forest-fed hill streams, a tidal river and the Bay of Bengal.[214] It represents a transitional zone for the fauna of the Indo-Himalayan and Indo-Malayan ecological sub-regions. Unfortunately, the very same peninsula is a disturbed one, experiencing degradation due to anthropogenic pressures compounded with climate-induced stressors.

Originating from the Ukhiya hill-forests in this peninsula, the Madhur *Chhara* stream flows through forests, cropland, settlements, growth centres and finally merges with the Naf River on the southeastern part of the county bordering Myanmar. The Madhur *Chhara* watershed is an important source of ecosystem services that provides freshwater and supports livelihoods (fishing, farming and extraction of forest products, such as wood fuel, wild food, grasses, woods and bamboo) of local communities, especially the poor. The central portion of the *Chhara* passes through 11 refugee camps, including Kutupalong refugee camp.

The Kutupalong and Nayapara refugee camps are the two major government-run camps in Cox's Bazar. The Bangladesh government, international organisations, donors and NGOs have been working to tackle the Rohingya crisis, with a major focus on responding to the humanitarian aspects while paying relatively less attention to ecosystem protection, restoration and governance-related barriers and challenges.

Encroachment and conversion of streams all along the Madhur *Chhara* are increasing water scarcity and leading to the loss of common pool resources. Upstream forest clearing and unplanned hill slope cultivation has led to a reduction in the soil's water retention capacity. This has resulted in soil erosion, sedimentation, increased monsoon water flows and thereby flooding, stream bank erosion, landslides, sand carpeting of crop land and loss of livelihoods. Downstream, the area falls within the tidal zone and is affected by tidal flooding and salinity intrusion due to changes in the land cover and an increase in the share of aquaculture-dominated land use.

Within the refugee camps, the *Chhara* is extremely polluted, impacted by a high solid waste load, segmentation, and encroachment and land use change along streams. The construction of refugee camps has led to hills being cut and levelled, thereby changing the landscape, the filling of streams by earth, and closure and stream diversion. All of these impacts have affected the natural water dynamics of the area.

Moreover, the majority of the social infrastructure (schools, markets, mosques, madrasas, community places, etc.) in the area is built on the network of streams. This has further degraded the morphological features of stream networks, including natural vegetation patterns (natural blue-green networks), which has ultimately impacted the streams due to flow obstruction. Rohingya refugees, in a bid to become self-sufficient, practice vegetable farming on stream beds, which exacerbates sedimentation and flow obstruction. Additionally, vegetation from surrounding hills and forests has been removed to source building materials for shelters and firewood fuel.[215]

Adding to an already burdened area are the adverse effects of global climate change and extreme events. These are manifested as frequent cyclonic events, prolonged droughts, high temperatures, erratic rains, intense heavy rain-based flooding, water scarcity, erosion, landslides, loss of crops and livelihood assets. The original host communities living upstream and downstream of the Kutupalong refugee camp, particularly the poorer sections, are the worst affected by these hazards.[216]

Restoring Kutupalong Mega Camp (KMC) through NbS

While the local inhabitants living in Ukhiya are the most at risk to the hazards listed above, the Rohingya refugees are also increasingly vulnerable, especially given their living conditions. In response, the Centre for Natural Resource Studies (CNRS) and the UN Refugee Centre (UNHCR) jointly conducted a rapid assessment and developed a set of NbS intervention packages aimed at restoring the Madhur *Chhara* watershed, moderating the adverse effects of climate change and supporting improved protection of refugees living in the catchment of Madhur *Chhara*.

> **Although challenging, NbS provide tangible and no-regret benefits for nature and society even in humanitarian contexts, and hence environmental restoration and humanitarian responses should go hand in hand.**
>
> – Dr. M. Mokhlesur Rahman, Executive Director, Centre for Natural Resource Studies

Although a refugee protection-focused UN agency, the UNHCR in 2019 undertook a pioneering role in restoring the natural environment from a humanitarian perspective in the government-run Kutupalong Mega Camp in Ukhiya. As a pilot, the project activities were limited within the Madhur *Chhara* basin – one of the major hill streams (*chhara*) that cut across 11 refugee camps. The Madhur *Chhara* is considered to be the "natural lifeline in Ukhiya", and the project focussed on how this was gradually affected by the large-scale settlement of refugees in the Kutupalong area after August 2017.

CNRS, as the implementing partner of UNHCR, developed a detailed technical plan, adopting NbS approaches to restore the degraded riparian ecosystems. The project aims to build wider social-ecological resilience by creating an environment that will enable strengthened refugee protection.

The CNRS designed and implemented several environmental restoration activities within the watershed of Kalam *Chhara*, which is one of two major tributaries of Madhur *Chhara*. These interventions include stream restoration, riparian afforestation/reforestation, wastewater treatment, water reservoirs, conservation agriculture, silt trap piloting, stream bank protection, construction of walkways and environmental awareness. Since these environmental restoration activities are being implemented within and adjacent to refugee camps, the assumption is that the effects of these activities have positive contributions to refugees living in camps.

The overall outcomes envisaged by the intervention were building water security, food security, livelihoods, and regional biodiversity of the areas (not only for the camps but also for the host community areas). The NbS approach was designed to develop the socio-ecological resilience of the Madhur *Chhara* watershed with support from environmental specialists and hydrologists. The restoration targeted to meet local challenges within the SDG framework through equal prioritisation of ecosystem preservation and human well-being.

NbS interventions that were mainly piloted in the Kalam *Chhara* basin since January 2019 include:

- Rehabilitating degraded *Chhara* reaches (deepening and widening);
- Arresting soil erosion through green cover development;

- Creating water reservoirs including facilitating ground water recharge;
- Piloting bio-mechanical (green infrastructure) wastewater treatment plants,
- Re-greening stream banks using riparian and block plantation with Vetiver/grass hedging using local species;
- Demonstrating and sensitising communities about solid waste management;
- Demonstrating conservation agriculture practices in stream basins; and
- Engaging communities and local stakeholders in management of the stream, both within and outside the camps.

How the initiative was implemented

Through a field assessment and participatory problem appraisal both the host communities and refugees prioritised loss of forest cover, scarcity of dry season water and water pollution to be urgently addressed. Considering the time and budgetary limitations, the main focus was on implementing environmental restoration interventions within the Kalam *Chhara* basin, located within Camp 4 and Camp 4 extension along the north-western edge of KMC. The NbS intervention packages focused on four interrelated areas: (i) water security/stream restoration, (ii) water pollution management, (iii) stream-bank stabilisation, and (iv) planting/regreening denuded camp areas. Regular awareness events targeting refugees and host communities were also conducted.

Water security/stream restoration included stream deepening and widening to increase water flow and the creation of water reservoirs to store water year-round for social and ecological purposes. A silt trap was established in the camp 4 extension to trap sand and silt in situ within a specific part of the stream channel, providing for periodic extractions of sand/silt for productive purposes, such as land filling and construction material.

Constructed wetlands © CNRS

Water pollution management activities focused on three approaches: (i) piloting bacteria-based wastewater treatment, (ii) constructed wetland-based wastewater treatment, and (iii) plant-based wastewater cleaning. With the technical assistance of the Environmental Science Department of the University of Chittagong, a bacteria-based wastewater treatment plant was piloted in Camp 1 East and found to remove pollutants effectively from Lambasia Chhara. The clear water that resulted was used by farmers for producing crops, adjacent to the plant. Though the treated water is not

drinkable, it can be used for other household and commercial purposes. The system has potential for upscaling and replication in other areas within camps having similar problems. Two constructed wetland systems were also piloted in Kalam *Chhara* in 2019. Another approach piloted was planting Kolaboti (*Canna* sp.) along the beds of small streams carrying wastewater so that the plants can directly absorb pollutants/organic nutrients from wastewater.

A green approach to **stream-bank stabilisation** was adopted for bank protection/stabilisation by maintaining adequate slope terracing, compacting, planting Vetivers (*Chrysopogon zizanioides*) and various other local grasses such as bhadails (*Cyperus rotundus*), and broom grass (*Thysanolaena latifolia*) on banks and slopes, supported by bamboo poles. These activities have been carried out at selected erosion-prone points in the streams. Additionally, 500 bamboo seedlings were planted along the stream to reduce soil erosion and create habitats for targeted wildlife species.

Development of water reservoirs © CNRS

Floating Vetivers © CNRS

Planting-related actions included green bank protection with Vetiver hedging to protect the stream and arrest soil erosion; riparian mixed species planting to green the basin and protect it from soil erosion; planting for camp greening and a cooling effect; and street planting for greening.

A plant nursery and a Vetiver nursery were established in the camp to ensure supply of quality planting materials. A total of 21,000 tree seedlings were produced from the nursery in 2019 and 288,000 Vetiver saplings were raised and planted in 2020. Over the last two years, a total of 144,000 tree seedlings were planted by CNRS on 57.2 hectares of denuded land within the camp. Palmyra palm (*Borassus flabellifer*) trees were planted within camp areas.

Planting native species © CNRS

Impacts

The NbS interventions piloted within KMC have demonstrated positive socio-ecological outcomes. Within the area there has been increased water and food security, reduced risks from disasters, re-colonisation of wildlife, fisheries, pollinators, and butterflies in restored riparian sites where mixed species forest is growing close to water sources (streams or reservoirs). Interim results, experience and community narratives suggest that riparian ecosystem-restoration activities have started providing ecosystem services, such as provisioning (food, water), regulating (micro-climate regulation, carbon sink, disaster risk reduction), cultural (aesthetics) and supporting services (wildlife habitat, pollination).

The World Food Programme (WFP) commissioned an independent assessment of the initiative in 2020, which revealed that 80–90% of the planted trees had survived within the Camp, which also looks greener compared to 2018. The survey results indicated that the NbS approach works well in rejuvenating degraded ecosystems, recolonising species and improving local ecosystem services.

Stream restoration, including bank protection, increased the water retention capacity of the river, thereby reducing erosion and damage from flooding, as well as increasing the availability of surface water for a longer period in streams than before. Water reservoirs created within camps now store rainwater year-round and ensure water security for refugees to meet their various needs such as bathing, washing and cleaning. These reservoirs also provide water for wildlife, food production (via irrigation) and ground water recharge to maintain aquifer levels. Wastewater treatment facilities reduce the extent of water pollution and make the water usable for refugees and host communities for various purposes. Higher numbers of people (mostly Rohingya) were observed to engage in fishing in Kalam *Chhara* and Madhur *Chhara* waters almost year-round, which peaked in monsoon months in 2020 compared to 2019. This indicates that greater water availability is helping diverse fish species to colonise stream habitats.

Biodiversity monitoring reports documented the re-colonising of wildlife in the stream basin restored sites. A large difference in the presence of wildlife was observed between two sites within the Kutupalong Mega Camp. Kalam *Chhara*, a site where ecosystem restoration was done, recorded a total of 76 faunal species in October 2020, compared to a total of 34 species at other camps where no ecosystem restoration had taken place. Moreover, the highest numbers of reptilian species (15) and second highest numbers of amphibian (10) and mammalian species (six) were recorded in the Kalam *Chhara* restoration site, while only four species of reptiles, three amphibians and three mammals were observed in other monitoring sites within camps. This accounts for a 123% increase in wildlife in the project restoration site in Kalam *Chhara*.

CNRS is continuing to monitor the functions and long-term results of the restoration. Proposals have been submitted to replicate the approach in other locations within camps and adjoining areas suffering from similar environmental damage. UNHCR is interested in expanding the restoration activities within degraded camp areas in the coming years. A recent partnership between the Site Maintenance and Engineering Project (SMEP), the engineering unit (formed by WFP-UNHCR-International Organisation for Migration [IOM]) at Cox's Bazar, and CNRS has been formed to integrate NbS in engineering schemes. This is an indication of the adoption of NbS in wider refugee-impacted landscapes in the district.

TABLE 10: Riparian ecosystem restoration and social-ecological and refugee protection outcomes

NbS ACTIONS	WATER SECURITY (STREAM/ RESERVOIR RESTORATION)	WASTEWATER TREATMENT	BANK PROTECTION AND GREENING	PLANTING/ FOREST RESTORATION
Outputs of actions	Water availability	Cleaner water	Green and stable stream bank	Green cover in denuded land
Biodiversity outcomes	Fisheries and aquatic diversity; agricultural diversity	Fish and aquatic biodiversity	Herb and shrub diversity	Floral and faunal diversity
Food and livelihood security outcomes	Food security, nutrition and dietary diversity	Fish and nutrition, better health	Conservation agriculture, soil protection	Plant-based and diverse food systems, additional sources of livelihood
Climate change (adaptation and mitigation) and DRR-related outcomes	Micro-climate regulation, carbon sink, reduced flooding and landslides, reduced drought effects, crop diversity/ farming systems	Reduced water-borne diseases, stream bottom ecology, reduced degradation	House and soil protection, land fertility, stream productivity, water availability	Micro-climate regulation, carbon sink, reduced drought effects, fewer flooding events
Aesthetics, beauty of nature and mental peac-related outcomes	Water reservoirs, increased water flows in streams, fishing opportunities	Cleaner water – free from bad odour and mosquito problems	Green bank, walkways, fruits, vegetables, trees	Green landscapes, wildlife, low dust, clean air, shelter from the sun

NbS ACTIONS	WATER SECURITY (STREAM/ RESERVOIR RESTORATION)	WASTEWATER TREATMENT	BANK PROTECTION AND GREENING	PLANTING/ FOREST RESTORATION
Refugee protection outcomes	• Refugees feel safer and are better protected than before • Better ambient air quality, improved micro-climate within camp areas • Improved livelihood through additional sources and reduced disaster risk • Greater water security and dietary diversity			

TABLE 11: Outputs generated under the project

BRIEF DESCRIPTION OF THE OUTPUT	SITE/ LOCATION	PERFORMANCE	TARGET ACHIEVED (AS OF 30TH DECEMBER, 2020)
The interventions focus on sustainable management of natural resources through the adoption of NbS (restoration, protection of streams, restoration of vegetative coverage) and pro-environmental behavioural change of refugees and host communities in the proposed camps and adjacent areas.	Camp 1W, 2W, 3, 4, 4 Ext, 5, 6, 7, 8W, 8E	# of Persons of Concern (PoC) receiving environmental education	2,000
		# of education/training sessions conducted	50
		# of re-excavation activities performed	4
		# of areas (acre) being piloted with Alternate Drying and Wetting (AWD) with 30% water savings	2
		# of area (hectare) covered by riparian planting	12
		# of water reservoirs established	4
		# of saplings planted	12,500
		# saplings planted and protected by households	70,000
		# of households growing vegetables on shed cooling structure	931

Enabling factors

The context of the intervention remains unique, being the largest refugee camp settled almost overnight in a vast forest area.

A skilled and experienced team with adequate knowledge on ecological restoration, ecosystem and watershed management was absolutely imperative to accomplish the proposed scheme work in the Madhur *Chhara* basin. This team was supported by renowned hydrologists and specialist consultants from both private agencies and line departments of the Government of Bangladesh line departments.

The solutions were generated through substantial knowledge exploration, which included a rigorous study of various secondary information, consultation with experts and the community at large, transect walks in the entire Madhur *Chhara* basin, mapping of different geographic aspects, and further investigation of methods and approaches to design suitable interventions. Approaches were designed around locally-available resources, including equipment for re-excavation of canals, seeds/seedlings which were further developed in the nursery, construction materials like bamboo,

sand, cement, etc. To ensure the durability of the interventions, engineering knowledge from different disciplines, including civil and environmental engineering, was also applied.

Funds made available from international donors UNHCR, formed the crux for carrying out the initiatives and planning appropriate activities.

The interventions were designed considering the natural and artificial physical landscape and the available natural resources in the area.

Regular consultations with the relevant government departments, including the Forest Department, Department of Environment and Universities, ensured interventions were aligned with existing policies, rules and regulations. Furthermore, only activities approved by the relevant camp authorities and the Office of the Refugee Relief and Repatriation Commissioner (ORRRC) were implemented. An energy and environment technical working group coordinated activities and knowledge sharing across the camps.

INITIATIVE: IMPROVING DEGRADED RIVERINE AREAS IN ROHINGYA CAMPS OF UKHIYA, COX'S BAZAR	
Knowledge factors	• External experts in hydrology and engineering, specialist consultants from private agencies and government departments supported the development of integrated solutions for the Madhur *Chhara* watershed. • The team from CNRS is experienced in ecological restoration, ecosystem and natural resource management, which made them well-equipped to design and implement relevant NbS.
Technical factors	• External consultants from different engineering disciplines provided technical inputs. • Locally-available technologies were implemented, including those for canal re-excavation and seedling inputs.
Institutional factors	• Consultations conducted with government departments and alignment with priorities of camp authorities and RRRC. • The energy and environment technical working group offered platforms for learning and knowledge dissemination.
Economic factors	• UNHCR funds primarily, financed the NbS implemented.
Social factors	• Consultation with the refugee community enabled participatory problem solving and the local tailoring of solutions. • Environmental education and awareness sessions were conducted with refugees.

Replication

In order to carry out the restoration of riverine areas in the refugee camps of Ukhiya, the following resources proved critical:

Finance/assets: Given the context within which this type of intervention was implemented, funds are extremely important. Presently, there exist a large number of funding and relief agencies working towards different goals to ensure quality of life for Rohingya refugees. Dovetailing related schemes through partnerships and a common platform will yield more meaningful results.

Staff/capacity: Resources were mostly driven to meet the basic needs of the people living in the camps, although environmental degradation remained a concern. In this context, the interventions

required engaging a number of people investing their effort in building community consensus, creating space for implementation, diversifying the benefits and maintaining the confidence of respective authorities.

Time for planning and implementation: Designing interventions took time as a rigorous process was followed, starting with efforts to improve understanding of the context in terms of demography, topography, socio-cultural, economic and other features. Analysing this information, aligning with local needs and then implementing solutions in a participatory way, while still allowing space for flexibility to accommodate changes, required endurance and dedication.

Stakeholder engagement: The consistent engagement of all relevant stakeholders was required, including local communities, relevant government departments, camp authorities, thematic experts, academics and professionals.

Costs and funding

The total cost incurred from 2019–2021 for the implemented NbS interventions was US$ 441,396.

Key contacts	
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Improving degraded riverine areas in Rohingya Camps of Ukhiya, Cox's Bazar

Building disaster resilience in Rohingya refugee camps through Nature-based Solutions.

SDGs: **Aichi Targets:**

NbS approach: Ecosystem protection

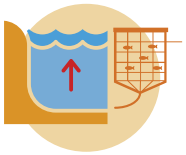
Local government	Ukhiya Upazila
Country and state	Bangladesh, Chittagong
Population	27,317 (2011)
Total area	18.32 km² (2020)
Main geography type	Coastal & Highland

Context

840,000 displaced Rohingya population in **34 camps**

Upstream

- Forest clearing and unplanned hill slope cultivation
- Reduction in the water retention capacity
- Stream bank erosion and landslides



Downstream

- Tidal flooding and salinity intrusion due to changes in the land cover
- Increase in the share of aquaculture-dominated land use

Impacts

Socio-environmental benefits

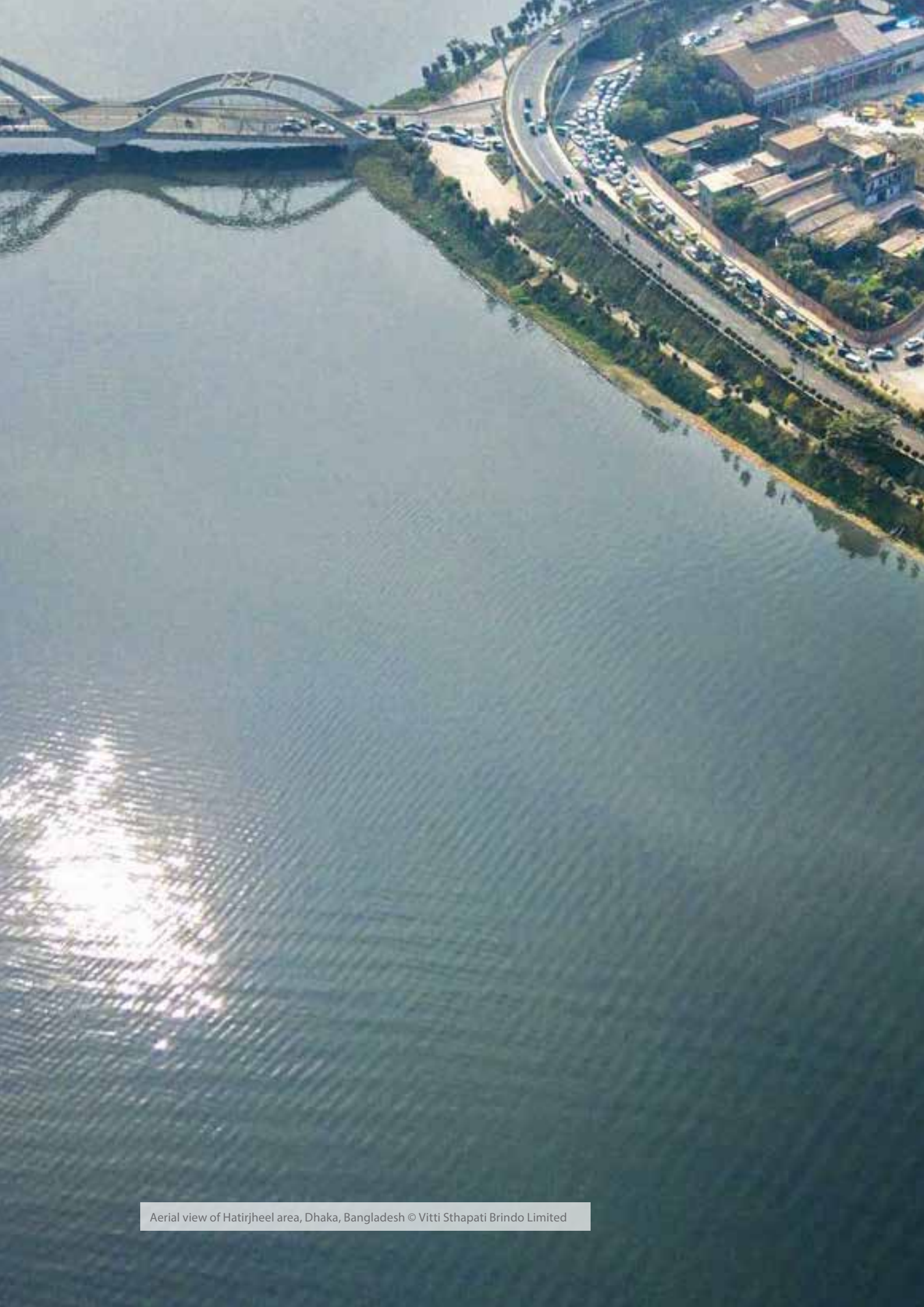
Green cover in denuded lands, plant-based food diverse systems, livelihood enhancement, reduced extreme events like floods and droughts, conservation of agriculture practices and **123% increase** in wildlife.

Waste water treatment

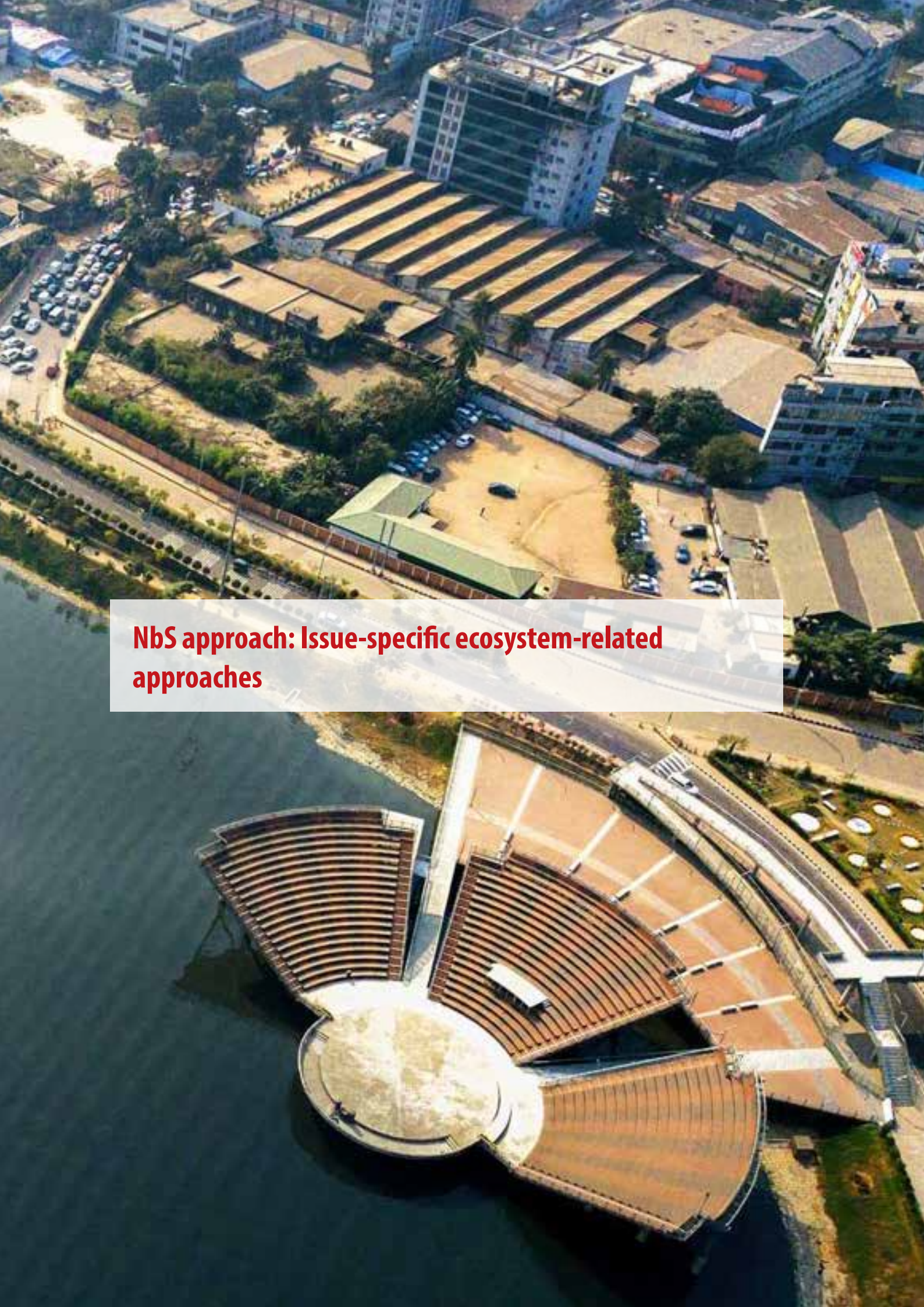
Increase in the availability of cleaner water, increase in fish and other aquatic diversity, and reduction of water-borne diseases.

River bank restoration

Stabilised river banks, prevention of soil erosion, improvement in soil fertility, improvement in water availability and reduction in landslides.



Aerial view of Hatirjheel area, Dhaka, Bangladesh © Vitti Sthapati Brindo Limited



NbS approach: Issue-specific ecosystem-related approaches

Stakeholder consultation during project implementation © GEAG

GORAKHPUR, INDIA: A city trying to keep its head above water

NbS approach: Issue-specific ecosystem-related approaches	
FACTS AND FIGURES	
Local government	Nagar Nigam Gorakhpur
Country and state	India, Uttar Pradesh
Population	692,519 (2011)
Total area	147 km^2
Main geography type	Lowland
GDP	US$ 1.67 billion (Gorakhpur district, 2012)[217]

Gorakhpur, a tier II city, located at the union of the Rapti and Rohin rivers in eastern Uttar Pradesh in India, is a rapidly-expanding city in the great plains. It is in close proximity to the Himalayas and lies in the Terai region. Gorakhpur city is unique in that it has a large number of water bodies within its boundaries, the biggest of which is Ramgarh Tal in the south-eastern part of the city. The city is divided into 70 wards, administered by Nagar Nigam Gorakhpur. The old wards of the city have a very high population density and the slum population constitutes roughly 33% of total population of city.

Being in close proximity to the Himalayas, Gorakhpur is vulnerable to floods. As a result, the livelihoods of vulnerable sections of the city such as poor and marginalised communities, are often affected. In the last 20–30 years, negligence of drainage infrastructure led to water-logging conditions in the city, causing property damage and livelihood loss. This problem was bigger than the floods. Most of the areas in the city are low-lying, present along a very low slope gradient. Health issues have been increasing exponentially with a large number of deaths reported every year due to water and vector-borne diseases. There is rapid depletion of open areas in the city due to largescale unplanned construction. Public infrastructure and basic services are also insufficient to make any significant contribution to the city's resilience.[218]

Peri-urban Gorakhpur is agricultural in character. This part of the city is commonly affected by recurring floods and water-logging for at least two to three months every year. This leads to losses in the agricultural sector. The floods have the greatest impact on small and marginal farmers. With climate projections indicating that the intensity of similar rainfall events will increase by 10–20% in the future, Gorakhpur will likely experience more flooding events.[219]

Peri-urban agricultural lands are a source of ecosystem services and can support urban settlements by contributing to the area's food security. Unfortunately, unplanned urbanisation has resulted in large-scale conversions of these agricultural lands to non-agricultural uses, affecting natural drainage and lowering climate resilience of an area. It is of great significance therefore, to conserve peri-urban agricultural land areas as they serve to climate-proof cities and build resilience.

Peri-urban areas: A flood buffer and source of food security

Gorakhpur's peri-urban area is at risk of being swallowed up by the rapid urbanisation taking place. The Gorakhpur Development Authority (GDA) has classified the 7,000 hectares occupied by Gorakhpur's peri urban area, as green and open areas. Of this area, 54% is under agricultural use[220] and is occupied by

> **The concept of urban climate change resilience is incomplete without the consideration of peri-urban spaces and its ecosystems.**
>
> – Dr. Shiraz Wajih
> President
> Gorakhpur Environmental Action Group

100,000 inhabitants, most of whom are small and marginal farmers. These farmers are socially and economically vulnerable, primarily because they are affected by floods and water-logging, sewage dumping, increasing cost of agricultural inputs, inaccessibility to agricultural services and changing land-use patterns, among others.

Ironically, peri-urban agriculture offers a solution to flooding. If kept free from construction, the area will maintain its natural function by acting like a flood water receptacle and allowing for water storage and infiltration. This also has flow-on effects on vulnerable populations as their vulnerability will decrease and their adaptive capacity will increase. Protecting peri urban areas also helps to improve food sources, food access and income available for peri-urban agricultural communities.

The Gorakhpur Environmental Action Group (GEAG), a well-established local organisation, initiated work with the Nagar Nigam (an urban local body) and citizens to develop Gorakhpur's city resilience strategy. During this work, it was revealed that the wards on the fringes of the city were the most vulnerable and that to maintain the city's resilience, peri-urban ecosystems and associated livelihoods are critical. GEAG concluded that to reduce flood risk in Gorakhpur city, promoting the maintenance of open spaces in the form of peri-urban agriculture would be an ideal strategy. It presented a practical mechanism for diversifying urban livelihoods and ensuring availability of local food supplies, while maintaining open areas that can serve as flood buffers. This would help to maintain the land-use pattern and ecosystem services in these areas, promoting climate-resilient peri-urban agriculture that uses innovative methods.

The 'Enhancing climate resilience of Gorakhpur by buffering floods through climate-resilient peri-urban agriculture' project was part of the Asian Cities Climate Change Resilience Network (ACCCRN), financed by the Rockefeller Foundation. It was initiated in December 2012 and completed in June 2016. The project was implemented in eight villages, developed outreach plans for over 50 surrounding villages located in the Gorakhpur Development Area, and targeted 30 'model' farmers, who were the direct beneficiaries.

This project was designed to demonstrate how ecosystem services generated by peri-urban agriculture can positively address the impacts of climate change in Gorakhpur. Specifically, it set out to "demonstrate flood risk mitigation through the preservation and improved management of open spaces by strengthening agriculture-based livelihoods in peri-urban areas". The project had the following set of interlinked objectives:

- Develop models of climate-resilient integrated agriculture-horticulture-aquaculture-livestock systems in small, marginal landholdings in the peri-urban context, employing a diversity of water systems;
- Enhance the income and food security of the poor and vulnerable population;
- Ensure the sustainability of peri-urban agricultural lands through different regulatory and incentive mechanisms; and
- Enhance the flood-buffering capacity of the city as it expands, through institutionalising and replicating the sustainable management of agricultural ecosystems.

Reduced input costs, crop diversification, crop intensification, expansion of land under cultivation, and reduced crop loss from natural hazards led to the doubling of the average agricultural income of model farmers within the project implementation area. However, given the limited size of the study, additional research is required that will document the full extent of the impacts that such practices could have on overall flood mitigation in Gorakhpur. The pilot suggests some tangible ways in which actions that protect ecosystems can have positive impacts for agriculturalists and the communities they support, through coordination and information sharing between stakeholders.

In the absence of the initiative, at the local level, farmers of the eight project villages may have sold their agricultural land in a distress sale to real estate investors, leading to more unsustainable development, the discourse around peri-urban areas may not have taken place and knowledge dissemination may not have existed in the way that it does now.

Building climate resilience through peri-urban agri-interventions

The peri-urban interventions carried out with farmers had four major components:

i) Farm models with low external input and sustainable agriculture (LEISA) and climate-resilient practices;

ii) The formation of local institutions such as farmer clubs, farmer field schools, and *laghu seemant krishak morcha* (LSKMs) or farmer unions;[221]

iii) Weather and agro-services provided by SMS and notice boards; and

iv) Established linkages with government line departments and GEAG.

Fieldwork focused on eight villages located in two clusters of two river catchments, one in the north and one in the south of Gorakhpur, covering an area of approximately 450 hectares (see Figure 4).

The project introduced several LEISA and climate-resilient practices, including the use of composting, *Trichoderma viride* (a fungus), bio-pesticides, oil cake, tree planting, mixed farming, seed production, Integrated Pest Management (IPM), kitchen gardening, loft farming, bag or thermocol farming, a low tunnel polyhouse, permanent raised beds and relay cropping. These practices were introduced to increase farmer income.

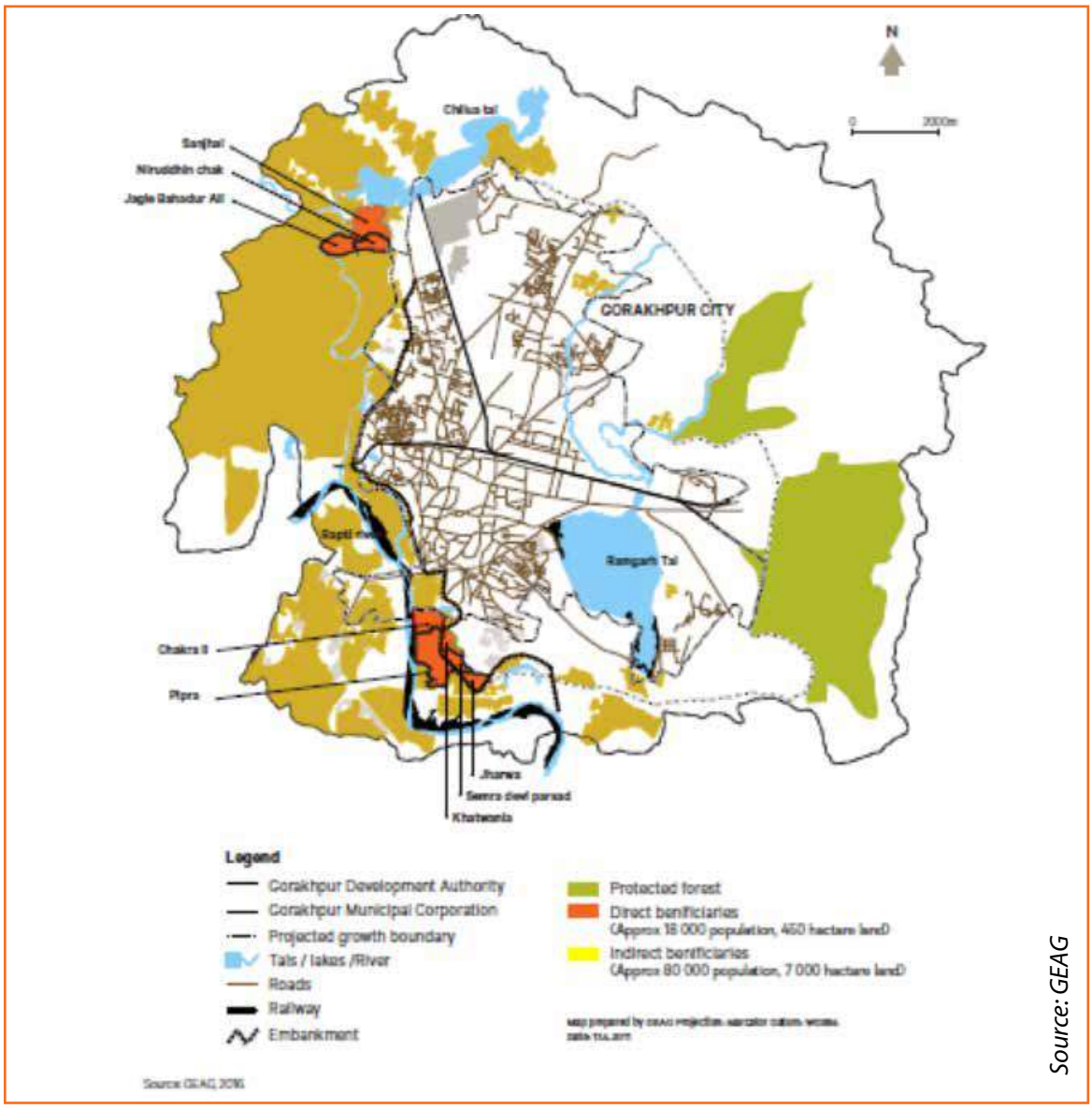
According to the project report, the following practices proved very successful: composting, with or without adding *Trichoderma viride* to improve the soil fertility, followed by mixed or relay farming using several types of vegetables and fruits, and the application of bio-pesticides in case of diseases and pests. This allowed farmers to harvest three crops a year instead of one or two. Adopting thermocol farming and loft farming allowed for growing of seedlings during the flood season, which were later transplanted in the fields when the water receded. In addition, marginal farmers through the project were able to rent equipment that they required from the agro-service centres to irrigate their fields during water shortages.

TABLE 12: LEISA practices introduced by the project

Composting	Several different composting types and technologies
Trichoderma viride	Introducing this fungi strain which enhances plant and root growth
Bio-pesticides	Mostly made from locally-available resources to deter pests
Oil cakes	Mostly using locally-available mustard oil and neem as additional fertilisers
Tree planting	Establishing tree plantations of teak, but also other species such as guava
Mixed farming	Growing more crops (mostly a variety of vegetables) on the same piece of land during a single growing season
Seed production	Producing seeds on farm or buying them. Climate-resilient varieties were also supported
Integrated Pest Management	Promoting the lowest possible use of pesticides and only using chemical pesticides if bio-pesticides did not have sufficient effects
Kitchen gardening	Gardening for home consumption
Loft farming	Farming on a loft or roof

Composting	Several different composting types and technologies
Bag or thermocol farming	Planting seeds in thermocol or jute bags and hanging them on poles above waterlogged or inundated land
Low tunnel polyhouse	Raising early nurseries and vegetables in tunnel greenhouses
Permanent raised beds	Raising beds, so that they remain above waterlogged soil during the monsoon season
Relay cropping	Starting a second crop along with the first crop before it has been harvested

The major advantage of the system introduced by the project was that it saved time, ensured that all of the available space (especially vertical space) was used optimally during floods, and farmers had the opportunity to grow three crops a year instead of only one or two. Opening up access to agricultural equipment from agro-service centres at subsidised rates supported irrigation of fields throughout the year. Crop diversification and the removal of constraints to grow crops irrespective of the season contributed to increased income, and food and nutrition security among the participating farmers.



Source: GEAG

FIGURE 4: Project Location

Climate-resilient farming – eggplant cultivation © GEAG

Impacts

The LEISA and climate-resilient practices that were introduced under the project were taken-up and overwhelmingly supported by the farmer clubs, farmer field schools, agro-service centres, and Laghu Seemant Krishak Morchas (LSKMs). The LSKMs also provided support to farmers by lobbying with them for their basic rights and entitlements. Through farmer clubs and farmer field schools, local farmers were capacitated through a simple exchange of knowledge and information. This, in turn, increased their confidence in implementing the newly-learned practices. The agro-service centres provided agricultural equipment on a rental basis, such as diesel-powered water pumps, irrigation pipes, and materials for preparing nurseries and constructing polyhouses.

The project provided weekly weather and agro-services via Short Message System (SMS), on notice boards for those without mobile phones and was communicated during farmer field school meetings. Providing information in this way helped in making informed decisions about which agricultural practice to employ during those time periods.

Finally, establishing linkages to line departments and GEAG, improved access to expert knowledge, services and government subsidy schemes. For e.g., linkages were established with the National Bank for Agriculture and Rural Development (NABARD), whose programme supports farmer clubs financially for a period of three years. The project also involved local citizens (including influential people) and the local media through a citizen platform called 'Mahanagar Paryavaran Manch' for urban resilience activities.

Peri-urban agriculture, adopted as a strategy to build climate resilience in the flood-prone areas of Gorakhpur, is serving as a means to keep the areas vulnerable to flooding free from construction. With no barriers to the delivery of peri-urban ecosystem services, the city is experiencing fewer floods and reduced impacts from high-intensity, short-duration rainfall. During the project, none of the farmland targeted by intervention was sold, indicating that the farmers were benefitting from the intervention.

Collective marketing of vegetables by peri-urban farmers © GEAG

Small and marginal farmers of the area were able to enhance their capacity to deal with the impacts of floods. The project also reported that the average agricultural income of the model farmers more than doubled due to reduced input costs, crop diversification, crop intensification, expansion of agricultural land under cultivation, and reduced crop loss from natural hazards such as floods. Better market linkages and prices for products also contributed to improved income.

Two female small-holder farmers who received training on LEISA practices from GEAG from the villages of Semra Devi Prasad and Sanjhayi received the 'Rani Laxmi Bai Veerta Puruskar' award from the Chief Minister of Uttar Pradesh in March 2018. These women in turn, have trained numerous other farmers in their villages.

The project has enhanced the resilience of both the farmers directly involved in the project who were based in the villages targeted by the project ('model' farmers), as well as farmers who were linked to the project through farmer's clubs and farmer field schools ('link' farmers). The initiative increased their resourcefulness, access to information and responsiveness, and benefitted over 1,377 households and 6,985 people. The project has also led to the conservation of common property resource areas, such as open land, water bodies, forests and pastures in the participating villages. This was done through the LSKMs formed under the project, allowing farmers to bring up their concerns about encroachment on these common areas to the attention of local decision-makers.

One success story has been the conservation of a 2227.8 m^2 water body and 2150.7 m^2 of community land. 3.5 acres of open land was also conserved through establishing a tree plantation and installing two decentralised wastewater treatment systems (DEWATS) in two project villages, which give farmers access to clean irrigation water.

At the local Government level in Gorakhpur, the impact has been less satisfactory with some line departments being unconvinced about the potential that maintaining peri-urban agricultural lands has with regard to buffering floods. Departments such as horticulture and agriculture traditionally focus more on rural areas and therefore, pay little attention to peri-urban farmers and agriculture areas. However, other public institutions understand the importance of conserving peri-urban water bodies to reduce flood risks, illustrated by the steps taken to conserve a water body in the Maheva area. The project was also able to bring about the recognition of peri-urban lands at higher public institutional levels, which has resulted in the inclusion of these areas in several policies and programmes.

While the project has indirectly demonstrated the impact that conservation of peri-urban agricultural lands has on building climate resilience of Gorakhpur, long-term monitoring is needed to quantify the flood-buffering benefits.

TABLE 13: Outcomes of the project at various levels (reproduced from Mani et al., 2014[222])

HOUSEHOLD AND FARM LEVEL	CITY LEVEL	ECOSYSTEM LEVEL
• Establishment of sustainable and climate-resilient models of agriculture in marginal land holdings in peri-urban areas • Increase in farm productivity • Increase in crop diversity • Reduction in chemical inputs and increased use of organic inputs • Reduced inputs and enhanced net gains for small-scale marginal farmers • Increase in inter-linkages amongst different farm subsystems • Improvement in soil quality • Enhanced livelihood security of vulnerable groups in peri-urban areas and food security of urban poor • Increase in annual income • Enhanced food security • Reduced dependence on markets for food	• Enhancement of the city's food security, as peri-urban agriculture is providing fresh vegetables, fruits, milk, meat, eggs, etc. • Peri-urban agriculture ensured conservation of open and green spaces and has thus enhanced the buffering capacity of the city against flooding and water-logging	• Conservation of agricultural land in peri-urban areas has enhanced the flood buffering capacity of the city as a whole • Conservation of water bodies has enhanced their water retention capacity • Soil conservation • Enhanced food security of the urban population (of both the city and peri-urban areas) • Reduced energy footprint as food is produced close to consumers

Solid waste management to generate compost © GEAG

Enabling factors

Most of the technical knowledge inputs came from GEAG staff who are well-qualified and have relevant experience. It was their background in sustainable farming and environmental science that guided the development of the initiative. Their collective technical capacity helped guide citizens and the farmers with presenting their issues in a way that is understood by the local *Lekhpal* (authorities) and representatives of the people (politicians). A strong understanding of participatory processes is essential to involve communities in participatory decision-making and enables good buy-in.

There were numerous technology elements that enabled the initiative, such as the LEISA techniques detailed above, DEWATS (Decentralized Sewage Water Treatment Systems), resilient seed inputs, plantation inputs, weather advisory and associated cropping techniques and various solid waste management techniques to generate compost. The knowledge for these came from the Horticulture Department, Agriculture and Livestock Department, Acharya Narendra Deva University of Agriculture and Technology (NDUAT), Kumarganj, Ayodhya, Uttar Pradesh, Forest Department, GEAG and the traditional knowledge of the farmers themselves.

A large number of the activities adopted as a part of peri-urban agriculture practices in Gorakhpur, were based on local soil conditions of water-logging. Although the initiative was not dependent on local environmental conditions, the strategies adopted were researched and implemented according to the local environmental situation.

While the project itself was funded by the Rockefeller Foundation, through the ACCCRN programme, during its entire implementation phase, no financial resources nor any technical inputs were provided to the farmers for free. Services were provided to the community as a whole and not on individual basis, for example tools and equipment such as a winnowing fan and hand-driven tractor were provided on a small-rental basis. The project did not provide resources as a charity but as a facilitating mechanism. This helped to ensure long-term community participation and ownership.

The project team also worked tirelessly to establish linkages between government line departments and farmers/farmer groups. They brought about awareness of various schemes and financial subsidies that the farmers could use. These included seed inputs from the National Food Security Mission (NFSM), improvement of drainage and sanitation through Panchayati Raj Institutions (PRI), skills and demonstration of techniques like mushroom production, and Vermi-composting, fast-growing species for tree planting, regular vaccination of livestock, agriculture equipment from the Uttar Pradesh agriculture department, loans for crops from Kisan Credit Card, and seed inputs for floriculture.

The citizen forum, *Mahanagar Paryavaran Manch*, proved to be a huge support to the project, supporting local farmers and calling for accountability within the government's various departments. The initiative was able to effectively bring together stakeholders from a variety of domains, such as the farmers and farmer fora set up under the project. The *Mahanagar Paryavaran Manch* comprised local citizens of Gorakhpur who were interested in sustainable development of the city, including hoteliers, environmentalists, media and journalists, and youth activists.

INITIATIVE: ENHANCING CLIMATE RESILIENCE OF GORAKHPUR CITY BY BUFFERING FLOODS THROUGH CLIMATE RESILIENT PERI-URBAN AGRICULTURE	
Knowledge factors	• Traditional knowledge and experience of farmers helped strengthen interventions implemented. • GEAG staff brought their knowledge and experience to co-evolve strategies with farmers.
Technical factors	• Seed inputs, species for plantation, solid waste management as well as technologies like DEWATS etc. • The knowledge for these were provided by government and other partner institutions. • Some of the knowledge regarding the various technologies employed through the project came through the project staff.
Economic factors	• The information on government subsidies and other financial schemes were made available to farmer groups. • Funding from the Rockefeller Foundation, through the ACCCRN platform, made the initiative possible. • Through the project, small and medium farmers became financially self-sufficient.
Institutional factors	• Linkage with several agricultural schemes such as NFSM, National Horticulture Mission, National Health Mission (for health camps and routine immunisation), Sustainable Agriculture Mission, NABARD for credit linkages.
Social factors	• Citizen involvement through the Mahanagar Paryavaran Manch; strong sense of community bonding and project ownership. • Awareness generated via the project on various knowledge, economic and technical factors resulted in successful strategies.

Replication

In order to carry out climate resilient peri-urban agriculture, the following resources are critical:

Finance/assets: While large budgets are not required, resources which support research are needed. Some of the technologies installed within the project, like DEWATS, were very expensive. These cost intensive interventions, however, do have local alternatives which may not be as effective, but have significantly lower costs.

Staff/capacity: Capacity of staff (technical capacity and approachability) is very important since their skills and knowledge facilitate interactions with the farmers to co-evolve mechanisms that will be successful locally. Willingness to adopt a participatory approach and in-depth technical knowledge are important qualities that staff should have in order to implement this type of an initiative.

Stakeholder engagement: Peri-urban areas are not a priority with regard to governance, although they may be recognised now at the national, state, and district levels. Therefore, for the replication of such initiative, stakeholder involvement is very important. The main activities which are needed include linking institutions with the government, disseminating information to the local communities and capacity-building processes. Community ownership engagement and support from the local citizen groups are critical for taking such an initiative forward.

Costs and funding

Total cost of the project was US$ 37,874,400.

Non-monetary gains were several in terms of people's capacities, built at several levels – community, city level and urban local body (ULB) level. The peri-urban agenda was much advocated for inclusion in policies and programmes. The recognition of peri-urban areas and the contribution of its ecosystems were highlighted in capacity building programmes, policies and programmes of National Institute of Disaster Management (NIDM). The peri-urban concerns were also recognised by the School of Planning and Architecture.

Links to SDGs, Aichi Targets and NBTs

SDGs	
Aichi Targets	
National Biodiversity Targets:	

Key contacts	
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Enhancing the climate resilience of Gorakhpur city

Peri-urban agricultural lands in Gorakhpur contribute to sustaining urban settlements by providing vital food and ecosystem services and building climate resilience.

NbS approach: Issue-specific ecosystem management

Local government	Nagar Nigam Gorakhpur
Country and state	India, Uttar Pradesh
Population	692,519 (2011)
Total area	147 km^2
Main geography type	Lowland

SDGs:

Aichi Targets:

Issues

- Rapid urbanisation and large-scale conversion of agricultural land for non-agricultural uses
- Proximity to the Himalayas makes the city vulnerable to floods, and climate change is increasing the risk of heavy rainfall in the area
- In the last 20–30 years, neglect of drainage infrastructure led to waterlogging conditions in the city

Initiated in December 2012

Completed in June 2016

Wards on the fringes were the most vulnerable and were therefore prioritised to improve the climate resilience of the city.

Promotion and maintenance of open spaces in the form of peri-urban agriculture was adopted as the ideal strategy in the project.

Impacts

- Conserved open lands, water bodies, peri-urban agriculture, forests and pastures
- Implemented farm models with low external input and sustainable agriculture and climate-resilient practices
- Formed local institutions, such as farmer clubs, farmer field schools and Laghu Seemant Krishak Morcha (farmers' unions), which are part of a national network
- Established linkages with government line departments
- Conducted expert consultations and training of farmers

Benefitted directly

1,337 Households

6,897 People

BOX 5: SHORT CASE STUDY ON ISSUE-SPECIFIC ECOSYSTEM-RELATED APPROACHES

BENGALURU, INDIA: Oota From Your Thota (food from your garden)

NbS approach: Issue-specific ecosystem-related approaches	
FACTS AND FIGURES	
Local government	Bruhat Bengaluru Mahanagara Palike (BBMP)/ Greater Bangalore Municipal Corporation
Country and state	India, Karnataka
Population	8,443,675 (2011)
Total area	741 km^2 (2021)
Main geography type	Lowland

The why

Over the decades, amidst the process of becoming the 'Silicon Valley of India',[223] the city of Bengaluru has witnessed a sea of changes in terms of population growth, infrastructure development and associated environmental impacts, such as water scarcity, and the use of pesticides and chemical fertilisers for growing crops. To popularise the idea of 'grow your own food' in homes and increase consumption of organic vegetables, Dr. B. N. Viswanath started a movement of promoting urban foodscapes in Bengaluru in 1995.

The what

Understanding the need to upscale the movement and encourage people to adopt urban gardening, Garden City Farmers, a not-for-profit organisation, was formed in 2011. Through its efforts, the members of the organisation conduct workshops and seminars to raise awareness and demonstrate the technique of growing vegetables in people's own homes. Other components of the workshops include sharing of knowledge regarding the use of containers for growing crops, composting of wet waste and the adoption of safe grey-water management practices.

The need to connect people to a proper system of supplies for the practice of urban gardening, led to the inception of Oota From Your Thota (OFYT), meaning 'food from your garden'. The concept of OFYT is 'grow what you eat and eat what you grow' and focusses on promoting urban foodscapes in the city.

The how

OFYT is an urban gardening event where people can attend workshops, get involved in discussions and purchase agricultural materials. The two-day quarterly event held in various venues around Bengaluru, provides a knowledge-sharing platform that can be accessed for free by all participants. Seed-sharing activities and a children's event named 'Chinnara Kaithota' is also organised on the OFYT premises.

The who

Garden City Farmers are the organisers of the movement and responsible for its success. Other stakeholders include local citizens, government agencies, horticulture and agriculture departments of universities, the Institution of Agricultural Technologists, the Vittal Mallya Scientific Research Foundation, the Agriculture Man Ecology Foundation, and the University of Agricultural Sciences Alumni Association.

‘Oota From Your Thota’: Promoting urban gardening

An urban gardening event that aims to popularise the idea of ‘grow your own food’ at home and increase the consumption of organic vegetables among urban dwellers.

SDGs: **Aichi Targets:**

NbS approach: Issue-specific ecosystem management

Local government	Bruhat Bengaluru Mahanagara Palike (BBMP)/ Greater Bangalore Municipal Corporation
Country and state	India, Karnataka
Population	8,443,675 (2011)
Total area	741 km^2 (2021)
Main geography type	Lowland

Issues

- Population growth
- Water scarcity
- Infrastructure development
- Chemical fertilisers

Sharing of seeds and knowledge

Two-day quarterly event to promote urban farming, and urban gardening workshops

Impacts

- Residents remained healthy and self-sufficient even in lockdown situations
- Promoted water conservation and reusing of organic waste
- Enhanced food security
- Contributed to circular economy through reuse and recycling
- Supported organic food production

Worked with local citizens, government agencies, horticulture and agriculture departments of universities, agricultural technologists and many more…

The where

The initiative takes place primarily in the city of Bengaluru. Training workshops have also been conducted throughout India in cities like Mumbai, Ahmedabad, Jaipur, Lucknow, Gorakhpur, Vishakhapatnam, Hyderabad, Chennai and Bhubaneswar.

Key contacts	
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DHAKA, BANGLADESH: Integrated development of the Hatirjheel Area, including the Begun Bari Canal

A megacity frequently inundated

NbS approach: Issue-specific ecosystem-related approaches	
FACTS AND FIGURES	
Local government	Dhaka North City Corporation
Country and state	Bangladesh, Dhaka
Population	2.5 million (2021) (DNCC area)
Total area	196.22 km^2
Main geography type	Mega delta
GDP	US$ 10 billion (2017)

Dhaka, the capital of Bangladesh, is an emerging megacity and one of the densest cities on earth. The city is situated at the very heart of Bangladesh, between 90°20′ E and 90°28′ E longitude and 23°44′ N and 23°54′N latitude.[224] Water defines the environment of Dhaka with the city located in the world's largest delta system at the confluence of four rivers: Buriganga, Turag, Balu and Tongi. These rivers flow to the south, north, east, and west sides of the city, respectively. Geographically, the city is on higher ground on the southern edge of an alluvial terrace in a low-lying region.

Dhaka is the economic, financial, cultural, and educational centre of the country and houses 44.5% of Bangladesh's urban population.[225, 226] It accounts for up to 35% of the country's economic activity, the major industries being the textile and garment industry, furniture, food and beverage, plastic products and leather.[227] In 1864, Dhaka was established as a municipality and, in 1978, it became a municipal corporation. In 2011, the corporation was divided into two: Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC).[228]

Overview of the Lake prior to the project © Vitti Sthapati Brindo Limited

Rampant solid waste dumping at the site © Vitti Sthapati Brindo Limited

More than 50% of Dhaka comprises of built-up area,[229] which has increased at the cost of lowlands and natural areas. In the 1950s, Dhaka contained as many as 60 canals and several wetlands that contributed to an effective drainage and hydrological system within the city.[230, 231] As the city expanded, unplanned urbanisation, encroachment and flouting of zonal regulations led to the disappearance of 33% of the city's canals and ponds, and 53% of its low-lying areas.[232] Several studies have indicated that the city's wetlands have decreased by 30% within a span of 50 years.[233, 234]

As a direct consequence, there have been problems of drainage and stagnation of rainwater, leading to flooding during the monsoon season. The city experienced destructive flooding events during the monsoons in 1987, 1988, 1998, 2004, 2020 and 2021, as a result of heavy downpours,[235, 236] which left several areas inundated. Outside of flooding, water-logging is a common occurrence that follows the annual monsoons due to inadequate and poorly maintained drainage systems, natural siltation, the absence of inlets and outlets, and the disposal of solid waste into the drains and drainage channels.[237] Water-logging affects the city's transportation, telecommunications, water supply and electricity systems.[238]

In 2009, WWF[239] declared that Dhaka was the megacity most vulnerable to climate change. The report stated, "This large, relatively poor city sits just meters above current sea levels, is regularly impacted by tropical cyclones and flooding, and has very limited adaptive capacity." As the frequency and severity of floods and storms are expected to increase as a result of climate change,[240] Dhaka must explore mechanisms and strategies that will strengthen its climate resilience and disaster risk reduction.

Hatirjheel wetland: A history of intentions

The name Hatirjheel has its roots in the historical use of the locality as an area where elephants were kept during British rule. During Bangladesh's colonial era, the Hatirjheel-Begunbari canal was part of the Nari River, flowing in an east-west direction and was a major waterway for goods and people.[241] The wetland was located in an overwhelmingly natural area connecting busy parts of

old and new Dhaka. Up until the 1960s, the Hatirjheel-Begunbari wetland was an important water channel in Dhaka. It had significance for the drainage of the area, in transportation and mobility, and in agriculture.

The Hatirjheel-Begunbari retention basin today is the largest natural water retention basin in Dhaka, draining a third of the city's catchment area. Hatirjheel is located at the centre of Dhaka between 23°44′ 58.47″ N and 90°23′ 48.35″ E. The Dhanmondi, Gulshan and Banani Lakes are hydrologically linked with this retention basin, and the combined outfall of the whole catchment area (about 30 km^2) is at Rampura where it meets Begunbari Canal and finally drains into the Balu River due to gravity.

As urbanisation accelerated in the 1960s, this lake, the canal and surrounding wetlands became a dumping ground for household and industrial waste. This resulted in large amounts of organic and chemical pollutants within the waterbody. In the 1990s it was transformed, encroached by approximately 1,200 illegal settlements, which included numerous slum dwellers, real estate companies and commercial establishments.[242] As a result, the retention capacity and function of the Hatirjheel basin has been reducing significantly in the past years.

Protection of Dhaka's marshlands and canals was recognised in 1959 in the first Master Plan of Dhaka city. Unfortunately, this was largely ignored and a substantial area of the marshlands and canals was filled. In the 1980s, box culverts were constructed unwisely through canals and waterways, causing encroachment of the valuable water bodies in the city. Railway lines were constructed through the Begunbari Canal, taking up a substantial area of the waterbody. The expansion of the Tejgaon Industrial Area resulted in significant encroachment of the Hatirjheel Lake, followed by Mohanagar Housing. Following the catastrophic floods in 1988, a sluice gate and pumping station were constructed on the Rampura Canal, causing immense damage to the Hatirjheel Lake and Begunbari Canal.

The Lake after restoration © Vitti Sthapati Brindo Limited

Demands for the restoration of the Hatirjheel basin commenced in 1995. In fact, within the Dhaka Metropolitan Development Plan (DMDP) 1995–2015, recommendations were made that the wetland be protected as a natural reservoir for drainage. However, the recommendations were not implemented in subsequent years.

The preliminary study conducted during 2004–2005 by Bureau of Research, Testing and Consultation, Bangladesh University of Engineering & Technology (BUET) assessed the restoration potential of the area. The feasibility study outlined retaining the low-lying areas, including the wetlands, for water retention and natural drainage. These recommendations led to the idea of an integrated project to develop the 302.87-acre area of Hatirjheel, including the Begun Bari Canal.

Since there was a need to acquire at least 235 acres of land, it took government and development agencies until 2007 to proceed further with the project. Although most of the land in the project was government-owned, a number of hurdles relating to the land acquisition were encountered, with up to 78 lawsuits, numerous writs and contempt cases against Rajdhani Unnayan Kartripakkha (RAJUK), the Capital Development Authority of the Government of Bangladesh. As a consequence, the cost of the project went up and the project framework had to be amended a number of times.

In 2007, it was decided at an inter-ministerial meeting that there would be roads all around the lake instead of an elevated road. In the same year, the Hatirjheel Development Project and the Panthapath-Pragati Sarani/Gulshan Avenue Link Road Construction Project were merged and a proposal was made for a comparatively less costly construction of the Panthapath-Pragati Sarani Gulshan Avenue Link Road, along the banks of Hatirjheel Lake. In August 2007, the Executive Committee of the National Economic Council (ECNEC) approved the project 'Integrated Development of Hatirjheel Area including Begunbari Canal'. The project's primary objective was to restore the retention capacity and function of the Hatirjheel system.

The project took almost six years to implement and was completed in June 2014. Once a symbol of environmental degradation, Hatirjheel is now a remarkable example of environmental restoration and remains a source of inspiration for the same, throughout Bangladesh. This project also acted as a technical reference for further waterfront development, as well as urban design for numerous projects, not only in Dhaka, but also within the country.

Plantations Undertaken along the Lake Boundary © Vitti Sthapati Brindo Limited

As a rapidly-developing megacity, Dhaka's future depends on its adaptability to cope with an increasing population and its demand for amenities like drinking water, sewage infrastructure and public space. Hatirjheel still remains one of the most significant of the city development projects that came about as a result of public demand and flourished as a regeneration of heritage, a large-scale but localised drainage system solution, and a reclaimed public space for locals and tourists.

Urban oasis: Integrated development of Hatirjheel area including Begun Bari Canal

Hatirjheel, a water retention body lying at the centre of the capital connects many prominent areas, stretching from the eastern side of the Tongi Diversion Road up to the Rampura Bridge on the Pragati Sarani. The management of the Hatirjheel basin is critical to reduce flood hazards in Dhaka city, thus prompting the government of Bangladesh to implement an integrated project including development of road communication in east-west direction in Dhaka city. A vital component of this project was to safeguard a large part of the city from flash floods by restoring its waterfront legacy. The main objectives were to preserve the low-lying floodplain areas of Hatirjheel, establish connectivity among major urban mobility corridors, reintroduce a water-based mode of transportation, integrate the northern and southern part of the city, and restore and conserve the urban environment.

> **"The restoration of Hatirjheel was not just a project, rather it was a result of a social movement to save Dhaka's distressed wetlands. Protests and demonstrations that spanned more than four years demanded that historical water urbanism of the demarcated (as per approved Structure Plan under Dhaka Metropolitan Development Master Plan) 'water retention' area of the city be reinstated. Hatirjheel became a symbol of 'urban justice' towards balanced and equity-based sustainable urban development. As urban environmental activists and later project architects, we tried to uphold this spirit as best as possible."**
>
> – Mr. Iqbal Habib
> Principal Architect and Managing Director,
> Vitti Sthapati Brindo Limited

How the initiative was implemented

The project area spread over 311 acres, which included 81 acres of Court of Wards, 80 acres of land of different government agencies and 150 acres of private land.[243] The total cost of the project was US$ 300 million.[244] It was implemented jointly by RAJUK of the Ministry of Housing and Public Works, and Dhaka Water Supply and Sewerage Authority (DWASA) and Local Government Engineering Department (LGED) of the Ministry of Local Government, Rural Development and Cooperatives. The Integrated Development of Hatirjheel Area including parts of Begunbari Canal intended to carry out the development of the Hatirjheel lowlands.

Three major objectives were set for achieving the desired development of the area:

i) To ensure protection of required area for storm water retention, in order to minimise the risk of inundation of the adjoining areas and also reducing related environmental hazards;

ii) To restore the degraded environment of the Hatirjheel area by transforming the wastewater canal into a freshwater lake; and

iii) To connect an important east west missing link between two major arterial roads namely the Tongi Diversion Road and the Pragati Sarani through constructing a peripheral road system to decongest traffic in the area.

Apart from these major activities, re-excavation of the entire Hatirjheel and parts of Begun Bari Canal has also been considered in an effort to enhance the stormwater retention capacity of the lowlands, so that the entire lowland can be transformed into a freshwater lake.

The project consists of 40 hectares of wetlands. During the dry season, the Hatirjheel Lake can hold approximately 3.06 billion litres of water, and during the rainy season about 4.81 billion litres of water. It has significant infrastructure, including 200 km of different types of roads, footpaths, eight bridges and aqueducts. The infrastructural and landscape components include:

- 8.5 km of expressway, service road and a footpath on two sides
- A 400-metre-long overpass
- 10 km of lakeside walkways with five foot-over bridges, one foot bridge over the lake, over 500 sitting benches, 24 viewing decks, two 100-metre long ghat, garbage bins, passenger sheds, a bicycle stand and vehicle parking bays. (A ghat is a broad flight of steps situated on a riverbank that provides access to the water, especially for bathing.)
- A children's play area
- Water gardens and floating walkways
- A floating amphitheatre, children parks, an information centre and celebration point
- Public toilets, police box, bus stop with a ticket counter, a food court and souvenir shop
- Four bridges with a total length of almost 475 m
- Three viaducts with total length of 270 m
- Two water taxi terminals of almost 200 m in length
- Four electrical sub-stations and a pump house
- Surrounding boundary walls
- Plantations and greening
- Street, walkway and bridge lighting

Although Vitti Sthapati Brindo Ltd. proposed a soft edge between land and water for the intervention, a harder edge was created. A thin green belt of vegetation exists along the edge. However, the project does not include large public parks as a result of the large amount of space required for water retention and vehicular mobility. The pedestrian path proposed by Vitti Sthapati Brindo Ltd. was six metres wide, including a bicycle lane, but the development agencies decided on a pedestrian walkway only 0.9 m wide. The scheme retained small public plazas along the pedestrian walkways, some of which are connected by bridges, ghats and look-outs. This has made it one of the major public meeting places in Dhaka city for middle- and lower-middle-income groups.

To improve safety, a boundary wall around the Hatirjheel Lake was constructed in 2014. This coincided with the initiation of the construction of rehabilitation apartments for displaced people. A comprehensive plan for the Hatirjheel area was prepared by RAJUK in 2015. This plan included several miniature parks for visitors. An amphitheatre was added in April 2017. Developed with the initial aim to decongest traffic, improve drainage and build flood protection, the final result has seen the development of the area as a pleasant extended recreational park within Dhaka.

Impacts

Overall, the initiative has had the following positive impacts:

Disaster risk reduction: Being one of the few open large water bodies in the city, Hatirjheel, was transformed from being a degraded, polluted and encroached area to one of Dhaka's largest stormwater retention bodies. Through the project, the retention capacity was increased by removing sludge and incorporating slope protection measures, thus protecting the adjacent area from flash floods.

Revitalising a grey urban backyard into a thriving new cityscape for the community: The construction of recreational facilities and landscape elements such as viewing decks, a children's play area, floating gardens, floating walkways, a deck, an amphitheatre, an information centre and a celebration point has created a community meeting and leisure space.

Enhancing city-wide accessibility and connectivity: Traffic intersections and support components are included in the construction of peripheral roads, which comprise the expressway, local roads and walkways around the project area, along with parking facilities and bus stops. The designed bridges and viaducts connect the northern and southern peripheral roads. The new roads ease traffic movement within the north and south parts of the city. Citizens can now reach Rampura from Karwanbazar, Moghbazar and Malibagh in only 10 minutes, which previously took more than 1.5 hours. The design integrates the northern and southern parts of the city, which was once roughly disconnected and created economic and social differences between the two. RAJUK inaugurated the Circular (Chakrakar) Bus service and Water Taxi service on the peripheral service road and the Lake respectively.

Re-establishing heritage: The project reintroduced a water-based mode of transportation. Hatirjheel, which was part of a larger system of canals, and the Begun Bari Canal were important waterways during the Mughal period and functioned as entryways to the city.

Challenges

Some of the challenges faced during the project term included:

Land acquisition and resettlement: Land acquisition was a critical issue that needed due deliberation. The proposed site area included private lands, unused government land and land that belonged to 'Court of Wards'. These lands were mostly encroached. The land acquisition law, 'Acquisition and Requisition of Immovable Properties Ordinance, 1982', only provides for monetary compensation and does not include resettlement and rehabilitation of affected people. This legal framework made the land acquisition process difficult. To overcome this, RAJUK offered to build apartments within a new area to accommodate over 200 affected households. A housing project is in progress to re-establish the 256 evicted legal land-owners within the Hatirjheel area.

Management and maintenance: Maintenance and management of the wide range of engineering infrastructure and recreational facilities is extremely difficult. A strong management organisation involving all stakeholders is, therefore, needed for smooth operation of the engineering structures (such as Special Sewerage Diversion Structure [SSDS], the sewer network, gates connecting the Hatirjheel and Begun Bari Canal downstream) and management of traffic and the recreational facilities. A five-year maintenance plan for the entire Hatirjheel area is being prepared to ensure multidimensional benefits of Hatirjheel for the people of Dhaka.

Enabling factors

The Hatirjheel project is recognised as a landmark project in the recent development of Dhaka, which illustrates the success of the creation of a new public space and transport solutions not by eliminating but by reclaiming wetlands.

The project carried out the development of Hatirjheel area by developing the *Jheel* (water body) and constructing grade overpasses, waterside roadways, reclaimed waterways, circular bus bays, and parking spaces for cars. This infrastructure development improved the environment of the area and traffic congestion in and around adjacent roads of Dhaka City. The project structures follow an innovative approach and the engineering design uses locally-available materials and innovative technology. The lowlands in the project site were excavated to remove sludge and increase their retention capacity. Deep tube wells were also installed for providing drinkable water for the visitors and dwellers in the area.

The entire project plan was developed from the combined analysis and proposals of BUET consultants and implemented through RAJUK, LGED, DWASA, Engineering Construction Battalion of Army and Special Works Organisation (SWO) (West). The project also achieved successful collaboration between government, multiple clients, the implementation authority, design and technical consultants and citizens, which inspired later development work along a similar model.

The Hatirjheel project has intervened in a major way in natural drainage and improving social cohesion and quality of life, with significant impact on both the immediate physical form of the city and its broader environmental performance. According to experts, drainage has improved markedly in the surrounding areas. It has improved waterfront public spaces, encouraged public activities such as walking, jogging and socialising as well as increased accessibility by connecting the different areas of the city.

INITIATIVE: INTEGRATED DEVELOPMENT OF THE HATIRJHEEL AREA, INCLUDING THE BEGUN BARI CANAL	
Knowledge factors	• Consultations with various experts and cross-disciplinary professionals. • Collaboration with government organisations and public representatives. • Initial recommendations made for the restoration of the Hatirjheel basin in the DMDP 1995-2015. • Site assessment report developed by the Bureau of Research, Testing and Consultation of BUET along with studies conducted on drainage and traffic systems, land excavation and walkway construction.
Social factors	• People's movement, i.e., the Bangladesh Poribesh Andolon environmental awareness campaign by civil society and environmental organisations. • Development of a housing project for rehabilitating displaced people and providing monetary compensation under the land acquisition law, i.e., 'Acquisition and Requisition of Immovable Properties Ordinance, 1982'.
Economic factors	• Funding from ECNEC, Government of Peoples Republic of Bangladesh.
Institutional factors	• Provisions under the land acquisition law. • Site excavation and land acquisition by RAJUK.
Technical factors	• Construction of bridges, grade overpasses, waterside roadways, reclaimed waterways, circular bus bays, and vehicle parking spaces by LGED. • Design of drainage and sewage system by DWASA.

Replication

In order to carry out this project, the following resources proved critical:

Finance/assets: A large budget and mobilisation of significant financial resources was required. In this case, government funds were mobilised. For future initiatives, cost-recovery options such as toll systems (where government collects taxes from users and allocates this money for road maintenance) could be adopted to support these types of projects in the long-term (but were not used in this case). Land was a critical asset that proved to be a challenge during the implementation of the project due to the various encroachments. This is a factor that should be taken into account in the planning stage for future projects.

Staff/capacity: The scale and scope of the project required that it be implemented by various experts through collaboration with cross-disciplinary professionals. It was a collaboration of government organisations, consultants and public representatives. The design and supervision phase required 578 professional staff months while the main contractor engaged at least 500 staff in the different phases. Besides this, around 3,000 staff comprising of various sub-contractors, were also engaged in the project implementation.

Stakeholder engagement: The project engaged a significant number of stakeholders as detailed in the previous sections. Inter-sectoral collaboration and cooperation was the main driver of success. The community played an important role in generating demand for the project, by stimulating public and political awareness that translated into an integrated management of the waterbody, while also re-establishing the importance of wetlands.

Costs and funding

The project was funded by the Government of Bangladesh, with an overall cost of US$ 300 million.

WORKS	IMPLEMENTING AGENCY	PROJECT COST IN MILLION USD
Land acquisition	RAJUK	150
Feasibility study	BUET	0.57
Design, supervision and management of roads, bridges, overpass, walkways and landscape components	LGED through the consultant VITTI-DPM- AIA JV Bangladesh Army carried out the construction	1.141
Excavation and removal of sludge, construction of diversion sewer lines, Special Sewerage Diversion Structure (SSDS)	WASA through the consultant BUET Bangladesh Army carried out the construction	148.289
Total		**300**

Links to SDGs, Aichi Targets and NBTs

SDGs	
Aichi Targets	
National Biodiversity Targets:	14, 15

Key contacts	
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Integrated development of the Hatirjheel area, including the Begun Bari Canal

Reducing flood hazards in Dhaka and improving the overall quality of life in the city through the use of an integrated grey-green approach.

SDGs:

Aichi Targets:

NbS approach: Issue-specific ecosystem management

Local government	Dhaka North City Corporation (DNCC)
Country and state	Bangladesh, Dhaka
Population	2.5 million (2021) (DNCC Area)
Total area	196.6 km^2
Main geography type	Mega Delta

Spread across **311 acres** of land, including:

81 acres of Court of Wards
80 acres of different government agencies
and **150 acres** of private land

History

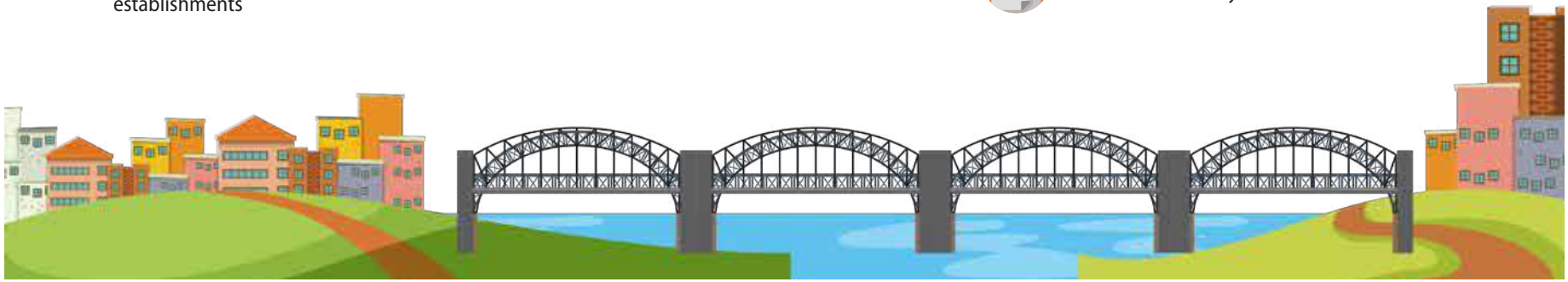
- Urbanisation accelerated in the 1960s
- High levels of pollution due to dumping of household and industrial waste
- High levels of encroachment from illegal settlements, including slum dwellers, real estate companies and commercial establishments

Project goals

- Improving storm water retention
- Transforming a wastewater canal into a freshwater lake
- Connecting an important link between two major arterial roads, the Tongi Diversion Road and the Pragati Sarani

Impacts

- Reduced flood risk
- Revitalised a grey urban backyard into a thriving new cityscape for the community
- Enhanced city-wide accessibility and connectivity
- Re-established heritage through the re-introduction of water-based modes of transport
- Improved living conditions for the local community



Karupannya Rangpur green factory, Rangpur, Bangladesh
Source: https://www.showcase.com.bd/architect-column/a-green-workspace-karupannya-factory/

NbS approach: Infrastructure-related approaches

Aerial view of mangroves at Piroshanagar, India © Godrej & Boyce Manufacturing Company Limited

MUMBAI, INDIA: Greening and conserving Pirojshanagar's mangroves

A city that could soon be reclaimed by the sea

Located along the western coast facing the Arabian Sea, Mumbai is one of India's largest cities and the country's financial, commercial and industrial capital. It houses the largest population in India, after New Delhi and is projected to remain among the top 10 of the world's most populated cities in 2030, according to the UN Habitat.[245] Being an important seaport and trade hub, the city also possesses specialised technical industries, with a modern industrial infrastructure and vast, skilled and unskilled human resources.[246]

NbS approach: Infrastructure-related approaches	
FACTS AND FIGURES	
Local government	Brihanmumbai Municipal Corporation
Country and state	India, Maharashtra
Population	1,24,32,830 (2011)
Total area	437.71 km^2
Main geography type	Coastal, lowland
GDP	US$ 310 billion (2017)

Most of Mumbai is low-lying (except Northern Mumbai), much of it having been formed through a series of natural and human-made reclamations from seven small islands including former mangroves. Several parts of the city lie just above sea level, with elevations ranging from 10 m to 15 m. A major part of Mumbai is built on the old island of Salsette, which lies at the mouth of Ulhas River.[247] As the city has urbanised, it has grown in a northern direction, limited by physical geography, and has expanded into the suburbs and extended suburbs. It is under the political administration of the Municipal Corporation of Greater Mumbai also known as the Brihanmumbai Municipal Corporation.

Numerous creeks and bays notch the city's coastline all the way from Thane creek on the eastern to Madh Marve on the western front.[248] The eastern coast of Salsette Island is covered with large mangrove swamps, rich in biodiversity, while the western coast is mostly sandy and rocky. Major

Undertaking plantations © Godrej & Boyce Manufacturing Company Limited

mangrove areas are along the Vasai creek, Thane creek, Manori and Malad, Mahim-Bandra, Versova, Sewree, and Mumbra-Diva areas. The multiple benefits associated with mangroves include natural storm buffering, breeding and nursery grounds for biodiversity, water filtration, purification and prevention of saline intrusion, air quality, climate and water regulation, fishery stocks enhancement and so on.[249] The ability of mangroves to trap silt is a vital service rendered to Mumbai which is extremely prone to erosion since it was built on reclaimed land under a very strong influence of the sea.[250] Conservative estimates put the cumulative value of Mumbai's mangroves in the order of US$ 0.13 billion, assuming a short lifespan value of 25 years.[251]

Unfortunately, coastal resources, including mangroves, are the first to be depleted as Mumbai urbanises. With real estate values in Mumbai being among the highest in the world, the aerial extent of mangroves was 37 km^2. Since then, conservative estimates put mangrove loss at around 40% of their original extent, primarily driven by reclamation for housing, slums, sewage treatment and garbage dumps.[252]

The significance of preserving and enhancing mangrove areas grows with the projected impacts of climate change on Mumbai. As global average sea levels are expected to rise by 0.43 m to 0.84 m by 2100,[253] Mumbai's mangroves may represent an important adaptation and mitigation mechanism for the city's continued existence.

Pirojshanagar: How an industrial establishment came to be one of Mumbai's flourishing natural mangrove stretches

Pirojshanagar Township is an industrial and residential establishment of Godrej & Boyce Mfg. Co Ltd (G&B). It is located in Vikhroli suburb of Mumbai city, along Thane creek. The area has diverse natural and human-made habitats which include creeklets, mangroves, mudflats, saline blanks, grasslands, open spaces, terrestrial gardens, terrace gardens, plantations, vertical gardens, roadside avenues, ponds, natural streams and constructed buildings. Of the 16 km^2 area of the Township, approximately 12 km^2 is occupied by the mangrove ecosystem and its associated habitats. Interesting, Pirojshanagar with its biodiverse mangrove forest, is sandwiched between two solid waste dumping grounds of the Brihanmumbai Municipal Corporation. This only increases its importance in the landscape.

Pirojshanagar mangrove management has become a national and international benchmark for its many 'first of its kind' initiatives such as:

- First large-scale mangrove plantation in Maharashtra
- First ISO 14001 EMS certified mangrove forest of India
- First mobile app of Asia with 67 true mangrove and mangrove associate species in 11 languages
- First children's story book on mangroves in English and Marathi
- First Marathi website on mangroves
- First mangrove awareness campaign across eight coastal states of India

In 1948, Godrej, who had acquired several hundred acres of land in Vikhroli to set up an Industrial Garden Township, upon recognising the importance of this ecosystem, decided to prioritise conservation of the mangroves that grew along the banks of the newly acquired land (along the Thane Creek west bank). To formalise these efforts, the late Shri. Sohrabji P. Godrej and late Shri. Naoroji P. Godrej established the Soonabai Pirojsha Godrej Foundation in 1985.

The Soonabai Pirojsha Godrej Marine Ecology Centre, which was setup, focussed on the conservation of this ecologically sensitive area, bringing all of the land with mangrove cover under protection. Given the paucity of information around mangrove ecosystems at that time, the late

Maharashtra's first large-scale mangrove plantation at Pirojshanagar by Godrej © Godrej & Boyce Manufacturing Company Limited

Shri Sohrabji P. Godrej decided to support a doctorate study during 1985 to 1992 on the mangroves, titled 'Vikhroli Mangroves: Conservation and Management'. The study's outcomes generated valuable insights as well as provided a roadmap for its conservation. As part of the road map, an implementation arm, the 'Mangroves Project', now known as the Wetland Management Services (WMS), was created, lending conservation efforts a distinct identity and adequate resources.

Since then, the initiative has shifted from being a philanthropic endeavour to institutionalising the conservation of mangroves under a fully devoted department under an 'Integrated Management System'. Employing a three-pronged strategy of research, conservation and awareness, G&B mangroves became India's first ISO 14001 certified forest in 1997, which guarantees SMART (Specific, Measurable, Achievable, Realistic and Time-bound) performance indicators and targets for conservation initiatives.

Almost 50 years later, around the early 2000s, the health of the mangrove ecosystem and its biodiversity were clearly visible and G&B decided to extend their research and outreach to the Mumbai Metropolitan Region by appointing a dedicated Education Officer. Subsequently, NGOs and CBOs, academic and research institutes, citizen forums and other stakeholders became involved.

Environment conservation information and values are imparted to every G&B employee through a mangrove awareness programme, which is integrated in the corporate induction plan. Using platforms such as World Wetland Day, Earth Hour, World Environment Day, Van Mahotsav, World Mangrove Day and Wildlife Week, the WMS team engages Godrej's business units, township residents, and students of Udayachal primary and high schools. Taking it a step further in the Udayachal schools, 'Mangrove Clubs' were formed in 2003, dedicated to the cause of mangrove awareness. Incorporating green values into their corporate operations, G&B's Pirojshnagar Township in Vikhroli is a 'Zero Garbage to Landfill' township since 2014, while G&B is 'Water Positive' since 2016 and 'Zero non-hazardous waste to Landfill' for manufacturing operations across India.

Besides land stabilisation, the mangrove ecosystem plays a vital role in natural cycles and nutrient recycling to maintain the environmental balance. They help moderate extreme events, like flash floods and storms, by acting as a natural sponge. They also help treat Mumbai's wastewater by breaking complex pollutants into nutrients with their biological systems. The extensive root

network of Pirojshanagar mangroves protects the eastern shoreline of Mumbai from erosion, making it a stable habitat for wildlife and humans alike. Through these efforts, this unique urban forest is able to coexist with industry.

Improving natural Infrastructure in Mumbai: Managing and replenishing mangroves

How the initiative was implemented

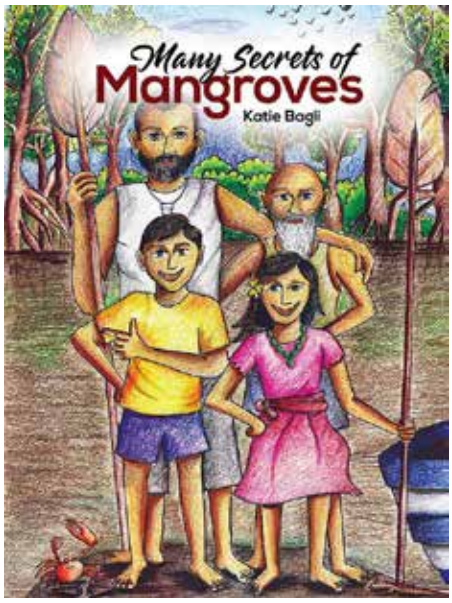
Pirojshanagar mangrove management is carried out by the Wetland Management Services (WMS) Department of G&B, through a three-pronged approach of research, conservation and awareness.

It also includes monitoring and treatment of biotic and abiotic factors. Biotic factors involve protecting and planting true mangrove, mangrove associate and terrestrial plant species. Abiotic factors involve air, water, soil monitoring initiatives that include water treatment and recycling, and 'zero waste to landfill' initiatives to ensure pollution control.

The Pirojshanagar initiative has progressed since the 1940s with an increased understanding of the mangrove ecosystem and its services through a doctorate study sponsored and supported by G&B. The research findings resulted in the development of a systematic approach and dedicated team for mangrove management.

> **It has taken decades for Godrej & Boyce to experiment and succeed in the conservation of the Pirojshanagar mangroves. Organisational commitment, adequate infrastructure and appropriate governance are the three pillars employed to implement our three-pronged strategy of research, conservation and awareness. Participation of internal stakeholders such as senior management, employees, township residents as well as external stakeholders such as research and academic institutes, NGOs and CBOs, government agencies, citizen forums, expert consultancies, etc. has been sought on various occasions to ensure participatory management of Pirojshanagar mangroves.**
>
> – Ms. Tejashree Joshi
> Environment & Sustainability Division
> Godrej & Boyce Mfg. Co. Ltd

A capture from the camera trap study of wildlife at Godrej mangroves © Godrej & Boyce Manufacturing Company Limited



Many Secrets of Mangroves – India's first storybook for children on the mangrove ecosystem © Godrej & Boyce Manufacturing Company Limited

Launch of Asia's first mobile app on the mangroves by Maharashtra's former Chief Minister and Godrej family © Godrej & Boyce Manufacturing Company Limited

Research includes facilitation of short-term, mid-term and long-term studies undertaken by schools, undergraduate, postgraduate, doctoral students and professional researchers. The WMS Department supports and coordinates research on different aspects relating to mangroves, with a focus on the Pirojshanagar mangroves. Some of the commissioned research is around the medicinal properties of mangrove species, their carbon sequestration properties, associated intertidal flora and fauna, environmental education techniques to develop effective pedagogical tools and generation of updated scientific data. The research informs conservation and awareness activities.

Conservation includes on-site protection of the mangrove ecosystem by providing security to the premises, developing and managing a mangrove nursery, running regular planting programmes, and developing and managing educational infrastructure, such as nature trails, theme gardens, a mangrove information centre, a marine aquarium and a watchtower.

In 1999, 80 acres of mangroves were planted along its southern border for the Municipal Corporation of Greater Mumbai by G&B. The intervention included topographical and hydrological interventions to control the high salinity of the area. Fish bone technique, which involves digging

trenches at a certain angle, was adopted in Thane creek. This ensured good circulation of water leading to lowering of salinity. Mangrove plantations includes species such as grey mangrove (*Avicennia marina*), red mangrove (*Rhizophora mucronata*), milky mangrove (*Excoecaria agallocha*) and meswak (*Salvadora persica*). The saplings were raised in a mangrove nursery developed on-site. The plantation continued for two years. The plantation survival rate and increase in green cover was recorded through ground studies and remote sensing. It was the first successful large-scale mangrove plantation in Maharashtra, which led to State, NGO and academic agencies taking up further mangrove plantation all along the coastlines. The plantation reduced saline blanks (indicators of degradation) and improved the area's geology and hydrology.

As part of the company's mangrove plantation programmes, a mangrove nursery of true mangrove and mangrove associate species was developed at the creek side. These saplings are then used for plantation drives on the Godrej campus or are provided to other organisations on request. Plantations offer an effective means of engaging stakeholders in mangrove conservation, for eg; symbolic mangrove plantation drives are conducted regularly involving G&B employees, residents and other organisations to improve local buy-in.

The township also developed three thematic gardens to engage visitors to the mangroves while also supporting local biodiversity via local food chains. Basic information such as the layout and plant profiles of each garden is displayed prominently. The butterfly garden houses more than 100 species of nectar and host plants catering to the 82 butterfly species found in the township, while there are more than 100 species of grasses, herbs, shrubs and trees in the medicinal plant garden. The palmetum which is still under development has 18 species and also houses a cactarium in one section. A nesting colony of Baya Weaver birds comes here every summer, a rare sight for Mumbai city.

Awareness includes outdoor nature walks and indoor activities for organised groups from schools, colleges, citizen groups, corporate employees, professional associations and others. The outdoor activities encourage citizen science action through plant and wildlife (insects, birds etc.) diversity photo documentation, bird and butterfly watching, tree trails, interactive and educational games and participatory plantation drives. Film screenings, quizzes, presentations, talks, exploring the mangrove information centre and indoor games make up some of the indoor activities. Mangrove walks take visitors on a tour around the mangroves educating them on generic or specific aspects of the ecosystem. Visitors are also allowed access to the township's peripheral areas for public awareness and education. There are five nature trails with pathways which offer close interaction with the Pirojshanagar mangroves. A marine aquarium has been developed as a tool to sensitise visitors on marine fish diversity within mangroves.

To overcome the absence of popular field guide for mangrove identification, G&B developed a mangrove mobile app which covers all the 24 mangrove and mangrove associate species found in Maharashtra. The app is Asia's first mobile app for a mangrove ecosystem developed by a corporation and is widely available in Play stores on Android, iOS, and Windows platforms. Parameters such as leaf shape, flower colour and name can be used to identify a species. Besides the identification feature, a description of every plant species and its uses, information on mangrove distribution, mangrove adaptations, faunal biodiversity in mangroves, threats, conservation measures and role of stakeholders in mangrove conservation is also available on the app. There is also a glossary of technical terms and information about the Godrej mangroves. The app encourages citizen science and is useful for teachers, students, researchers, Forest Department staff, NGOs, CBOs and nature enthusiasts interested in mangrove ecosystems. G&B has also developed an awareness kit that comprises the app, identification guides, posters and a children's book titled 'The Many Secrets of Mangroves'.

At Godrej's Mangrove Information Centre, there is a collection of books, magazines, research reports, conference proceedings and other publications on various aspects of mangrove ecosystems which is available to the general public.

In 2020, on the occasion of International Day for the Conservation of the Mangrove Ecosystems, G&B in collaboration with WWF-India, launched 'Magical Mangroves', a nationwide campaign which highlighted the significance of conserving mangroves while urging citizens to participate as volunteers in the conservation movement. The campaign spanned across eight states including Maharashtra, Goa, Gujarat, Andhra Pradesh, Tamil Nadu, Kerala, Odisha and West Bengal. The volunteers who signed up were engaged over six months and participated in webinars, film screenings, online quizzes, digital storytelling sessions, among other activities. More than 10,000 people were reached through this initiative.

TABLE 14: Engagement of external stakeholders

TYPE OF STAKEHOLDER	ACTIONS
Government departments and representatives	• Presentations by G&B at Government seminars, conferences and consultations. • Visits by Government organisations to Godrej campus for exposure and training. • Participation in Government drives and initiatives.
NGOs	• Facilitating NGO awareness programmes on Godrej mangroves. • Facilitating NGO visits to Godrej nursery for exposure and learning. • Participating in horticultural competitions organised by NGOs. • Engaging expert and authorised NGOs in wildlife rescue and rehabilitation. • Supporting NGO drives through donations, employee volunteering and technical support. • Collaborating on awareness programmes.
Research institutes	• Collaborating in in-situ and ex-situ biodiversity research. • Sharing expertise. • Providing financial support for collaborative research.
Academic institutes (schools and colleges)	• Running mangrove awareness programmes in Godrej campus. • Encouraging student research projects on biodiversity in Godrej campus. • Providing financial, logistics and technical support to academic conferences and seminars. • Conducing presentations and poster exhibitions in academic institutes.
Business consortiums such as the Confederation of Indian Industry (CII)	• Sponsoring biodiversity-related events or sessions. • Facilitating and conducting collaborative initiatives, such as the India Business and Biodiversity Forum. • Sharing expertise and delivering presentations in conferences and seminars.

TYPE OF STAKEHOLDER	ACTIONS
Godrej customers, vendors and other supply chain links	• Updating stakeholders on biodiversity management during vendor and other meetings. • Encouraging good practices such as plantations, responsible waste management and water conservation. • Awarding stakeholders for biodiversity conservation initiatives.
Citizens and other stakeholders	• Developing mangroves mobile app for mangrove species identification and ecosystem awareness. • Running popular articles in newspapers and magazines, and interviews on radio channels. • Conducting mangrove awareness programmes (in-situ and ex-situ). • Running Godrej Mangroves Facebook group for awareness and engagement.

Impacts

G&B's mangrove management initiative has resulted in the conservation of a 12 km^2 area of mangrove ecosystem at Pirojshanagar. This success of the initiative is evident from the township's biodiversity profile, which includes 16 mangrove and mangrove associate species, 208 bird species, 82 butterfly species, 81 spider species, 32 reptile species, 22 fish species, 13 crab species, 7 prawn species and 6 mammal species that include *Canis aureus* (golden jackal), *Sus scrofa* (wild boar), *Herpestes edwardsii* (Indian grey mongoose) and *Pteropus* (flying fox). Besides the mangrove species, the campus hosts over a 1,000 terrestrial plants. The green cover of Pirojshanagar as measured through remote sensing and ground surveys has shown steady growth over the decades. A two-year research study[254] revealed that the Pirojshanagar standing stock, with its biomass and sediments, holds 0.6 million tonnes equivalent of carbon dioxide and sequesters 60,000 equivalent tonnes of carbon dioxide every year. These findings indicate the success of G&B's initiative to improve Mumbai's natural infrastructure.

G&B has received recognition and accolades for their contribution to mangrove conservation by the Bombay Natural History Society (BNHS) in 2006, winning the 'Green Governance Award'. In 2018, JSW Foundation and the Times of India awarded the company, the 'Earth Care Award'. In the same year, the National Biodiversity Authority, Ministry of Environment, Forest and Climate Change, Government of India recognised G&B's efforts towards the conservation of mangroves and conservation of wild species through its National 'Biodiversity Award'. The Pirojshanagar mangroves were visited in 2013 by His Royal Highness, the Prince of Wales, who appreciated the infrastructure developed and contributions made towards educating the public on mangrove ecosystems.

The Godrej mangroves are a living laboratory for researchers and academia. The team at Godrej facilitates research on diverse subjects like biodiversity, ecosystems and their management, pollution trends, nature interpretation, etc. Every year, over 7,000-9,000 citizens visit Godrej mangroves to understand diversity, and the importance of mangroves and their own role in mangrove conservation.

Enabling factors

The G&B mangrove greening and management initiative is an important and rare corporate case study where a business has demarcated its hundreds of acres of land for a nature conservation initiative that is accessible to public and participatory in its initiatives.

When the initiative commenced with the acquisition of the land for the township in the 1940s, very little was known about mangroves and their importance. The G&B founders through the Soonabai Pirojsha Godrej Foundation began to build their knowledge base through research, enabling conservation and greening of Pirojshanagar's mangroves. As the management strategy employs a three-pronged approach of research, conservation and awareness, the core WMS department that manages day-to-day activities is made up of experts in the field of ecology and environmental science.

The WMS Department is supported by other departments such as Environmental Engineering Services (EES) for legal compliance, pollution control, environmental planning, design and deployment, environmental sustainability research and action, the Horticulture Management Services (HMS), for green cover enhancement and propagation of indigenous species. These departments are in turn supported by other maintenance teams to develop and maintain environmental infrastructure. Furthermore, there is significant engagement with mangrove experts, science-based organisations and government departments through partnerships and collaborations, which supports knowledge sharing and further enhancement of the initiative. Several pedagogical tools have also been developed which support awareness and education activities.

Since establishing the Soonabai Pirojsha Godrej Foundation in 1985, several technologies have been used and evolved through the research programme. The day-to-day management of the mangroves requires monitoring of soil, water and air parameters, which WMS Department undertakes. G&B carries out water treatment and recycling and 'zero waste to landfill' initiatives to ensure pollution control. Monitoring and protection with the help of security guards and dog squads is a daily activity. The theme gardens and marine aquarium established around the mangroves for educational purposes must also be managed. This includes maintaining access, watering, de-weeding, mulching, manuring in the gardens, monitoring of water quality and fish feeding in the marine aquarium.

The initiative is entirely funded as a part of business expenses of G&B. The Environmental Policy and 'Good & Green' Sustainability strategy of G&B guides mangrove protection, enhancement and management. Besides this internal policy, national legal frameworks and policies, such as the Wildlife Conservation Act of 1972, CRZ Notification of 2018 and the Compensatory Afforestation Fund Act of 2016, support mangrove greening and protection.

An important success factor for the initiative is the partnership developed with the local fishermen and other community members who now act as custodians of the area, supporting G&B with surveillance and wildlife rescue. Through sustained engagement, and comprehensive and innovative awareness programmes, citizens of Mumbai, scientists and other stakeholders are also slowly being inducted as caretakers of Mumbai's mangroves.

INITIATIVE: GREENING AND CONSERVING PIROJSHANAGAR'S MANGROVES	
Knowledge factors	• Knowledge is developed and applied through research partnerships with academic institutions, exposure visits and training on mangrove ecosystems • The Wetland Management Services Department, which manages the mangroves, has their own pool of expertise and is supported by the EES and HMS teams
Economic factors	• The entire initiative is funded by G&B
Institutional factors	• Some government programmes and policies, such as the Wildlife Conservation Act 1972, CRZ Notification 2018, Compensatory Afforestation Fund Act 2016, support the mangrove protection and enhancement efforts • The Environmental Policy and 'Good & Green' Sustainability strategy of G&B guides mangrove management

INITIATIVE: GREENING AND CONSERVING PIROJSHANAGAR'S MANGROVES	
Technical factors	• Mangrove nurseries are established • Regular peripheral plantations carried out. • The fishbone technique is used for 80 ha plantation • Ambient air quality monitoring • Creek and ground water monitoring • Soil carbon content monitoring
Social factors	• Sustained engagement with various stakeholder takes place through comprehensive and innovative awareness programmes

Replication

The following resources are critical to carry out a similar initiative:

Finance/assets: Budgets can be scaled down or up depending on the type and size of the initiative. Land is an important factor, but ownership can be public or private. There are a wide variety of funding instruments, such as Compensatory Afforestation Fund Management and Planning Authority (CAMPA) funds or Corporate Social Responsibility (CSR) funds, that can be used for similar initiatives. G&B facilitated 'Restoration, Plantation and Conservation of Mangrove in the Gulf of Khambhat, Gujarat State, India' on 200 hectares in coordination with Gujarat Ecology Commission at US $ 367 per ha.

City characteristics: Mangroves are only found in estuarine and saline habitats and therefore this type of initiative will depend on the geography and water profile of the area.

Time for planning and implementation: Depending on degree of degradation, time for planning and implementation will vary. Since mangroves are slow growing species, their establishment within a specific landscape will depend on abiotic factors, such as the pollution load within the ecosystem. It takes a minimum of 20 years for mangrove saplings to properly establish themselves and grow to a healthy height.

Stakeholder engagement: Engaging a variety of internal and external stakeholders including the local community results in greater visibility, and the conservation and enhancement of mangroves and their services. Education and awareness are important activities that have been taken up by G&B as part of their management strategy. Implementation needs expertise related to mangrove ecosystems, hydrology and geology to ensure the selection of appropriate mangrove species and suitable topography and water movement.

Costs and funding

The Pirojshanagar mangrove initiative is entirely funded by G&B Mfg. Co Ltd. The company is not at liberty to publicly disclose data regarding funding and costs, as per their organisational policy.

Greening and conserving Pirojshanagar's mangroves

Pirojshanagar, with its biodiverse mangrove forest, is sandwiched between two solid waste dumping grounds of the Brihanmumbai Municipal Corporation, making it a green oasis that acts as carbon sink.

NbS approach: Infrastructure-related management

Local government	Brihanmumbai Municipal Corporation
Country and state	India, Mumbai
Population	1,24,32,830 (2011)
Total area	437.71 km^2
Main geography type	Coastal, Lowland

SDGs:

Aichi Targets:

Of the 16 km^2 area of the township, approximately 12 km^2 is occupied by the mangrove ecosystem and its diverse habitats.

The Wetland Management Services Department of Godrej and Boyce Manufacturing Company Limited conserves the mangroves through a three-pronged approach of research, conservation and awareness-raising.

Research: Medicinal properties of mangrove species, carbon sequestration, associated intertidal flora and fauna, and environmental education.

Conservation: Security to the premises, development and management of a mangrove nursery, regular planting programmes, nature trails, themed gardens, a mangrove information centre, a marine aquarium and a watchtower.

Awareness: Documentation of plant diversity and wildlife photography, bird and butterfly watching, interactive and educational games and participatory planting programmes, film screenings, quizzes, presentations, talks and exploration of the mangrove information centre.

Links to SDGs, Aichi Targets and NBTs

SDGs	
Aichi Targets	
National Biodiversity Targets:	

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BOX 6: SHORT CASE STUDY ON INFRASTRUCTURE-RELATED APPROACHES

RANGPUR, BANGLADESH: Karupannya Rangpur Green Factory Initiative

The why[255]

NbS approach: Infrastructure-related approaches	
FACTS AND FIGURES	
Local government	Rangpur City Corporation
Country and state	Bangladesh, Rangpur
Population	0.35 million (2012)
Total area	205.7 km^2 (2012)
Main geography type	Lowland

The Karupannya Rangpur Factory adopted a 'green' approach to architecture in order to address environmental and social development concerns[256] in the rug weaving industry in Bangladesh. Employing the approach of maximising the use of natural aspects and the concept of 'Reuse and Recycle', the factory architecture integrates cultural and indigenous knowledge with the use of natural light, wind, water and vegetation.[257]

The what

In 1991, Mr. Shafiqul Alam founded Karupannya Rangpur Limited, a rug weaving enterprise that produces a traditional handicraft of Rangpur called *Shataranji*.[258] In later years the Karupannya Rangpur Green Factory was established, responding to the need to address factors such as socio-environmental development, an emerging demand for rugs in the global market and the need to manufacture quality products through sustainable and cost-effective techniques.[259] The architectural design of the factory aims to ensure sustainable water management, fuel and energy efficiency and the maintenance of favourable ambient temperature within the factory's premises. It also aims at improving the welfare of its workers by improving working conditions and providing recreational spaces.

The factory is spread over an area of about 27,870 m^2 and comprises seven floors, each covering around 3,716m^2.[260] It employs about 5,000 workers, with local women forming about 90% of the total workforce. The structure of the factory building is designed to be fuel and energy efficient, and has led to an 80% reduction in electricity consumption. For water management as well as passive cooling, four large reservoirs have been constructed to store and reuse water for dyeing purposes.

Promoting circular economy: Additionally, the factory is contributing to the development of a circular economy by using cotton waste and garment factory waste from other industries to prepare a recycled raw material, yarn, to produce the rugs. Vegetation cover in the form of shade trees, green walls and rooftop gardens serves to cool and conserve biodiversity as well as providing aesthetic value to the factory.

The how

Karupannya Rangpur Green Factory illustrates a blend of modern and traditional architectural design.[261] The main building of the factory hosts a range of climbing and herbaceous plants in the form of green wall structures. These structures, placed at a distance of 4.6 metres from the main building wall to avoid dampness, also provide habitat to a large variety of bird species. An open green space, Nandini Park that's located on the first floor of the building, also adds to the overall greenery of the factory.

Karupannya Rangpur green factory initiative

Green infrastructure and traditional knowledge were used by a private factory owner to promote biodiversity conservation, build climate resilience and support human well-being.

SDGs: 

Aichi Targets: 

NbS approach: Ecosystem protection

Local government	Rangpur City Corporation
Country and state	Bangladesh, Rangpur
Population	0.35 million (2012)
Total area	205.7 km^2 (2012)
Main geography type	Lowland

Issues

High use of fuel and water in operating the factory

Difficult working conditions due to high temperatures inside the factory

Area of
27,870 m^2
5,000 workers, seven floors

Local women comprise about 90% of the total workforce.

Impacts

Ensured maximum use of natural features for human well being

Maintained ambient temperature through green building techniques within the factory's premises to improve working conditions

Stored and reused water; recycled raw materials

Enhanced fuel and energy efficiency

Reduced electricity consumption by **80%**

The building is equipped with an effluent treatment plant as a part of an integrated closed-loop water cycle management system, which comprises four water reservoirs with a 1,393 m^2 radius that holds about 500,000 litres of water. The building also maintains well-ventilated indoor spaces and floor-based dust removal mechanical ventilation ensures continuous air circulation throughout the building.[262] Wall decorations using mud bowls and textured walls depicting rural houses made of clay give a traditional touch to the overall design of the building.[263]

The who

Mr. Shafiqul Alam, founder of Karupannya Rangpur Limited, is the main champion of this initiative. Architect Bayejid Mahbub Khondker and his team at Nakshabid Architects designed the Karupannya Rangpur Green Factory, while artist Saidul Haque Juise contributed to the factory aesthetics.

The where

Karupannya Rangpur Green Factory is located in Robertsonganj, Rangpur.

The when

The construction work of the Green Factory commenced in August 2013 and ended in August 2016.

Reference

Rayment, M. 2011. Design, implementation and cost elements of Green Infrastructure projects. Final Report to the European Commission, DG Environment, Contract no. 070307/2010/577182/ETU/F. 1, Ecologic Institute and GHK Consulting.

Key contacts	
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Organisation	Karupannya Rangpur Limited

Pocket park at Lalitpur, Nepal© Milan Rai

LALITPUR, NEPAL: Pocket parks: The greening of degraded public spaces

The artistic capital losing its cultural fabric

NbS approach: Infrastructure-related approaches	
FACTS AND FIGURES	
Local government	Lalitpur Sub-Metropolitan City
Country and state	Nepal, Bagmati Pradesh
Population	284,922 (2011)
Total area	37.4 km^2
Main geography type	Highland
GDP growth	~ 7 % in FY 17/18

Kathmandu is the capital city of Nepal.[264] The city forms the heart of the densest urban region of Nepal and consists of two major urban centres, Kathmandu Metropolitan City and Lalitpur Sub-Metropolitan City. Lalitpur Sub-Metropolitan City, locally known as Patan, is located in Lalitpur district and is the second largest municipality in the Kathmandu Valley. Lalitpur is situated on the elevated tract of land in Kathmandu Valley on the south side of the Bagmati River, while the Karmanasa Khola acts as the boundary on the eastern side. It is surrounded by Kritipur Municipality in the west, Kathmandu Metropolitan city in the north, Mahalaxmi Municipality in the east and Daksinkail Municipality in the south.[265]

The city is considered the artistic capital of the country since it is an important centre of cultural heritage and craft production in Nepal, having the largest community of artisans, especially metal and wood workers.[266] It is well known for its Durbar Square, a World Heritage Site that comprises palaces, temples, shrines and monuments.

Nepal is recorded as one of the top 10 fastest urbanising countries in the world.[267] The Kathmandu Valley is the most populated urban region of the country and one of the fastest-growing urban agglomerations in South Asia, accounting for 24% of the total urban population.[268] According to a report by the World Bank[269] "rapid urbanisation, combined with inadequate development control and management, have led to deterioration of the urban fabric in the Kathmandu Valley, which is manifested in low rates of job creation, social segregation and a tangible erosion of cultural identity; increased vulnerability to natural disasters and an increase in slums and squatter settlements". Urbanisation in the valley has also introduced environmental challenges such as traffic congestion, air pollution, a declining water table and loss of open space.[270]

Open spaces, more specifically public open spaces, contribute to the urban architecture that reinforces many social, ecological and economic activities, and are vital to a healthy urban environment.[271] With evidence[272] pointing to a decline in these types of spaces in Nepal and a per capita open space of only 2m^2 in neighbouring Kathmandu Metropolitan City (7m^2 less than World Health Organisation (WHO) standards), failure to formulate and implement urban development strategies will lead to further deterioration of the urban fabric. A projected doubling of the Kathmandu Valley population by 2030,[273] would further impact available infrastructure, services leading to socio-environmental consequences, including stagnant economic productivity, low quality of life, and an increase in inequality.

Pocket parks: A mini-solution to urban regeneration?

In Lalitpur Sub-Metropolitan City, open public spaces within the city occupy around 5% of the total developed area. Almost 90% of the houses are built informally, following the traditional practice of owner-built housing development and the city lacks comprehensive zoning regulations. Limited capacities of local authorities and limited resources have impaired the preparation of urban planning and design guidelines for the valley's newly developed areas.

The paucity of local mechanisms to develop adequate and responsive open public spaces requires immediate addressing. Urban open spaces play an important role in sustaining the microclimate of the region as well as providing recreation opportunities to the people.[274] A high rate of in-migration and urbanisation leading to encroachment, high speculation and land-use change, are the major reasons for decreasing public open spaces in Kathmandu.[275] In order to reverse this decline, a fresh approach to urban regeneration is required.

In 2012, a local artist, Mr. Milan Rai, began to explore how he could popularise art among the average Nepali and use it to bring about awareness on social and environmental issues. He recognised that global phenomena such as urbanisation and rapid population growth has caused air pollution, deterioration of open green spaces, and rampant construction and infrastructure development in the region. His earliest art installation, White Butterflies, was in response to tree felling around the ring road that encircles the cities of Kathmandu and Lalitpur.

In 2017, using a gas mask as a means to voice his concerns about the air pollution in Nepal, Mr. Rai began visiting several Government offices. After years of dealing with bureaucracy and constant attempts at engaging city officials, he received the attention and support of the Mayor of Lalitpur. Understanding the need to address issues such as air pollution and negligence of the local government authorities and citizens alike towards these issues, Mr. Milan Rai, along with a team of volunteers, started expanding their initiatives. This led to the foundation of a community-led art practice that eventually covered environmental issues as well. His environmental advocacy focused on how open spaces have shrunk, both in spatial and democratic terms. Mr. Rai requested the Mayor to rethink public spaces and offered an alternative solution. After three years of sustained efforts to raise awareness about air pollution and urban greening, the idea to develop a pocket park emerged.

Pocket parks, also known as mini-park or vest-pocket parks, are urban open spaces at a very small scale.[276] Usually only a few house-lots in size or smaller, pocket parks can fit into and be scattered throughout the urban neighbourhood and cater to local residents. One of the unique characteristics of pocket parks is that they may be created out of vacant lots, underused spaces or otherwise forgotten voids in urban landscapes. Many pocket parks are the result of community groups, private entities, or foundations reclaiming these spaces and they can provide enormous opportunity positively impacting the community.[277] Although the ecological function of pocket parks is finite, they do serve to increase the proportion of permeable surfaces and as small habitats for biodiversity in the city. Trees and other plants that form a part of these pocket parks act as "green lungs", helping to create a micro-climate and reduce the effects of urban heat islands.

The concept of a pocket park emerged from the need to improve the quality of urban life and public spaces, especially in big cities, where there is a lack of green areas or recreational spaces to serve local communities. Due to dense development in such cities, it is difficult to find a vacant plot of land that could become a new public space. The problem was recognised in the USA in the 1950s and 1960s. During the mayoral campaign of Congressman John Lindsay in early 1965, his associate Thomas P. F. Hoving called for the creation of open spaces and green areas, arguing that they could be as small as one building lot.[278]

Creating pocket parks in Lalitpur

The idea behind creating pocket parks in Lalitpur was to develop a network of breathing spaces, a community haven and improve the green cover, while making these parks innovative and environmentally sustainable. The initiative also intended to create habitat for micro-fauna, particularly insects and pollinators, to improve the microclimate and provide better access to green spaces. The specific objective was to develop an integrated open space planning strategy through:

- Building a well-designed network of open spaces with improved connectivity, accessibility, better ecosystem services, safety and inclusion;
- Formulating categories of open spaces in Kathmandu Valley to better identify and characterise their historical, religious, social, cultural, natural and regional significance; and
- Developing guidelines and methodologies for the design, planning, development and management for different categories of these open spaces.

How the initiative was implemented

In the beginning, Mr. Rai organised people from within his circle to popularise the idea of developing a pocket park. He held discussions with young, like-minded people and gradually gathered the support of the community in order to materialise the idea. With collective effort and realising the need to work with various stakeholders across different sectors under the project, Vriksha Foundation was formed in early 2019. The Foundation adopted a multidisciplinary approach involving the community from the start, in order to create outcomes that were inclusive and beneficial for everyone. The Foundation remained committed to the creation of artful and regenerative sustainable landscape designs that unite people, aesthetics and ecology.

> **Between the everyday politics and influences that control urban public spaces, democratising boundaries and creating green spaces with counter-narrative strategies is the genesis of my eco-social art practice and post-disciplinary investigations across landscape architecture, urban dynamics, and socio-ecological processes. This work shifts from the general perception of art and moves towards an understanding of the cultural asset as something that lives and evolves. Instead of commodities, each park becomes a place with social meaning and transformative stories associated with it. These are the fields where art is integrated into daily life.**
>
> – Mr. Milan Rai
> Social Practice Artist, Vriksha Foundation

Adopting a solutions-based approach, Vriksha Foundation with the support of the Mayor's office acquired a piece of land for creating a pocket park in Pulchowk, a commercial area characterised by significant grey infrastructure. The selected site for the initiative had been encroached upon for several years and, therefore, required the city's intervention. The people inhabiting the area were mainly temporary residents, including employees and working individuals associated with various business entities, both big and small. Work on transforming this 800 m^2 piece of land into a pocket park took four months and was completed by April 2020. The park is presently maintained through voluntary efforts of the residents and the employees of some local businesses.

The initiative also attracted the attention of UNDP's Accelerator Lab Programme. In order to demonstrate the effectiveness of a pilot project, partial funds for the initiative were raised by the team from Vriksha Foundation from WWF Nepal and UNDP's Accelerator Lab. Some of the funding also came from Lalitpur Sub-Metropolitan City.

In the first phase the development, a work plan to design the small piece of land was chalked out with the involvement of interns and civil engineers. Unfortunately, the city had also planned a road expansion in the vicinity, which led to a reduction of the total land area available for the park, and this required a change to the original design.

To incorporate the different elements envisioned into the design of the park, an analysis of the history, culture and traditional practices for open space management was carried out. The historical use of the land was also researched. Local materials that were robust and required minimal maintenance were chosen in the construction of the park. As the site was very small, most of its surface was hardscaped to accommodate a fair number of users.

Both construction and community and stakeholder engagement elements were considered in the the design of the park, as follows:

Construction elements: After the final design of the park was prepared, the team initiated the work of site clearance and demarcation. Stone was chosen as the main material in the construction of various elements because it was locally available and enhanced natural aesthetics. A low brick wall was also constructed to define the boundaries of the park and act as a visual barrier to the surrounding cluttered privately-owned areas. The 1.2 m level difference of the site is connected via a ramp with a gradient slope that merges with the natural traits allowing informal seating opportunities/areas.

Keeping in mind that the original use of the land before the encroachment was as a shortcut walking passage between two roads, the new pocket park included a meandering path. The path provided a sense of aesthetic as well as a natural course of passage to the people thereby fulfilling the original purpose of the land. The seating arrangements in the park encompass natural canopied areas, which provide shade during summers and other seating areas suitable for enjoying the winter sun. As the site is very small, efforts have been made to balance the rigidity and limitations of the space. Most of its surface was hardscaped to accommodate a fair number of users; however, to allow the movement of rainwater across the site and reduce run-off, contrasting flagstones with random gaps are set on the ground.

With the motive of allowing hassle-free, safe passage and improved accessibility, the entrance to the park was kept open on both sides of the road. Furthermore, in order to address the socio-cultural challenge and to promote a sense of community amongst the people, it was ensured that no fencing around the boundaries of the park would be built. This social design element assisted in imparting a feeling of openness and belonging amongst the local people.

Realising the need to bring a change in the ways of increasing the greenery in the city, native and mature trees of suitable species were transplanted from nurseries to the site. Green elements were carefully evaluated and integrated into the design after consultations with eminent botanist Dr. Tirtha Bahadur Shrestha. The team settled on local-viable species which included various hardy and fragrant species. Herbs, ferns, shrubs, and grasses were planted in mounds cut in between the stone walls up to 1.2 m in height. Trees such as *Ficus benjamina*, and native Cherry (*Prunus cerasoides*) were also added. Wild and native grasses were sourced from peri-urban areas around the city and planted at the site. In due course, other floral elements such as mosses and ferns have anchored in the stones of rock ledges. These add age and calmness to the place, effectively stitching together the urban and the natural environment.

Community participation: Vriksha Foundation's approach to designing and creating better public spaces for city dwellers is a community-based participatory one. To create awareness regarding the park's construction and discuss project sustainability, Vriksha Foundation organised a 'collective intelligence' workshop on 3 December 2019 for the officials of Lalitpur Sub-Metropolitan City and also involved local communities and the private sector. A 'Design Charrette' was also held to discuss the green pocket parks at the studio of Sustainable Mountain Architecture (SMA) Nepal. Forty-four people, including architects, interns, professors, environmentalists and urban planners, joined the event to discuss sustainable design of public open space. Through various engagement activities, a new partnership with permaculture practitioners also came into being and these practitioners and environmental volunteers will ensure supply of native plants and grasses.

Vriksha Foundation is working continually to shift the ownership of the park to the community and make the park an institutionalised component of Lalitpur Sub-Metropolitan City. To ensure the smooth transition to community ownership and guarantee sustainability of this pocket park, the Foundation engaged local residents in upkeep activities. At the time of writing this case study, the

park was being maintained through voluntary efforts of the employees of some local businesses. Electricity is taken care of by the neighbouring shop owners, and locals, such as bike mechanics, voluntarily water plants. The design of the park and materials used for construction, both living and other, requires minimum maintenance. At the time of documenting this case study, the Foundation was still exploring mechanisms for a maintenance grant that will be used to fund a part-time gardener who will take care of overall park upkeep. Waste management and littering is presently a challenge within the park.

Inspired by the outcome of the project, the Mayor of Lalitpur, Honourable Chiri Babu Maharjan, has since provided more land to develop these parks. The Vriksha Foundation team is also in the process of building 11 parks of various sizes in Lalitpur. Through the course of their engagement with the city, the Foundation hopes to develop guidelines and methodologies for the design, planning, development and management for different categories of these open spaces.

The site before the intervention © Milan Rai

The site post the intervention © Milan Rai

Enabling factors

Mr. Milan Rai and his team at Vriksha Foundation pooled their collective resources and knowledge to identify an innovative solution to address Lalitpur's degraded and dwindling public open spaces.

The coordinated efforts of an inter-disciplinary team brought together by a common vision is the starting point for an initiative of this type. While it is not essential that team members be formally educated in matters of ecology and architecture, an understanding of the basic principles, a keen eye for detail and the willingness to learn is important. Integration of indigenous knowledge with technical knowledge helps to translate the vision into a workable solution that brings about community ownership and sustainability.

The pocket park made use of locally-available construction materials, native plants and applied basic design principles that would improve community accessibility and ownership. There were no specific technical elements that were incorporated into the development of the park. However, as the concept of pocket parks evolve, there is scope for integration of technological innovations into the design of such parks.

While the funds required to construct pocket parks are not substantial, a budget that covers operation and maintenance should be developed and vested with the local government, since public open spaces fall under its portfolio. Local businesses can also be encouraged to offer support. In the case of the first pocket park in Lalitpur, funding avenues that were explored included the local government, local businesses and international organisations.

City support was a significant factor that allowed the initiative to take place. The land for the project and removal of encroachment was taken care of by the Mayor's office. At present two initiatives launched by the Lalitpur Sub-Metropolitan City include a 'green fence transparent project',[279] which aims to replace the high brick compound walls of office buildings, public university campuses and parks and playgrounds with railing fences and a 'city-wide green park project'. Beyond these, there are no rules and policies in place to regulate or amplify such initiatives. In order to address this, the project aims to leave behind a legacy that will result in a policy framework and guidelines on greening within the city.

The current practices of public space development (done at the bureaucratic level, designed and implemented by outsiders with little to no community involvement) leads to spaces where accessibility is barred by fenced boundary walls. The main aim of the project was to involve the community at the start, in the planning and execution of the pocket park and finally transfer the ownership to them. Awareness generation, interactions with locals and large-scale community involvement in the process of development of the park are the major elements that enabled the initiative to be successful.

INITIATIVE: POCKET PARKS IN LALITPUR CITY	
Knowledge factors	• Large body of volunteers with multi-disciplinary experience. • Consultations with experts from the fields of botany, urban planning and architecture. • Multi-disciplinary team of Vriksha Foundation and their experience. • Partnerships with professionals from related fields.
Technical factors	• Basic construction and architecture technologies.
Economic factors	• Funding from WWF Nepal, UNDP Accelerator Lab and Sub-Metropolitan City of Lalitpur.

INITIATIVE: POCKET PARKS IN LALITPUR CITY	
Institutional factors	• City support in the form of land for the project and removal of encroachment.
Social factors	• Maintenance of the park has been taken over to a large extent by the local community. • Awareness programmes and community engagement run by the team at Vriksha Foundation.

Replication

In order to develop degraded public spaces into pocket parks, the following resources are critical:

Capacity

An interdisciplinary team, which brings together a variety of perspectives to realise a common vision is beneficial in these types of projects. A dedicated volunteer base or a limited number of dedicated individuals would help in achieving targets. Partnerships have been found to be an important source of innovation and knowledge in the case of the first pocket park, and this observation has also driven the development of knowledge-sharing mechanisms in subsequent park development.

Time for planning and implementation

Depending on the size of the plot and the degree to which efforts from the various stakeholders can be coordinated, timeframes range from between four to six months to develop a single park. It is also recommended that an additional period of one to two years be factored in to monitor the parks, to determine whether any design alterations are required.

Stakeholder engagement

Given that the targeted beneficiaries of these initiatives are the public and local residents, community consultation and engagement is extremely important from the initial planning stages to project execution. Not only does this improve ownership and use, but it also brings in traditional knowledge and fresh perspectives. Furthermore, inviting city officials, who sanction and develop public open spaces, on board ensures a smoother process and can lead to a multiplication of inclusive projects.

Costs and funding

For this particular initiative the total cost of developing 800 m^2 into a pocket park was US$ 13,000. Since the selection of materials and vegetation inputs was done such that minimal maintenance is needed, the maintenance cost of the park is almost zero per month.

Links to Sustainable Development Goals, Aichi Targets and National Biodiversity Targets

SDGs	
Aichi Targets	
National Biodiversity Targets:	2, 3

Key contacts	
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Pocket parks: The greening of degraded public space

Pocket parks can be created out of vacant lots, underused spaces or otherwise forgotten voids in urban landscapes.

SDGs: 

Aichi Targets: 

NbS approach: Infrastructure-related management

Local government	Lalitpur Sub-Metropolitan City
Country and state	Nepal, Bagmati Pradesh
Population	284,922 (2011)
Total area	37.4 km²
Main geography type	Highland

Issues

90% of the houses are built informally

Open public spaces only occupy around **5%** of the total developed area

The city lacks comprehensive zoning regulations

Insufficient green areas or recreational spaces

Actions taken:
Historical land use taken into consideration, local materials, rainwater passage planting, open accessibility and voluntary maintenance by local residents and business employees.

Impacts

800 m² piece of land at Pulchowk, in a commercial area, has been transformed into a mini park through systematic planning, scientifically-guided planting and community participation.

Trees and other plants forming part of these pocket parks act as **'green lungs'** helping to regulate the micro climate and reduce the urban heat island effect.

A multidisciplinary approach was used that involved the local community.

Another 11 parks of various sizes in the city of Lalitpur have been gazetted.

Recharge pond along with contour trench constructed at Dhulikhel, Nepal © Kamal Devkota

NbS approach: Ecosystem-based management approaches

Floating treatment wetland technique implemented at Neknampur Lake, India © Madhulika Sharma Choudhary

HYDERABAD, INDIA: Integrated wetland management system: The case of Neknampur Lake

A city of fast-disappearing lakes

NbS approach: Ecosystem-based management approaches	
FACTS AND FIGURES	
Local government	Manikonda Municipality and Greater Hyderabad Municipal Corporation
Country and state	India, Telangana
Population	6,731,790 (2011)
Total area	625 km^2
Main geography type	Dryland
GDP	US$ 50.6 billion (2018)

The city of Hyderabad is the capital of the newly-formed state of Telangana, located where the rivers Krishna and Godavari intersect in the peneplain. (A peneplain (an 'almost plain') is a low-altitude plain formed as a result of stream erosion.). The city has a rich history and tradition while also being a major hub for trade and commerce. It has emerged as an internationally renowned centre for Information Technology (IT) and in 2018 was named as one of the 'Top 10 fastest growing cities in the world 2019–2035' by Oxford Economics.[280] The Greater Hyderabad Municipal Corporation (GHMC), a civic body which was formed in 2007, administers most of Hyderabad (except the Secunderabad Cantonment area). Manikonda is a commercial hub and residential suburb in Hyderabad, parts of which are governed by Manikonda Municipality. [281]

Plantations undertaken along the periphery of the lake © Madhulika Sharma Choudhary

Hyderabad has many epithets attached to it – such as the City of Pearls, the City of Nawabs, the Biryani City, and at one point, the City of Lakes, because of a series of artificial and natural lakes within its boundaries. Hyderabad is in an area with a hard-rock aquifer, which only allows 7–8% of precipitation to permeate into the ground water table. Past ruling dynasties recognised this geological constraint and built several big tanks between 1534 and 1948 to provide water to their citizens.[282] These were then linked to each other in a cascading form, enhancing natural drainage and acting as reservoirs for stormwater. They were also an important part of the urban ecology.[283] Unfortunately, over the years, urbanisation, urban sprawl and a boom in the real estate industry has led to these water bodies being encroached upon and polluted, diminishing their present significance[284, 285, 286] and increasing the city's vulnerability to climate change.

From 1973 to 1996 Hyderabad went from having 932 tanks occupying an area of 118 km^2 to 843 tanks occupying 110 km^2.[287] This meant the loss of 18 water bodies of over 10 ha and 80 tanks below 10 ha in size. Simultaneously, real estate growth accelerated the extinction of numerous small water bodies in the peri-urban zones.[288] Between 2000 and 2012, a further 3,245 ha of water bodies were lost[289] within the city.

Rapid population growth, industrialisation and agricultural practices since the 1970s have led to the city's aquatic ecosystem becoming so polluted that its original functionality is now redundant. Sewage and industrial discharge make the water unsuitable for domestic purposes and threaten human health through bioaccumulation. For Hyderabad to contribute towards achieving SDG 6, 'Clean water and sanitation for all' (which also feeds into SDG 3 'Good health and wellbeing' and SDG 11 'Sustainable cities and communities'), innovation and improving existing water treatment facilities is required. Within this context, the integrated wetland management of Neknampur Lake presents a low-cost, low-maintenance model that can be scaled up within or outside the city's environs.

Neknampur Lake: From royal to polluted

Neknampur Lake, also known as Ibrahim Bagh Cheruvu, was built under the reign of Ibrahim Quli Qutub Shah, who ruled from 1550 to 1580. It is situated opposite the historical Taramati Bardari Resort, Premamati Mosque and Qutub shahi tombs, and barely 2 km away from Golconda Fort. The lake's purpose was to water Ibrahim Bagh, the Royal Garden. Building gardens was an ancient art of the Qutub Shahi dynasty, which included its own traditions as a material and spiritual representation. Home to trees of sustenance, flowers of fancy, earth of peace and waters of love, the Persian garden was a complete and harmonious world on its own. To irrigate the garden, the Neknampur Lake bund was raised to 80 m converted it into a tank allowing for the constant flow of water from higher level to lower level. Neknampur Lake also was a drinking water source which catered to travellers at Taramati Bardari, religious devotees at Premamati Mosque and the Qutub Shahi Tombs.

LAKE STATISTICS
Location: Latitude 17°39'N and Longitude 78°37'E
Altitude: 185.02 m above mean sea level
Catchment area: 77 acres
Lake area: 97.830 acres
Lake maximum depth: 20 m
Lake perimeter: 5,120 m
Existing sources of water to the lake: A natural nalla from the northern side and ground water infiltration
Average annual rainfall in the lake catchment area: 592.85 mm

Located in Neknampur village, under Manikonda Municipality, on the fringes of the boundaries of GHMC, the lake was part of a water reservoir network for irrigation and drinking and had been an inalienable part of the rural ecology of the village. It is downstream of another important lake in Hyderabad, Durgam cheruvu, connecting to Musi River behind Taramati Bardari.

Between 2006 and 2013, as the area urbanised and its real estate value sky-rocketed, several lakes and tanks were encroached upon and replaced with concrete buildings, leaving only Ibrahim Bagh Cheruvu. This lake, too, was not untouched. It underwent drastic changes in ecology, land- use and management in the past decade. The biodiversity of the lake began to decrease, and by 2008 the lake had begun to dry up because the incoming water channels were blocked by construction activities, the dumping of debris and garbage. By 2013, the lakebed was a slushy, malarial hotspot of sewage and waste. It remained severely polluted with domestic and industrial effluents until 2016.

Scientific investigations conducted by the Telangana State Biodiversity Board on Neknampur Lake highlighted that the water body was full of sludge and extremely eutrophied, showing elevated algal growth. This was mainly because of the unabated entry of sewage and other waste over an extended period into the lake.

The metamorphosis: Reviving the lake ecosystem

How the initiative was implemented

In June of 2016, Madhulika Choudhary and her NGO, Dhruvansh, decided to adopt Neknampur Lake and thus began a series of interventions that incorporated bioremediation and phytoremediation techniques into a restoration plan for the lake. They used traditional and technological methods to restore Neknampur Lake as a low-cost sustainable model without sewage diversion or a sludge treatment plant.

> **Lakes are resilient entities that represent centres of knowledge and skill development for those who are willing to see it. Since I took up this project, I have learned how to think outside the box, how to transform waste into wealth, how to innovate on a tight budget and how to adapt ecological principles within an urban environment. With the future of water security being uncertain especially in cities like Hyderabad, I believe water recycling through the restoration of our urban lakes will secure our water supply.**
>
> – Ms. Madhulika Sharma Choudhary, Founder, Dhruvansh

With support from various government institutions like the Manikonda Municipality, State Irrigation Department, Ranga Reddy District Collector, Hyderabad Metropolitan Development Authority (HMDA), Telangana State Pollution Control Board (TSPCB), Telangana Fisheries Department and Telangana State Biodiversity Board, Dhruvansh began the revival of the lake across two phases: 1) Revival of the lake periphery and the lake body, followed by 2) Revival of the lake ecosystem.

The following activities were undertaken to conserve the lake: planting, cleaning, desilting, catchment area treatment, fringe area protection, solid waste management, installation of floating treatment wetlands, implementation of phytoremediation techniques, removal of aquatic weed systems and composting.

The main principles that were incorporated into the management of Neknampur Lake are **bioremediation** and **phytoremediation**. This involves aquatic plants absorbing inorganic and organic compounds including heavy metals from the water, incorporating the dissolved materials into their own tissues and thus purifying waste or contaminated water. The inlet water stream carrying domestic waste is stored in a wetland and is purified by species of aquatic plants (such

Removal of weeds from the lake © Madhulika Sharma Choudhary

as common reeds, bulrushes, water hyacinth, duckweed, elodea, hydrilla, lotus) suitable for the local condition and is then allowed to flow into the receiving water body. Moreover, the aquatic plants can then be harvested and safely used as fertiliser, for fibre or biogas production. Nitrates, ammonium compounds, phosphates and organic carbon are nutrients often needed in fertiliser composition. Aquatic plants used for purification (phytoremediation, as above) therefore show promise in providing an indigenous, inexpensive source of organic fertiliser and soil conditioner available to low-income farmer groups.[290]

a. Phase 1: Revival of the lake body and periphery

The various steps taken to revive the lake periphery and the lake body are detailed below:

Phytoremediation, a clean-up technology for polluted soils and water that is both low-tech and low-cost, is defined as "the engineered use of green plants (including grasses, herbs, and woody species) to remove, contain, or render harmless such environmental contaminants as heavy metals, trace elements, organic compounds, and radioactive compounds in soil or water".[291]

To implement the phytoremediation techniques, cleaning of the lake, pitting and removal of garbage was executed. Around 5,000 saplings of various trees like *Millettia pinnata, Azadirachta indica, Delonix regia, Magnolia champaca, Grevillea robusta, Manikarnika zapota, Ficus religiosa, Cassia* sp., *Canna* sp., *Carica papaya, Phyllanthus emblica, Alstonia scholaris, Bougainvillea* sp., *Thevetia peruviana, Plumeria* sp. and *Hibiscus rosa sinensis* were planted on the lake periphery. The species selected were primarily based on the species freely available in GHMC nurseries. Phytoremediation species like sunflower, elephant ears and *Canna* were also introduced.

Composting of organic material – such as aquatic weeds, leaves, surface weeds and decomposable garbage – if done effectively can reduce the viability of the weeds and allows for the safe re-use of the nutrients and organic matter contained in the weed material. Aquatic weeds are removed regularly from the lake and converted into nutritious fertiliser to be used by local farms or nurseries.

A stormwater treatment pond at the inlet was constructed to restrict the direct input of sludge and metals and to inactivate phosphorous. Phosphorous is precipitated by clay and carbonate particles present in water and sludge is filtered by gravel and wetland plants absorb a large amount of nutrients and heavy metals.

Separate pond for idol immersion: An integral component of the celebrations associated with festivals like Ganesh Chaturti, Durga Pooja or Vishwakarma Puja is idol immersion. Traditional idols were made of clay and natural colours and were much smaller in size than those sculpted today. Idol immersion is a significant source of water and soil pollution because of the presence of contaminants like Plaster of Paris, plastic decorative material, thermocol and chemical lead-based paints and are toxic to aquatic ecosystems. To protect the lake from these contaminants, a separate tank adjacent to Neknampur Lake was established and is dedicated for idol immersion.

b. Phase 2: Revival of the lake ecosystem

Biological treatment: Biological control methods are employed to control the growth of aquatic weeds in rejuvenation practices. Organisms used for this purpose are called biocontrol agents or simply bioagents. The more promising bioagents of aquatic weeds are the *Cyprinus carpio* (common carp), *Ctenopharyngodon idella* (Chinese gram carp), *Oreochromis* (tilapia) and *Hypophthalmichthys molitrix* (silver carp). These carps are voracious feeders, consuming their body weight in plant material.

In Neknampur Lake, after consulting the State Fishery Department, grass carp were introduced as a bio-agent along with species like *Labeo rohita* (rohu), *Catla catla* (catla) and *Cirrhinus cirrhosus* (mrigal). *Melanochelys trijuga* (Indian terrapins) already exist in the lake in addition to *Lissemys punctata* (flap-shelled turtles). These species help to control the excessive growth of some aquatic weeds introduced as phytoremediation agents.

Aeration of lake water accelerates digestion of the organic bottom deposits that stimulate excessive weed and algae growth. Aeration reduces anoxic conditions and produces aerobic conditions by bacterial seeding which speeds up aerobic digestion. It is a practical solution for taste and odour control when volatile compounds, such as hydrogen sulphide or ammonia cause problems and it can reverse pond and lake aging.[292]

Aeration is mainly based on artificial water circulation by pumps, jets and bubbled air, or a diffusion aeration system, which causes destratification of the lake. Destratification has the potential to reduce phosphorus concentration, which is responsible for algal blooms in lakes.

In the case of Neknampur Lake, three fountains were installed using sludge motors along with one subsurface diffuser for bottom aeration and six floating aerators of two horse power.

Sediment basins result from processes of sedimentation, the deposition of soil particles that have been transported by water or wind. As the sediments get deposited in a river or reservoir, its total storage capacity reduces, leading to a reduction in the life of the waterbody. Regular desilting is critical as the sediment deposited leads to erosion of the banks and side slopes, affects the aquatic life, and alters physical and chemical properties of water.

A sediment basin is a water storage area provided by excavating a pond and placing an earthen embankment across a low area to intercept sediment-laden runoff.[293] These basins are generally larger and more effective in retaining sediment load than temporary sediment traps. These are also known as desilting basins, which collect and trap sediment runoff. Sediment basins are installed such that the maximum amount of sediment is entrapped in the basin allowing sediment-free, clear water to pass through the basin into the reservoir/ lake. They are located and designed in such a way that failure of the structure would not result in loss of life, houses or construction to public property like commercial buildings, streets etc. Five sediment basins were constructed around the lake.

Floating Treatment Wetlands (FTWs) are an innovative solution engineered to boost the natural process that occur in an aquatic ecosystem between water, plants and microorganisms in order to passively remove pollutants from wastewater and stormwater.[294]

FTWs are human-made ecosystems that mimic natural wetlands. Though similar to traditional constructed wetlands in many ways, FTWs rely on artificial buoyant scaffolds to support plant material grown hydroponically.[295] The rafts float on a wet pond water surface and can be used to improve water quality by filtering and consuming nutrients from lake water. FTWs may represent a relatively low cost and sustainable engineered best management practice for reducing pollution in lake water.

FTWs were chosen over constructed wetlands for water treatment at Neknampur Lake because of: (i) the area limitation owing to disputed land ownership of the peripheral land, (ii) theft of saplings as well as destruction of plants by animals, (iii) absence of a secured periphery, and (iv) because it would treat the sewage at the inlet directly. The floating islands also provide refuges for various animals that use the lake. A 232 m^2 floating island with 3,500 wetland plants was installed. The island structure comprises 27 units of a 3 m by 3 m raft with thermocol on all four sides attached to plastic bottles and bamboo to ensure that it remains afloat, a plastic mesh, a gunny bag placed on the top, followed by a layer of gravel in which aquatic plants known to absorb pollutants are planted. The plants used include vetivers, canna, bulrush, lemon grass, fountain grass, lilies, *khus*, and other flowering plants. Mosquito repelling plants, such as citronella, lemon grass, were also planted.

Several activities take place on a weekly basis at the lake, such as cleaning drives, cultural programmes, pottery workshops and bird watching. Institutions who are affiliated with certain activities conducted at the lake include:

1. WWF Telangana
2. People for Animals
3. Snake for Shelter
4. Helping Hands
5. Hyderabad Birding Pals

Floating treatment wetland technique being applied in the lake © Madhulika Sharma Choudhary

TABLE 15: Actions undertaken as part of the Neknampur Lake restoration initiative

TYPE OF ACTION	ACTORS INVOLVED AND ACTIONS UNDERTAKEN
Policies/strategies/plans	• Dhruvansh, TREDA SS Green Community Members, Grampanchayat Neknampur, CI Narsingi, 11 schools and two colleges undertook planting drives under the Haritha Haram[296] and HMDA plantation scheme.
Governance/organisational	• Telangana State Pollution Control Board regularly monitors and tests the water. • The Collectorate of Rangareddy district together with Dhruvansh undertook cleaning of garbage and installed electric poles at the lake. • The Collectorate, Irrigation department and GHMC supported the installation of Telangana's biggest tank of 21m width and 2m depth. • The Fishery department introduced 20,000 fish in the lake to support bioremediation.
Stakeholder engagement	• Barbed wire fencing was introduced at the lake through stakeholder engagement by the SS Green Community. • After introduction and survival of fish, the initiative received support from the fisher community.
Funding/finance/fiscal measures	• USD 2,212 for lake cleaning in 2017 was released by HMDA. • Monthly salaries for 11 staff and a monthly maintenance budget are taken care of by the Rangareddy District Collectorate.
Technical and technological measures	• Dredging utility craft to dredge the lake and remove aquatic weeds and Ganesh idol residue was provided by the HMDA. • The first floating island (3mx3m) at the lake was introduced, followed by India's biggest humanmade floating island in Neknampur Lake, with support of HMDA and TSPCB.
Awareness raising	• 32 programmes on the importance of the lake and its ecosystem between 2016–2018 were conducted by Dhruvansh. • Clay Ganesha idols annually distributed at lake and awareness and facts provided about Ganesh Festival by Dhruvansh with HMDA support.

Impacts

The first phase of the restoration was completed in October 2018. Restoration activities continue as part of the operation and maintenance of the lake. The lake now hosts a total population of 60,000 plants represented by 132 species of plants, 178 species of birds, 12 species of mammals, 21 species of reptiles, varied species of insects and a population of around 20,000 fish consisting of *rohu, catla, mrigal* and grass carp. Today, the floating island occupies an area of 557 m^2 with 7,000 saplings.

Water quality parameters such as dissolved oxygen improved considerably while Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and other nutrient inputs decreased, which demonstrated the project's success. A small nursery was also established with wetland species alongside a small-scale waste-to-wealth set-up (composting and recycling unit). In the absence of the initiative, in a business-as-usual scenario, the lake would likely have completely disappeared due to eutrophication or encroachment.

TABLE 16: Results of water quality analysis of Neknampur Lake over the course of the intervention

PARAMETER	2016 NOV	2017 JUNE	2018 JAN
pH (µmhos/cm)	7.63	7.87	7.18
Dissolved Oxygen (mg/l)	2.5	NIL	4.2
Nitrates (mg/l)	9	12	21
Phosphates (mg/l)	0.5	10	1.93
BOD (mg/l)	8	6	3.8
COD (mg/l)	153	59	32

A major success reported by the initiative is that the lake is now being included as a water body to be regularly monitored by the TSPCB under the National Water Quality Monitoring Programme. Not only has the project led to an increase in aquatic biodiversity and conversion of sewage water into freshwater, but it has also provided a source of livelihood to the locals who are employed to maintain the plants and lake. The compost generated from maintenance of the aquatic weeds is sold to local flower shops and nurseries. Further, micro-initiatives such as the upcycling of solid waste collected from the lake cleaning, development of a mini-vegetable patch irrigated by the lake water, and manufacture of pots and bricks from desilted lake clay have also been taken up to generate some revenue. A small nursery has been started that sustains further planting at the lake. The lake is also a knowledge hub for school and college students with at least 35 institutions visiting it regularly for the purpose of education and research.

Challenges

The main challenge in this project was forging new approaches for governing and managing the urban commons in a fast-growing city where the communities that live around the lake are constantly in flux. The main technical challenges encountered were the constant flow of sewage and re-growth of aquatic weeds. Although biodiversity increased in and around the lake, this led to new difficulties. Pythons were crushed under four wheelers travelling along the lake bund, birds and terrapins were being poached, and incidences of forest fires increased in the afforested areas around the lake. Permanent solutions to these challenges are yet to be found.

Enabling factors

Madhulika Choudhary and her NGO Dhruvansh initially took up Neknampur Lake's restoration as a personal project. The entire process from start to finish required hands-on learning and adapting to the various challenges that presented themselves. The lake now stands as a low-cost, knowledge-incubator, generating essential ecosystem services for the area.

Although a comprehensive knowledge of restoration ecology was not critical to the success of the intervention, it was important that those involved understand the basic carbon and water cycle. Monitoring water quality through regular testing continues to be essential to the project's success. Traditional knowledge which was brought in by local community members who were employed as staff further contributed to the intervention's success and proved essential to long-term maintenance.

Phyto and bioremediation were the main technologies that enabled the intervention. The lake also served as a laboratory where experiments could be carried out to determine what did and did not work. The selection of plant species, for example, are ecologically unconventional, relying on readily-available urban/ornamental species. However, resource constraints and constant experimentation through trial and error as well as regular monitoring determined their choice.

This restoration is an example of a low-cost sustainable model that can easily be replicated where funds are a constraint. In fact, lack of funding was the main driver for innovation within the project, which motivated cheaper, outside-the-box solutions. Furthermore, the project has also begun to convert waste collected from the lake into opportunities for wealth, reusing material like discarded cloth for banners, upcycling coconuts into pots, flowers into bio-enzyme cleaners, converting collected clay and silt into flowerpots and bricks, etc. Recyclables collected are also sold. The main requirement in terms of funding in this case, is a budget for maintenance without which the lake will revert to its original state.

The Haritha Haram programme, implemented by the Government of Telangana to increase the tree cover in the state, supported the project with funding for protection and maintenance. In the absence of a specific law aimed at protecting and conserving lakes, wetlands or other aquatic ecosystems, this programme has proved to be the most effective protection for Neknampur Lake. Further economic support has come from the local governments who pay regular monthly salaries to the staff and bear some of the maintenance costs.

INITIATIVE: INTEGRATED WETLAND MANAGEMENT OF NEKNAMPUR LAKE	
Knowledge factors	• Traditional knowledge of hired local community members who work as maintenance staff. • Basic knowledge of water and carbon cycles. • Constant on-the-ground innovation through trial and error.
Technical factors	• Integrated wetland management through phytoremediation and bioremediation.
Economic factors	• Support from local government for maintenance and staff salaries. • Entrepreneurial innovation by converting waste to wealth.
Institutional factors	• Haritha Haram Programme.
Social factors	• Local villagers supported the initiative. • Awareness programmes around good sanitary practices, the importance of the ecosystem and its biodiversity.
Environmental factors	• Lake biodiversity that buffered phyto and bioremediation techniques.

Replication

In order to carry out an integrated wetland management system for Neknampur Lake, the following resources proved critical:

Staff/capacity

Staff familiar with greening and maintenance work was essential. Ideally hiring from within the local community will improve ownership of the initiative, promote green jobs and protect traditional knowledge linked to biodiversity and ecosystem management.

Time for planning and implementation

Two and a half years was needed in this project for the lake to regain full ecosystem function and for the restoration to be complete.

Stakeholder engagement

Institutional support was an important factor in this project since it involved common property resources. By engaging with the relevant administrative bodies and gaining their support, the project was able to overcome obstacles posed by local real estate factions. Engaging with community members also supported acceptance of the project, created awareness and recruited labour for the project.

Costs and funding

The total cost of the project was US$ 50,410.

The project involves monthly maintenance cost of approximately US$ 2,725.

Links to Sustainable Development Goals, Aichi Targets and National Biodiversity Targets

SDGs	
Aichi Targets	
National Biodiversity Targets:	

Key contacts	
Name	Ms. Madhulika Sharma Choudhary
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Restoring Neknampur Lake

The ecological restoration of Neknampur Lake has improved the ecological services it provides and restored the glory of this historically significant lake.

SDGs:

Aichi Targets:

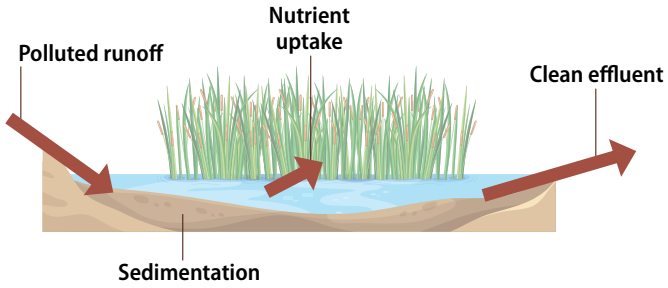
NbS approach: Ecosystem-based management

Local government	Manikonda Municipality and Greater Hyderabad Municipal Corporation
Country and state	India, Telangana
Population	6,731,790 (2011)
Total area	625 km²
Main geography type	Dryland

Issues

- Between 2006 and 2013, as the area urbanised, its real estate value sky-rocketed.
- Several lakes and tanks were encroached upon and replaced with built infrastructure.
- By 2013, the only lake left in the vicinity was a slushy, malarial hotspot, filled with domestic and industrial effluents.

Solutions



Floating treatment wetland technique

Biological treatment | Phytoremediation (using plants to remove pollutants) | Composting of organic material | Planting | Desilting

Results

- Restored lake
- Improved water quality
- Improved dissolved oxygen levels
- Enhanced biodiversity

Number of species

178 Birds

132 Plants

12 Mammals

21 Reptiles

BOX 7: SHORT CASE STUDY ON ECOSYSTEM-BASED MANAGEMENT APPROACHES

BENGALURU, INDIA: Kyalasanahalli Lake rejuvenation

The why

NbS approach: Ecosystem-based management approaches	
FACTS AND FIGURES	
Local government	Bruhat Bengaluru Mahanagara Palike (Greater Bangalore Municipal Corporation
Country and state	India, Karnataka
Population	8.44 million (2011)
Total area	741 km^2 (2021)
Main geography type	Lowland

Bengaluru was once known as the 'city of lakes'. However, owing to rapid urbanisation and a swelling population, Bengaluru has now become the 'city of concrete'.[297] Infrastructure development in the city has led to encroachment of the lakes and a decrease in groundwater levels. To help restore the lake ecosystems through groundwater recharge and conserve biodiversity to maintain a natural balance, Mr. Anand Malligavad, a lake conservationist, initiated the Kyalasanahalli lake rejuvenation project in April 2017. The rejuvenation process took 45 days and was completed on the 5 June 2017, with a budget of US$ 135,000.

The what

Kyalasanahalli Lake is spread over an area of 36 acres. It is located in Jigani Link Road, Anekal Taluk, Bengaluru. Over the years, the lake had been reduced to a shallow pond, mainly because almost 15 acres were encroached upon by villagers, who had been using the land for cultivation and to graze cattle. Realising the need to restore the lake's water and to provide surplus potable water to nearby settlers, Mr. Malligavad rejuvenated the lake. The Sansera Foundation provided financial support.

The how

For eight months, Mr. Malligavad along with a team of volunteers carried out extensive research on the revival of the lake. Nearby villagers were consulted to incorporate indigenous knowledge and stakeholder buy-in to the conservation process. Based on a field survey, the municipal corporation then demarcated the lake boundaries in order to examine the extent of encroachment.

Around 4.6 m^3 of soil was excavated from the lake and bunds were created all around the lake to increase the lakes' capacity by 25 times. To capture rainwater during the monsoons and thereby increase water flow into the lake, open stormwater drains were unclogged and water inlet channels were cleaned. In addition, five islands were created within the lake on which saplings of fruit-bearing and flowering trees were planted. Using the Miyawaki method, about 18,000 saplings of medicinal and native tree species were planted around the lake.

Miyawaki is a technique pioneered by Japanese botanist Dr. Akira Miyawaki, that helps build dense, native forests. The approach is supposed to ensure that plant growth is 10 times faster and the resulting plantation is 30 times denser than usual,

Recreational infrastructure, including demarcation of an area for jogging around the lake and benches for sitting, was also added.

Kyalasanahalli Lake rejuvenation: Restoring the City of Lakes

Restoration of a degraded lake to augment ecosystem services, improve quality of life and reinstate the glory of the City of Lakes.

SDGs: Aichi Targets:

Issues

- Increased cultivation in the lake area
- Lowering of the groundwater table
- Infrastructure development
- Encroachment due to grazing by domestic animals

Lake encroachment

Of the total 36 acres of the Kyalasanahalli Lake, 15 acres had been encroached, leading to significant degradation.

NbS approach: Ecosystem-based management

Local government	Bruhat Bengaluru Mahanagara Palike (BBMP)/ Greater Bangalore Municipal Corporation
Country and state	India, Karnataka
Population	8,443,675 (2011)
Total area	741 km^2 (2021)
Main geography type	Lowland

Rejuvination approach

- **4.6** m^3 of soil was excavated to increase the depth of the lake bed.
- Drains were unclogged. Water inlet channels were cleaned.
- Through the Miyawaki method* about **18,000** saplings of medicinal and native tree species were planted.
- Trails for jogging around the lake and benches for sitting were also added.

*An afforestation technique that uses native species to create dense, multi-layered forests

The who

Mr. Malligavad, a lake conservationist, is the major driving force behind the initiative. Other stakeholders involved the initiative's success include the Sansera Foundation, local community and volunteers, local government agencies, the Taluk Municipality Committee and other local authorities.

The where

The lake rejuvenation initiative took place in the city of Bengaluru and has now spread to adjoining areas. Since 2017, nine lakes, including Kyalasanahalli Lake, have been rejuvenated. 450 borewells in more than 23 villages have also been successfully recharged.

Key contacts	
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BOX 8: SHORT CASE STUDY ON ECOSYSTEM-BASED MANAGEMENT APPROACHES

DHULIKHEL, NEPAL: Building water security in Dhulikhel municipality through the revival of traditional solutions

NbS approach: Ecosystem-based management approaches	
FACTS AND FIGURES	
Local government	Dhulikhel Municipality
Country and state	Nepal, Bagmati
Population	33,981 (2011)
Total area	54.62 km^2
Main geography type	Highland

The why

Dhulikhel is a popular hill station in Nepal, for local and international visitors where tourism is the mainstay.[298] In recent years, the water demand in Dhulikhel has sharply increased because of the influx of tourists and establishment of big institutions such as Kathmandu University and Dhulikhel hospital. Together, these add to the ever-increasing demand for water for purposes beyond drinking,[299, 300] leading to springs drying up in the surrounding hills.

The what

The key stakeholders in Dhulikhel realised the problem of declining water flow in local springs and worked with a local organisation, the Southasia Institute of Advanced Studies (SIAS), to pilot water recharge techniques.[301, 302, 303] The water recharge system[304] used a network of ponds and trenches to recharge springs in the area.[305] The first phase of construction was co-financed by SIAS and Dhulikhel Municipality, whereas the Municipality alone allocated funds for the second phase of pond construction.

The how

Dhulikhel initiated evidence-based policy and planning and co-developed an innovative tool for evidence-informed dialogue called *Pani Chautari*.[306] Indigenous knowledge from stakeholder groups was dovetailed into technical knowledge and the assessment of three factors i.e.; runoff collection, drainage channels and safe disposal of excess water. This was further supplemented by a micro catchment map and national guidelines provided by Department of Local Infrastructure Development and Agriculture Roads (DoLIDAR).[307, 308, 309, 310, 311]

The process identified three types of recharge ponds, excavated ponds, embankment ponds and contour trenches which were constructed inside forest land in the municipality at high elevations. 64 small-scale ponds varying in size and shape from 3.45 m^3 to 35.69 m^3 were piloted in two phases on the terraces of hills.[312]

The recharge ponds and trenches proved successful in increasing water discharge from the existing sources and steady spring discharge, thus leading to the initiative being upscaled by the local stakeholders and incorporated in the municipal planning due to its low cost and easy monitoring. This is illustrated in the Municipality's 'One Ward One Pond Programme' that has been included in the fiscal year 2017–2018 plan.[313, 314, 315, 316, 317]

The who

SIAS has been, over the last six years, supporting Dhulikhel Municipality to practice evidence-informed dialogues towards resolving local water management related problems.

The where

Dhulikhel Municipality is situated 30 km east from Kathmandu in Kavrepalanchok district. The Municipality was established in the 1980s and is comprised of 12 wards.

Key contacts	
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Organisation	Southasia Institute of Advanced Studies (SIAS)

Embankment pond built at Dhulikhel, Nepal © Kamal Devkota

Building water security through the revival of traditional solutions

NbS approach: Ecosystem-based management

Local government	Dhulikhel Municipality
Country and state	Nepal, Bagmati
Population	33,981 (2011)
Total area	54.62 km^2
Main geography type	Highland

SDGs:

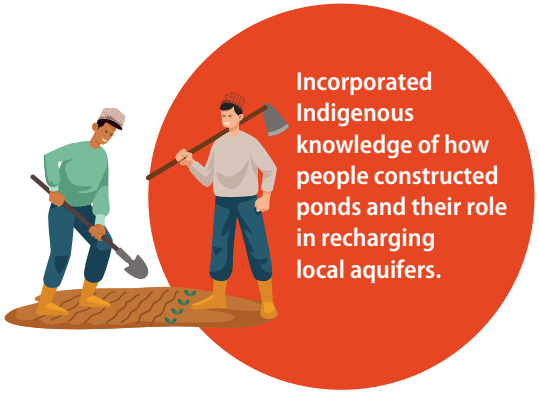
Aichi Targets:

Pani Chautari, a multi-stakeholder forum, provided the platform for collective learning among researchers and stakeholders supporting the management of water scarcity.

Issues

Built-up infrastructure is replacing agricultural lands, forests, open spaces and hills.

Impacts of urbanisation manifested in the form of water scarcity with the drying of springs around the hills.



Impacts

Revival of traditional groundwater recharge mechanism by constructing a network of ponds to recharge drying up springs.

64 small ponds were constructed in two phases.

A locally suitable Nature-based Solution for sustainable water management also served as a socially-inclusive climate change adaptation measure.

Restored forest at Jabarkhet Nature Reserve, India © Jabarkhet Nature Reserve

NbS approach: Ecosystem-protection approaches

Recovery of ground vegetation © Jabarkhet Nature Reserve

MUSSOORIE, INDIA: Protecting private forest patches: Jaberkhet Nature Reserve

Managing tourist congestion in a natural haven

NbS approach: Ecosystem-protection approaches	
FACTS AND FIGURES	
Local government	Nagar Palika Parishad Mussoorie and Mussoorie Dehradun Development Authority
Country and state	India, Uttarakhand
Population	30,118 (2011)
Total area	67.6 km^2
Main geography type	Highland

Located at an average elevation of 2,000 m above sea level, Mussoorie, the 'Queen of Hill Stations', was a popular summer getaway for the British gentry of colonial India. Today, it is a popular hill resort with hundreds of hotels catering to large numbers of tourists. The municipal corporation is divided into 12 wards administered by the Nagar Palika Parishad Mussoorie (NPPM). Situated in the Himalayan foothills, the landscape features high viewpoints, waterfalls, gardens and historic architecture. Tourism is the almost exclusive contributor to this hill-town's economy.[318] Other than tourisms, education is an important sector with several prominent boarding schools located here.

According to tourism department officials quoted in *The Hindustan Times*.[319] 2.7 million tourists visited Mussoorie in 2017 and over 2.8 million in 2018. The city's infrastructure and facilities to accommodate such large numbers is limited due to its geographical location and ecological

Degraded forest at the site, prior to the initiative © Jabarkhet Nature Reserve

Dense canopy cover of restored forest at the site © Jabarkhet Nature Reserve

fragility. This leads to issues such as acute water scarcity, traffic congestion, solid waste management problems and pollution.[320, 321] Excessive tourism beyond the city's carrying capacity coupled with various developmental activities has, therefore, resulted in the environmental degradation of Mussoorie.[322]

Mussoorie's green cover is characterised by forest vegetation consisting of oak (*Quercus leucotrichoflora*) and deodar (*Cedrus deodara*). Since the 1960s, this green cover has slowly been replaced by houses, hotels and other infrastructure that caters to the growing population as well as the growing tourist base.[323] The construction activity witnessed a significant surge between 1990 and 1997, reducing the forest cover by 4.38 km^2 and increasing the built-up area by over 4.32 km^2.

The vegetation, in general, and the oak forest have been heavily altered and degraded by human activities such as forest fires, solid waste dumping and deforestation.[324, 325] More than 50% of the garbage generated goes onto the hill slopes.[326] Between 1960 and 1985, of the 64 km^2 area occupied by Mussoorie municipal corporation, 26.9% had undergone land-use change. The maximum change recorded was in oak forests, followed by scrub/shrub, agriculture, habitation and oak-pine areas. This trend continued in 2009,[327] where the decline in forest cover was accompanied by an increase in built-up areas, especially in the Mussoorie Hills.

Given the serious and ever-increasing threat to the fragile ecology of the Himalayas, maintaining the ecological integrity of the area calls for more integrated and adaptive management approaches and innovations.

Jaberkhet Nature Reserve: A long history of use

Jaberkhet Nature Reserve (JNR) is located on the Mussoorie-Dhanolti Road, just a few kilometres from the centre of Mussoorie. The history of the area where the Reserve has been traces back to

records from the mid-1800s kept by the British owners. Originally known as Rockville, the 952 acres of mostly oak and pine forest was primarily used to source wood for charcoal, to meet the needs of the Mussoorie town, the brewery and the cantonment. During this period, cutting trees in the area was rampant with little done to sustainably manage the property.

In the 1900s the property passed into the hands of various Indian owners and their heirs. The forests were managed during this time according to various working plans in partnership with the Forest Department. The estate was divided between three brothers, one of whom was Mr. J. P. Jain, owner of Jabarkhet Estate I (part of which forms the JNR) who deeply cared for his property and the surrounding area. Mr. Jain made serious efforts towards conserving and managing the Jabarkhet land and forests.[328]

A formal working plan was designed by the estate owners in the 1960s, which divided the forest into 50 compartments that were rotated annually for the purposes of logging, removing dead and fallen trees and planting. This was done in order to harvest the forest to meet the local needs of firewood, timber and charcoal while ensuring adequate regeneration and sustainability.

Under the supervision of Mr. J. P. Jain, valuable species like deodar, pine, were planted in various areas of the estate. Experimenting with horticulture and floriculture produced varieties of walnut, chestnut and other fruits that were suitable in the region and could also be replicated in other villages of Tehri-Garhwal. The estate provided employment to over a hundred local people generating local economic benefits. During this period because of the robust management plan, despite harvesting of trees, forest cover improved and wildlife thrived in the area.

In 1980s, the government ban on tree felling on slopes above 1,000 metres in Uttarakhand, completely disrupted the estate's major source of income. This affected forest management in the estate, leading to unchecked use and exploitation of the area. Locals conducted a number of extractive activities in the form of deforestation, fodder and firewood collection and cattle grazing. In summers, forest fires spread into the estate from neighbouring estates leading to the destruction of the habitat.

In spite of all of these issues Mr. Jain maintained his efforts to engage with the local people on how shifting to more responsible and sustainable practices would still have benefits to them. The rich biodiversity at the JNR is primarily due to his efforts to enhance and preserve the ecosystem over five decades. Post his death in 2007, new management challenges emerged because his descendants no longer reside in Mussoorie.

By 2012, the area had deteriorated. The ground vegetation was completely degraded as a result of overgrazing while hillslopes were covered with invasive weeds and trash left behind by visitors. Grass and timber were overharvested on one hand and wildlife was being poached. Forest fires were increasing in frequency.

Turning a neglected and degraded forest into a biodiversity haven

The present conservation efforts that began in 2013 were a joint effort between the owners of Jabarkhet Estate I and a conservation professional, Dr. Sejal Worah, who had been visiting the area since the 1980s and was concerned about its deterioration. Jabarkhet Estate I is an important catchment for Mussoorie, making its conservation even more essential. Over the last seven years, significant progress has been made towards the restoration of the natural beauty and ecology of about 100 acres of the estate. The idea was also that the estate, while contributing to conservation of the area, would be an economically-viable model.

The initiative was established to demonstrate how conservation can also make good business sense and encourage other private forest owners (and community-owned forests) to promote forest

conservation. The JNR initiative was launched as a Limited Liability Partnership (LLP) between the owner and the conservation professional. Together they put in the initial seed investment for the initiative.

How the initiative was implemented

During the restoration period, over 800 kg of trash was removed and the area was completely cleaned up. Over three tonnes of the exotic weed, *Eupatorium*, was uprooted and sections of the forest are being maintained as 'weed free' to allow native vegetation to recover. During the clean-up over 100 snares were also removed from the site. Three waterholes have been developed to augment water supply for wildlife in the area. Several hundred indigenous trees have been planted.

While the project employed traditional ecological restoration techniques, the main focus was to remove human pressure, allowing the forest to recover naturally. This required substantial interaction with the local users. Pre-restoration, the area was used by several stakeholders including hikers and joggers, and locals who collected firewood and grass or grazed livestock and used/sold other natural resources. There was significant initial resistance to the idea of converting an area that was being used without any restrictions to what was being proposed. The project team set out to change local mindsets from free-use to controlled-use. They highlighted how the initiative would not put a stop on all activity within the estate, but that it would transition towards bringing in other kinds of economic benefits, such as those from ecotourism and other stewardship activities.

In creating jobs for locals who used the area, the project team was able to mobilise support. The first recruits were local women who were collecting various natural resources from the forest. These women were trained to be the first line of defense, acting as rangers who would receive visitors

Restoration of water sources © Jabarkhet Nature Reserve

and deter miscreants. The women also helped regulate the use of the estate by graziers and wood collectors. Unemployed but educated young boys were trained as nature guides, some of whom were absorbed into the initiative to act as guides, taking visitors out onto the trails. The JNR now has a total of seven full-time staff, which include three local women, three local guides and a local villager who looks after the general management of the place. Others are employed part-time and on a needs basis.

Based on agreements with the villagers, grazing has been controlled, along with hunting, tree cutting and lopping, as well as grass collection and gathering of other forest products. At the same time, provisions are being made to generate jobs and employment for the local villagers and to help augment the local economy.

The main revenue generator is guided nature walks, which have been designed keeping in mind carrying capacity and minimal ecological disturbance. There are currently eight well-demarcated trails that visitors can navigate with a trained local guide or using a map. The trails are marked on the ground and on a map that provides a description of each trail, including the best seasons to visit and what to look for on each trail. The trails are linked to the field guides through colour coding and, depending on the season, one can look for specific trees, flowers or mushrooms. The area is divided into various zones that allow certain activities, such as picnic spots, view-points, and areas for grazing and firewood collection. There is no major, permanent infrastructure. The number of visitors to the reserve is tightly regulated (never more than 30 a day) to ensure the carrying capacity of the area is not violated. Visitors are also not allowed between sunset and sunrise.

Part of the revenue also comes from memberships (both individual and institutional), which provides a stable source of income. From the outset, the founders were clear that rewilding and restoration of the forest was the primary aim and that nature walks with minimal infrastructure would be the main activity. It was also an aim that financial benefits should accrue to the surrounding communities. Therefore, no restaurant or accommodation has been developed in the reserve; rather, locals in the surrounding area have set these up.

In an attempt to expand the walking circuit as well as bring in additional economic incentives for surrounding villages, JNR has also connected with three nearby villages to provide food, taxis and accommodation for longer curated walks. This ensures that the economic benefits accrue locally, which helps to generate and maintain interest in this type of conservation model.

The reserve officially opened in 2015. Research and restoration efforts started two years prior to that, in 2012–13. JNR has been leased for a period of 30 years with conservation of the forest being the main objective.

Impacts

JNR is fast becoming a well-recognised model by the Forest Department for managing small forest patches, since almost every village in Uttarakhand has Van Panchayats (a legally demarcated village forest) that tend to yield very little economically for the Panchayat. Several groups of Sarpanchs (local government authority representatives) from the various Forest Divisions have already begun to visit the JNR site in order to learn from its success. Replicating this financially-sustainable model will have several benefits for local institutions that manage them, while also contributing to conservation of these areas.

JNR has created direct employment for seven local community members, including three women, and has enhanced livelihoods in the local economy from visitors using local restaurants, homestays and local transport. One of the villages that has benefitted from the longer walks is Kanda. Possibly due to increased awareness in this village, the villagers collectively saved a sacred deodar grove from being lost due to a road construction project, by stopping the road one kilometre before the village.

A leopard sighted at JNR, after restoration © Jabarkhet Nature Reserve

Another major outcome is the way the lives of the local youth, especially the nature guides who are trained and employed by the reserve, have been transformed. The very first young individual who was trained received a national award for the 'Best Nature Guide'. He is now a role model for other young boys like him in the village, who have been trained and are employed as nature guides, thus illustrating the potential of this avenue of growth being generated in such an ecosystem.

JNR is the first privately owned and operated wildlife sanctuary in Uttarakhand, a tangible example of the promise and potential of conservation. The primary intent behind the development of the reserve was to demonstrate that conservation provides a viable economic model for land owners and local communities. This successful model can be showcased to other public and private land owners to encourage them to opt for conservation of the areas under their control. This will, on one hand, lead to strengthened ecological protection of the area, as well as income generation on the other hand. The JNR model can thus play a significant role in promoting ecotourism in the Himalayas by combining education, livelihood and conservation.

> **"The camera footage recorded joggers, gorals, leopards, pheasants using the trails running through the forest at different times within the space of a day. This tells us a lot about co-existence and how wildlife adjusts itself. In a country like India, sharing spaces is really important because exclusivity is a luxury for us. With the JNR initiative, despite it being a private forest, the sense of ownership of the place taken up by the locals is just phenomenal. Young boys working there as nature guides are passionate about the place. Everyone within and around the ecosystem sees that nature and conservation pays, not just economically, but also brings personal transformation and gain. This is what we set out to achieve."**
>
> – Dr. Sejal Worah
> Managing Director, Jabarkhet Nature Reserve

The physical landscape exhibited immense resilience with the capacity to restore itself on the removal of human pressure. Thus, outside of some restoration and plantation activities, including removal of invasive species, the initiative focused more developing stewards who would help protect the site and regulate degrading activities. The initiative has showcased that unless rampant hunting occurs, wildlife, domestic animals, and humans can adjust, share the same space.

Management and monitoring must be constant to stop the site from slipping back to its original state. A local institution is needed to manage the same. The first guide who was trained is now a manager and sees to the basic functioning of the property. In order to build sustainability of the initiative, training and building a capable management team made up of the local youth has been established.

There are 1,000 acres of privately-owned forest, surrounding the 100 acres of JNR. The future vision is to connect these areas and other adjoining private forests under this model. However, since the people associated with these forests have different objectives, buy-in is proving to be challenging. On the flip side, giving an identity to Jabarkhet is in itself a big win. The reserve has become a tourist destination in the area and a training incubation centre for other Van Panchayats. JNR has also been recommended to be included as an Other Effective Area-based Conservation Measure (OECM) by the Government of India.

Ecological milestones

The reserve is a rare example of a space so close to an urban centre where forest and wildlife recovery can be observed relatively easily. Within the first year of controlling pressures on natural resources, the results seen were remarkable. The forest's plant communities started recovering rapidly, as did the wildlife. Several local scientists visited the reserve and conducted baseline studies that documented 370 species of flowering plants, over 150 species of birds, over 100 species of fungi, and over 60 species of ferns. In the second year of the initiative, camera traps recorded a black bear and cubs, a species not seen for many years prior. Their return coincided with the revival of the oaks and a bumper crop of acorns. With the acorns and the grasses coming back, so did the animals who used these resources as food.

The cycle of restoration and recovery played out with species like the jungle cat, sambar, hares and foxes being recorded. Breeding populations of more common species such as the barking deer, goral, wild boar and leopard are regularly recorded. Camera traps have also recorded interesting behavioural patterns between various groups of animals such as barking deer and *Kalij* pheasants and *Goral* and *Koklass* pheasants. Leopards are also regularly sighted in JNR and around up to three individuals are present in the reserve at any given time.

In the absence of the initiative, under the business-as-usual scenario, this patch of forest would have been overused and degraded. Invasive weeds would have proliferated further, and the forest canopy would have become more and more open due to lopping. Continued disturbance and hunting would possibly have led to local extinction of wildlife.

Within five years, three milestones have been reached:

1) JNR has become a popular destination within the area and today it shows up in web searches as one of the top five places to visit in Mussoorie.

2) It has received recognition from the government, specifically the State Forest Department, who are putting in effort to replicate this model across the state.

3) It has been recognised as an OECM by the Government of India.

The reserve is surrounded by patchy, disturbed forest that is in various stages of degradation and has multiple ownership patterns, running through until the plains. It functions much like a core zone of a large protected area where the surrounding areas act as buffer zones. Thus, these forest patches act as ecological corridors for wildlife to move between. Therefore, from a climate change standpoint, the altitudinal connectivity that these types of patches provide from the plains to the hills is critical. Should this connectivity be maintained, it would offer wildlife a refuge when the impacts of climate change start to manifest in the area.

Enabling factors

In order to run the initiative, the first decision was to develop a viable and conservation-based business model. A cost-benefit analysis was carried out and it was understood that the revenue from the entry fees was enough to maintain salaries, fund upkeep and materials, and also build a small corpus fund. The fourth year of operations generated a small profit, which sustained the initiative during the first wave of the Covid-19 pandemic in India.

The forest acts as a catchment area and water from a stream originating in JNR is pumped up to supply water to a part of Mussoorie. Therefore, the initiative is exploring incorporating the principle of Payment for Ecosystem Services in the form of water access in its financial model. In this model, users of the ecosystem services upstream in Mussoorie will pay for the forest to be maintained and preserved, and compensate downstream villages whose water supply has been diverted.

The conservation professional who set up JNR brought with her the knowledge and technical expertise of both conservation and wildlife management, forest restoration and community-based tourism. Through her contacts, JNR was able to benefit from technical inputs provided by experts in plants, birds, wildlife, ferns, fungi, moths and more. All of this expertise was used to train local youth, who were further trained in ornithology, wildlife management and nature guiding.

The only technology deployed in JNR is camera traps, which help to record and monitor wildlife as well as impart knowledge and information to visitors.

The forest area that comprises JNR comes under the Private Forest Act, which requires owners to manage the land as a forest and have a management plan. The Uttarakhand Forest Department has also emerged as an important promoter of the initiative as a successful conservation model.

By investing in local talent and human resources, and assisting in the generation of livelihoods and transferring knowledge and expertise, the project helped develop a local sense of ownership. The reserve does not exclude locals, and extractive activities are not completely restricted. Some amount of forest product collection takes place, for wood, medicinal plants and grazing; however, this is regulated by the locals working at the property themselves.

There have been numerous factors that enabled the initiative, there are also some issues that have been encountered since the restoration. Challenges posed due to the Covid-19 pandemic led to increased poaching within the reserve (as no one was visiting) and a financial crunch (staff had to go on half salaries with the corpus funds running out). Presently there is a lack of resources to manage the ever-increasing incidences of forest fires, which have been exacerbated due to climate change, within the area. More policy-level action is needed into how such types of private forests can receive protection and government support without change in legal status. It is only then that the neighbouring private forest owners would probably come forward and join the JNR initiative to help develop a Mussoorie Nature Reserve, in the long run.

INITIATIVE: JABERKHET NATURE RESERVE	
Knowledge factors	• Local scientists provided technical inputs on taxa abundance, wildlife management and monitoring. • Knowledge and technical expertise of both conservation and wildlife management, forest restoration and community-based tourism. • Expertise was used to train local youth in ornithology, wildlife management and nature guiding.
Institutional factors	• Land is governed by the Private Forest Act, which requires owners to manage the land as a forest and have a management plan.
Environmental factors	• The physical landscape exhibited immense resilience with the capacity to restore itself with the removal of human pressure.
Social factors	• Local buy-in generated through training of local youth and women and providing them with sources of livelihood. • Trained staff now act as custodians of the land, helping to manage and monitor the area.
Technical factors	• Camera traps assist in monitoring the area.
Economic factors	• Seed funding from partners in the LLP. • The reserve sustains itself through entry fees and memberships.

Replication

In order to carry out this initiative, the following resources proved critical:

Finance/assets: The most important asset to start this type of initiative is a small patch of land with forest in any condition. In the case of JNR, the land was privately owned and, therefore, legally it has been leased for 30 years under an LLP.

A large budget is not necessary. As long as the revenue model takes into account the running costs of the reserve, such as the salary of the staff and maintenance activities, or collaterals such as producing nature guides, biodiversity booklets and maps, the initiative is likely to be economically successful.

Staff/capacity: Engaging local staff is extremely important to ensure buy-in and sustainability of the initiative. Livelihoods generated from these types of projects not only aid conservation locally, but also transform local lives.

City characteristics: This type of initiative can be implemented in any city. It would be extremely beneficial to implement this in an area where forest fragments exist. This will help to improve connectivity between the fragmented forested areas and support movement of faunal species

Time for planning and implementation: Planning the initiative and investing time in initial stakeholder engagement is crucial. In the initial phase of the initiative, Dr. Worah was present at the location every weekend. Convincing local stakeholders was the major challenge. Once they were on board, work was a lot smoother in executing and managing the initiative.

Costs and funding

The initial investment was around US$ 16,500. The running cost including salaries is about US$ 16,500–20,000 per year. A minimum annual income of US$ 27,500 is needed to maintain a small corpus and manage the expenses.

US$ 6.7 is charged for a guided walk. Membership is also offered to individuals at an annual rate of US$ 67 and to institutions at an annual rate ranging from US$ 270–1,340.

Links to SDGs, Aichi Targets and NBTs

SDGs	
Aichi Targets	
National Biodiversity Targets:	

Increase in sightings of faunal species at JNR © Jabarkhet Nature Reserve

Key contacts	
Name	Dr. Sejal Worah
Designation	Managing Director
Organisation	Jabarkhet Nature Reserve
Address	Nature Reserve, Jabarkhet, Landour, Mussoorie, Uttarakhand 248179, India
Website	http://jabarkhetnature.com
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Jaberkhet Nature Reserve

Community-based restoration of a degraded forest area to enhance ecosystem services, livelihoods, wildlife protection and responsible tourism.

SDGs:

Aichi Targets:

Nbs approach: Ecosystem-based management

Local government	Nagar Palika Parishad Mussoorie and Mussoorie Dehradun Development Authority
Country and state	India, Uttarakhand
Population	30,118 (2011)
Total area	67.6 km²
Main geography type	Highland

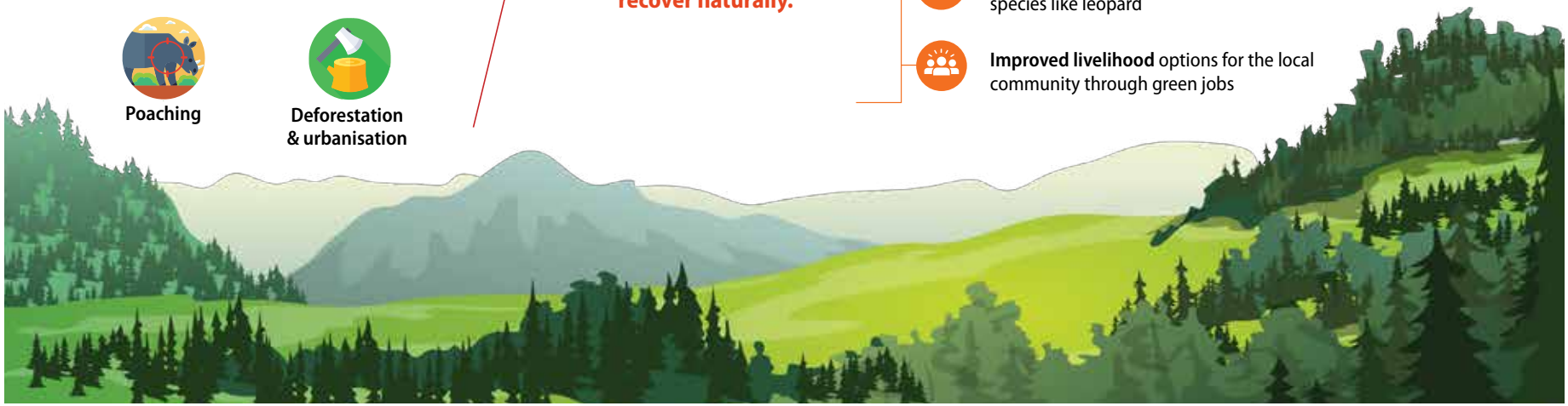
Issues

- Overgrazing
- Spread of invasive species
- Lopping
- Grass collection
- Poaching
- Deforestation & urbanisation

Simple practices were followed to restore the area as a wildlife refuge. The main focus was to reduce human pressure, allowing the forest to recover naturally.

Impacts

- Removal of over **800 kg of trash**
- Removal of **three tonnes of invasive weeds**
- Development of three-storeyed **pristine forest**
- **Breeding ground** for several species of wild fauna
- **Ecological corridor** for movement of wild fauna species like leopard
- **Improved livelihood** options for the local community through green jobs



Aerial view of Gangtok city, India© ICLEI South Asia

BOX 9: SHORT CASE STUDY ON ECOSYSTEM-PROTECTION APPROACHES

GANGTOK, INDIA: Urban sacred groves as carbon sinks

NbS approach: Ecosystem-protection approaches	
FACTS AND FIGURES	
Local government	Gangtok Municipal Corporation
Country and state	India, Sikkim
Population	100,290 (2011)
Total area	19.2 km^2
Main geography type	Highland

Some of the negative consequences of urbanisation include deforestation and increases in grey infrastructure that led to rising GHG emissions, local air temperatures and overall climate change. However, protected areas including small pockets of forests of religious and ecological significance, known as 'sacred groves',[329] and similar patches of trees can play a pivotal role in mitigating the adverse impacts of such human activities and related climate change.

Sikkim State harbours many sacred groves associated with the local monasteries known as *gumpas*. Two important sacred groves lie in Gangtok, the capital city of Sikkim state in north India; namely Deorali Chorten Monastery sacred grove and Enchey Monastery sacred grove.[330] These sacred groves comprise of native tree species and are a symbol of the local culture and ecology of the area.[331]

The what and how

Owing to the ancient tradition of nature worship, sacred groves are often preserved on religious grounds.[332] Deorali Chorten Monastery and Enchey Monastery are situated at an altitude of 1,556 m and 1,856 m and at a distance of 2 km and 4 km from the city of Gangtok, respectively.[333] The sacred grove present within the premises of the Deorali Chorten Monastery is 74 years old and covers an area of 22 hectares, while that of the Enchey Monastery is 111 years old, spread over an area of 16 hectares. The main species found in the two urban sacred groves include *Schima walichii*, *Castanopsis* sp., *Betula alnoides*, *Cryptomeria japonica* and *Eurya acuminata*.

In addition to holding spiritual value, these sacred groves are similar to urban forests, acting as 'green lungs' and assisting in the fight against climate change[334] in Gangtok city. Trees within the groves also help in reducing air pollution by trapping pollutants and particulate matter.[335]

As the rate of deforestation and loss of greenery due to urban sprawl in Gangtok city increases,[336] so does the value and significance of the city's sacred groves. The tree species planted in these groves such as *Betula* sp. have medicinal uses[337] while *Schima sp.* is viewed as ideal for conserving water and soil.[338] *Cryptomeria japonica*, locally known as Dhupi, has weather- and insect-resistant properties.[339]

Given the increase in atmospheric temperature and carbon dioxide levels owing to climate change, trees are more susceptible to pest attack,[340] thus making the plantations of Dhupi suitable for climate change adaptation in the city of Gangtok. Considering the basic function of trees is to provide oxygen, the sacred groves also act as important determinants of oxygen levels in the atmosphere. Furthermore, urban sacred groves forming small pockets of forests absorb carbon from the atmosphere, thereby enhancing the carbon sequestration process.[341] This has been verified in a study conducted by Devi et al.[342] in Gangtok city, highlighting the environmental importance of sacred groves in urban areas.

The who

These urban sacred groves are under the stewardship of the *gumpa* officials.[343] The local community usually protects sacred groves throughout India as part of local traditions.

The where

Deorali Chorten Monastery sacred grove and Enchey Monastery sacred grove are located in the capital city of Gangtok, Sikkim.

Key contacts	
Name	Yeshay Dorji
Organisation	Deorali Chorten Monastery, Sikkim

Urban sacred groves as carbon sinks

Primarily seen in rural areas, sacred groves are protected forested areas of religious and ecological significance. The urban sacred groves in monasteries in Gangtok comprise native trees, and play a critical role in mitigating the adverse impacts of anthropogenic activities and climate change.

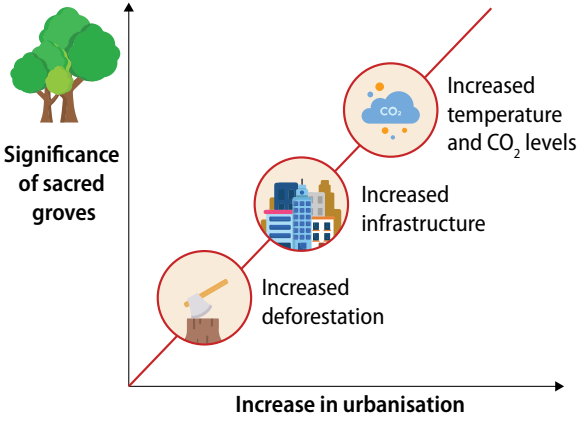
SDGs: 

Aichi Targets: 

NbS approach: Ecosystem protection

Local government	Gangtok Municipal Corporation
Country and state	India, Sikkim
Population	100,290 (2011)
Total area	19.2 km^2
Main geography type	Highland

Context



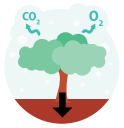
Chorten Monastery
74 years old
22 Hectares

Enchey Monastery
111 years old
16 Hectares

Impacts

Native tree species that provide protection against climate change

Symbol of local culture and ecology



Carbon sequestration and increased availability of oxygen

Saras Crane at Lumbini Crane Sanctuary © Rajendra N. Suwal

LUMBINI, NEPAL: Green Lumbini Initiative

A city marked by cultural and historical heritage

NbS approach: Ecosystem-protection approaches	
FACTS AND FIGURES	
Local government	Lumbini Cultural Municipality
Country and state	Nepal, Lumbini
Population	72,497 (2011)
Total area	112.21 km^2
Main geography type	Lowland

Lumbini Sanskritik is a municipality situated in Rupandehi District of Lumbini Province in Nepal.[344] It is located 18 km from the district headquarters, Siddharthanagar. Lumbini, a Buddhist pilgrimage site where Lord Buddha was born, lies at the centre of this Municipality, making the area an important pilgrimage and tourist site. Indigenous people including the Yadhav, Tharu community and migrants from India as well as the adjoining hills of Nepal, represent the local demography.

The municipality was formed through the merging of the existing Lumbini Adarsha Village Development Committee with six other Village Development Committees – Bhagawanpur, Tenahawa, Ekala, Khudabazar, Madhuwani and Masina – and is divided into 13 wards. Owing to its religious, cultural and archaeological importance, Lumbini was declared a UNESCO World Heritage Site in 1997.[345] To assist in its economic development, it was declared a 'cultural municipality' in 2014, following a notification of the Government of Nepal.[346] The declaration helped to boost tourism activities in the region, which is also one of the major sources of income for the local people. Within Lumbini, the Lumbini Development Trust (LDT) is the custodian of a 7.6 km^2 area dedicated to safeguarding Lord Buddha's birthplace.

Lumbini Cultural Municipality is constituted within the Greater Lumbini Area (GLA) which houses the districts of Rupandehi, Kapilbastu and Nawalparasi.[347] Geographically, Lumbini forms the core of Lumbini Cultural Municipality and is positioned in the Churia range of Terai Arc Landscape

Restoring the wetland at Lumbini Crane Sanctuary © Rajendra N. Suwal

Restored wetland at Lumbini Crane Sanctuary © Rajendra N. Suwal

(TAL).[348] The TAL-Nepal is a vast geographic region stretching east-west from the Bagmati River to the Mahakali River.[349] Major protected areas and tourist spots including Chitwan National Park and Lumbini are situated within the TAL. At its boundary, the TAL is home to 75% of the lowland forests and is rich in biodiversity. Lumbini, being a part of the TAL, also hosts a wide variety of flora and fauna.[350]

In 2005, Birdlife International[351] identified industrial development in Rupandehi district as a significant threat to birdlife in the area. A grid of power lines resulting from industrial and developmental activities had become hazardous to large, low-flying birds, especially cranes and storks. The publication also identified effluents released into the Dano River from a cement factory, a paper mill and a distillery as being sources of habitat degradation. In 2009, the Government of Nepal declared 828 km^2 in Rupandehi District and Kapilavastu District as a Lumbini Protected Zone (LPZ). Within this zone, the operation of carbon-emitting industries was prohibited.[352] Unfortunately, urbanisation within these districts has led to a rapid and uncontrolled growth of carbon-emitting industries and infrastructure within the LPZ, threatening the Lumbini UNESCO World Heritage Site and local biodiversity as well as creating health hazards.

The Lumbini UNESCO World Heritage Site has been attracting local and international visitors for over two millennia, and this is forecasted to increase substantially in the years to come. This presents an incentive for conservation of the natural environment of Lumbini, as well as a threat if not managed properly. Influencing and managing the behaviour of visitors and residents has the potential to inspire conservation globally and locally and will determine the protection and conservation of the area.

The TAL and Lumbini: and an unlikely partnership

The TAL is an important transboundary conservation area that stretches from Nepal's Bagmati River in the east to India's Yamuna River in the west. In Nepal, the TAL covers 24,710 km^2 and is spread

across 18 districts. The TAL encompasses six protected areas that harbour endangered species, such as rhinoceros and tigers. Lumbini, the birthplace of Lord Buddha and a UNESCO World Heritage Site, is located in the alluvial flood plains of the TAL.

The area under the Lumbini Development Trust is made up of the following:

- **The Sacred Garden Zone** including the UNESCO World Heritage property, Maya Devi temple, the Ashokan Pillar, various *stupas*, *chaityas* and old remains of the garden and its trees.
- **The Monastic Zone** including meditation centres and approximately 49 *stupas* and monasteries.
- **The New Lumbini Village Zone** including a museum, an international Buddhist research centre, a tourist information centre and facilities like hotels, pilgrims' inns and post offices.

Since Lumbini is situated in the heart of Terai Arc, it is often referred to as the 'Soul of TAL'. Apart from being an important Buddhist pilgrimage site, Lumbini holds significant archaeological, cultural and natural importance. Nepal's second largest population of sarus crane (*Grus antigone*), given that the area supports a rich and diverse natural ecosystem and it is the only known site in the country where the species breeds regularly.

The site and its surroundings represent one of the few remaining habitats for endangered fauna and flora. The fields and river channels provide an important habitat for many species and serve as a corridor for animal movement. Lumbini's farmlands were identified as an Important Bird Area (IBA) in 2005 by Birdlife International due to their conservation significance for large avifauna, such as the lesser adjutant stork, white-rumped vulture, and sarus cranes. Moreover, the Sacred Garden of Lumbini also serves as an important carbon sink because of its forest cover.

In the 1960s, a mosquito eradication programme aimed at tackling malaria was undertaken by the Nepal Government, which inadvertently led to the draining of the TAL wetlands. This paved the way for settlers from neighbouring parts to occupy these now available areas and convert the fertile soil into a rice-producing centre. Lumbini's natural ecosystems did not escape this land-use change.[353]

In response to this, the LDT was founded in the 1970s to preserve and protect the religious, cultural and natural significance of Lord Buddha's birthplace. The trust acquired 7.6 km^2 of farmland around the Lumbini Sacred Garden and designated this area as a Centre for World Peace. Following the protection, the area rejuvenated and several large flocks of birds began to revisit. The habitat inside the Lumbini Garden is mainly composed of grassland (58.8%), forest plantation (40%) and open water bodies (1.5%).[354] The dominant grass species include *Imperata cylindrica*, *Saccharum munja*, Phragmites and Vetiver. Along the two major rivers, Harhawa and Telar, there are many water bodies (ponds). The major wetland plants include *Vallisneria sp., Hydrilla sp., Potemogeton sp., Nymphea sp., Trapa biospinosa., Eichornia sp., Scirpus sp., Eleochris sp., Zizania sp., Typha sp., Polygonum sp., Leersia sp., Ipomoea sp., Oryza rufipogon.*[355]

In 1988, the International Crane Foundation (ICF) along with local crane conservationists, initiated a joint effort to manage the natural ecosystems of Lumbini and develop community outreach programmes. They began to conduct regular species counts to maintain baselines and monitor populations. The ICF went a step further in 1994 and signed an agreement with the LDT for a 50-year lease of 256 acres of land to establish the Lumbini Crane Sanctuary (LCS) in the northern block of the Lumbini Project Area. The ICF, locally known as the Lumbini Crane Foundation (LCF), works to secure the population of sarus crane in Nepal (particularly Lumbini) through community-supported conservation practices and governmental policies that maintain the rich biodiversity of agricultural landscapes.

The Sanctuary also acts an outdoor nature education centre. The refuge was built to showcase model wetland habitats for nesting cranes. The objectives of the Sanctuary were to restore and recreate the natural habitat diversity of the Nepalese Central Terai, with special consideration for the Sarus crane, involve the local community in the conservation and management of their natural resources and establish an education facility and wild garden.

> **The Sarus crane today, occupies a place of important symbolism in the hearts of the people of Lumbini. The journey that we have been undertaking over 30 years to protect the very bird once saved by Lord Buddha, has helped to forge a deep connection and a sense of responsibility that will sustain our efforts to nurture Lumbini's wilderness. Lumbini Crane Sanctuary has emerged an important instrument in doing so and must be preserved in perpetuity.**
>
> – Mr. Rajendra N. Suwal
> Head - Partnerships Development
> WWF Nepal

The LCF secured financial support from various sources for restoration of the seasonal wetlands within the Sanctuary. Five artificial wetlands (5–10 acres each in size) were created to capture rainfall and boost the local groundwater levels. The Foundation also planted over 4,000 saplings, tufts of Phragmites reeds, seeds of wild rice like *Oryza rufipogo*, and commenced outreach programmes on the conservation and protection of natural resources with villagers living along the Sanctuary's periphery. Soon, the area was (re) colonised by native vegetation and it was not long before sarus cranes and other water birds began nesting in area. Since its inception, the LCS has recorded over 210 species of birds, and 200–300 sarus cranes in and around its territory. The group also conducts regular monitoring activities.

Buddhist literature is replete with iconography depicting links between the natural environment and Lord Buddha's life. His birth, for example, is shown in images where his mother, Mayadevi, is supporting herself on a Sal tree (*Shorea robusta*). Another symbolically important story, especially in the case of Lumbini, is when Prince Siddhartha rescued a sarus crane, which was shot down by his cousin Devdutta.

Lumbini has over 20 monasteries that have been built by the various Buddhist groups allowing for the link between Buddhism and the environment can be channelled to initiate a closeness and respect for the same around Lumbini. Several monasteries have added greenery and waterbodies into their spaces, encouraging birds who visit the area for their breeding and feeding. However, once densely wooded, Lumbini Garden is experiencing reduced vegetation, primarily because of the lack of formal protection.

The sarus crane, the official bird of Lumbini Cultural Municipality, is also under threat due to habitat loss and degradation, and illegal hunting and collection of eggs resulting from the lack of awareness among local people.[356, 357] Sarus cranes use wetlands to feed and nest in, however the wetlands in Lumbini's farmlands are deteriorating due to encroachment and pollution caused by untreated effluents. Although the Lumbini Crane Sanctuary offers some protection, the area has, in recent years, experienced extended dry spells which have caused wetlands and water sources to shrink.

Experts predict that these changes in rainfall patterns in lowland Nepal will lead to "significant fluctuations in the breeding success of sarus cranes, particularly if the frequency and intensity of dry seasons increase".[358] As climate change brings with it erratic and extreme rainfall events, the future of the breeding grounds and nests of the sarus crane is on shaky footing.

Sarus crane nesting site © Rajendra N. Suwal

Lumbini: Greening, educating and conserving

Recognising the multi-faceted importance of Lumbini and the imminent challenges it is facing, WWF Nepal joined the conservation effort in 2010, partnering with LDT to develop Lumbini as a model site in which conservation finds a synergy with the Buddhist philosophy of interconnectedness and inter-dependence.

The Green Lumbini Initiative was designed by WWF Nepal in partnership with LDT as a movement towards conservation and the sustainable development of Lumbini region and surrounding areas. Public engagement is strong and occurs through the active participation of individuals, eco clubs, civil society and corporates at both national and international levels. The goal of the project is to improve the ecological integrity in Lumbini and enhance benefits to biodiversity and human well-being. The project engages non-conventional stakeholders to promote 'Trees Outside of Forests' to restore degraded lands, conserve sarus crane and its habitat through wetland restoration, and create accessible trails.

Together in Lumbini, WWF Nepal and LDT implemented pioneering and cohesive initiatives that build ecological integrity in partnership with local, national and international communities. Some of these include establishing and managing a peace garden; promoting environmental, cultural and religious values; conserving the sarus crane and other wildlife species and their habitats; promoting environmentally and socially responsible development; and raising conservation awareness among visitors and local people living in and around Lumbini.

How the initiative was implemented

Several milestones of Lord Buddha's life, such as his birth, his enlightenment, his teachings have depictions with trees. This significance of trees, along with the ecosystem services they render has a central role in the Green Lumbini Initiative. Three key projects which aim at propagating trees and participatory conservation in Lumbini: The Million Tree Project, My Tree Project and Pipal for People Project form the tangible components of the movement. This is further complemented by climate change messaging to influence, inspire and engage a wider audience.

One million trees in ten years

The Million Tree Project was launched on 26 March 2011 with the goal of planting one million indigenous trees in Lumbini by 2020. The first batch of 108,000 trees was planted in 2011, eventually resulting in the planting over 600,000 tree saplings.

As forests, with their ability to sequester carbon, take center stage in the fight against climate change, the million-tree project in Lumbini Sacred Garden is expected to be a leading example in participatory conservation. The saplings for the project are grown in a nursery, jointly maintained by WWF and LDT, which contain species that existed during Lord Buddha's era such as Neem (Azadirachta indica), Sal (*Shorea robusta*), Pipal (*Ficus religiosa*), Kadam (*Neolamarckia cadamba*), Arjuna (*Terminalia arjuna*) and Seemal (*Bombax ceiba*).

My Tree project

The My Tree Project offers individuals and organisations the opportunity to either plant a tree or have one planted for US$ 250 per sapling (which will include maintenance of the plant over its lifespan) in the Lumbini World Heritage Site. Donors are provided with a GPS location of their adopted tree, which will bear a nameplate of the owner and be planted in a private garden located near the Peace Pagoda, within the Sacred Garden along with biannual updates.

Pipal for People project

During the construction of the Maya Devi Temple in the Lumbini Sacred Area, a Pipal tree (*Ficus religiosa*) was uprooted. This tree marked the spot of the exact birthplace of Lord Buddha. To symbolically make amends for this, the Pipal for People Project through tissue culture is giving the uprooted tree new life. Saplings generated will be planted with the aim to propagate this native species, while promoting its importance on religious, personal and ecological fronts.

Instilling Green Lumbini project

The 'Instilling Green Lumbini Initiative' introduced in 2019 and completed in 2020, aligned closely with LDT's and ICF's concept and aimed to "promote responsible environmental practices and sustainable development processes in the sacred site of Lumbini". WWF, together with these organisations, worked to restore and create new wetlands through rainwater impoundments. The impoundments act as a reservoir during dry spells and store excess water during floods. Other activities implemented include establishing raised nesting grounds to minimize the impacts of flooding during heavy rainfall events, creating dykes and embankments to reduce sedimentation, and planting native varieties of rice, which are both flood and drought-resistant and provide a food source for cranes.

The project has so far has constructed 15 rainwater levees which collect between 50 million to one billion litres of water during the peak monsoon period, extended the wetlands through earthwork excavation, constructed five km long walking trails with excavated soil within the LCS area for outdoor nature education and secured the perimeter of the sanctuary by erecting a two km long fence. 30 eco clubs were established in the area and mobilised in various programmes such as sarus crane dramas, clean up campaigns and awareness programmes. Together with local partners, Lumbini Social Service Foundation (LSSF) and Green Youth of Lumbini (GYL), WWF also piloted a youth based sarus crane/wetland awareness and monitoring program called 'Adopt a Wetland' in 10 eco clubs in Lumbini. About 100 brown roofed turtles were relocated from a drying pond and over 50 kg of apple snails were stocked as a food source for birds. A water management system was also constructed to enhance water supply and check evapotranspiration within the wetlands during the dry seasons using water outlets from vertical water tanks. This will improve the climate resilience of the wetland during the dry season.

The crane sanctuary is an excellent model that demonstrates wetland management and conservation education through its interactive centre and a conservation outreach programme, which includes radio programmes on the environment. Crane conservation education camps, art exhibitions and crane festivals are annual activities organised to generate awareness amongst local people. Within the sanctuary the habitat has improved, the number of nesting cranes as well as other water birds has increased along with populations of the blue bull antelope or nilgai (*Boselaphus tragocamelus*). Surveys have also revealed that animals like the wild boar (*Sus scrofa*), hog deer (*Axis porcinus*), spotted deer (Axis axis), sambar deer (*Rusa unicolor*) have reappeared in the wetlands after a span of three decades.

In order to encourage local stewards, and to promote community-based conservation within the surrounding farmlands, the practice of organic farming has been promoted under the aegis of the Green Lumbini Initiative. Specifically, a local indigenous, high-aroma variety called Kala Namak rice was reintroduced in the area and 100 farmers were trained in its cultivation. Much like the sarus cranes, this variety, *Kala Namak* or 'Buddha's rice', has links with Prince Siddhartha. The crop holds a cultural significance among the locals, as it is believed that Lord Buddha distributed the rice among his followers after his enlightenment, as a gift and a mark of homage. The rice fields will provide foraging habitat for the sarus cranes. Market linkages have been setup in both Lumbini and Kathmandu through Raithane Agriproducts Nepal and Green Youth Lumbini. A sample plot growing Kala Namak has also been introduced within the LCS.

The project is presently exploring the potential of establishing a wetland demonstration centre/ nature education centre for awareness generation, and a knowledge centre for technology transfer to support subsistence farmers.

Several of the trees that were planted as part of the tree planting drive did not survive to maturity due to inadequate irrigation, fires, and grazing activities. In order to overcome this issue, WWF is enhancing water supply and protection, in partnership with LDT and ICF.

Enabling factors

The Green Lumbini Initiative – centred on protecting the sarus crane in Lord Buddha's birthplace – is a hallmark conservation programme that blends Buddhist philosophy with conservation. It amplifies conservation and education activities undertaken in partnership with the LDT, WWF and ICF along with local partners such as LSSF and GYL over the last three decades. Joint efforts between Nepali Conservationists and the ICF resulted in important research on sarus crane in Nepal, which ultimately led to the formation of the Lumbini Crane Sanctuary.

Well-rounded knowledge around sarus crane biology, wetland ecology and natural resource management was necessary in order to conduct the research. Exposure visits made to Necedah Wildlife Refuge in Wisconsin and parts of Cambodia – where the initiative 'Ibis rice' was being successfully implemented – also supported sarus crane conservation activities in Lumbini.

Monitoring of birds and other wildlife was done using equipment, such as binoculars, GPS, cameras, telescopes, camera traps and drones. The rainwater levees, walking trails, artesian wells and artificial wetlands were developed with machines, such as excavators, tractors and backhoe loaders.

For this type of initiative, much depends on the type of land and its surrounding areas since it involves wetland restoration to some degree. In the case of Lumbini, farmland that was restored back into its natural state with clay-heavy, water-retentive soil formed an important habitat for the wildlife of the area. The mosaic of land uses in Lumbini (grasslands, forests, wetlands, agricultural fields) also provides an important foraging and nesting habitat.

Funding for crane conservation since the late 1980s came from ICF and its networks and various grant disbursing organisations, such as the Keidanren Nature Conservation Fund, Ecosystem Conservation Society, Japan, the Vanderbilt Foundation USA, the UNDP Small Grants Fund, and the Ashoka Foundation. From 2010 onwards, WWF Nepal and its network supported the initiative.

The main institutions in the area -- the LDT and the Lumbini Cultural Municipality -- have been important stakeholders and partners. The LDT allowed leasing of the land for the crane sanctuary under the Lumbini Development Trust Act (1985). The Municipality also named the sarus crane as its mascot in 2019. The National Parks and Wildlife Conservation Act (NPWC) (1973) has provisions for the management of national parks, protection of wildlife and their habitat, regulation of hunting and conservation, and the promotion and development of places of special importance from the point of view of natural beauty.

The Buddhist philosophy of non-violence and no killing of living beings is a critical aspect that enables the protection and conservation of wildlife in Lumbini, given the religious significance of the area. Local Hindu communities, like the Ahirs and Yadavs, have cultural beliefs that prevent them from killing animals and there is a local taboo that protects sarus cranes. Since the objective of the LCF has been to involve the local community in conservation and management of their natural resources, various awareness drives are undertaken that encourage social support in and around the sanctuary.

INITIATIVE: GREEN LUMBINI	
Knowledge factors	• Knowledge partners, such as the ICF and Lumbini Buddhist University as well as exposure visits. • Scientific knowledge of avian biology, wetland ecology, natural resource management from ICF staff. • Facilitation of knowledge and education programmes through WWF.
Technical factors	• Civil work machinery supported the development of rainwater levees, walking trails, artesian wells and artificial wetlands. • Water management and tree planting technologies. • Binoculars, GPS, cameras, telescopes, camera traps, drones to monitor and record wildlife.
Environmental factors	• Farmland turned into natural land.
Economic factors	• Funds through ICF and WWF networks.
Institutional factors	• Lumbini Development Trust Act 1985. • NPWC Act 1973. • The LDT and the Lumbini Cultural Municipality are supportive.
Social factors	• Ahirs and Yadav and local communities' cultural beliefs of not killing animals. • Local taboo protects sarus cranes. • Buddhist philosophy of non-violence and no killing of living beings. • Education, livelihood and outreach activities through local partners GYL, LSSF as well as environmental camps for conservation awareness.

Replication

In order to implement this initiative, the following resources proved critical:

Finance/assets: Adequate and appropriate land to carry out conservation and protection of local wildlife was critical. Here, the ICF leased public land from the LDF for a period of 50 years and is looking into extending the lease in perpetuity. A greater volume of funds will be needed to support good conservation and therefore this is not an initiative that can be managed with a small budget.

Given the significance of the area, tourism is an important avenue that can sustain this type of initiative.

Staff/capacity: Dedicated staff with sound ecological knowledge, a strong technical base and innovative thinking were required. Additionally, it was important for ecologists to familiarise themselves with skills, such as inspection, supervision and guidance of civil work projects, as the local contractors, engineers and heavy equipment drivers were often not exposed to this type of intervention and may have compromised the site.

Partnerships were also found to be an important source of knowledge and innovation within the project that resulted in its successful implementation.

Time for planning and implementation: Because of the long-term nature of this type of initiative, significant time was required for planning, implementation, forging of partnerships and monitoring. In the case of the Lumbini Crane Sanctuary, the goal is to lease the land in perpetuity, adding it to the formal protected area network, to sustain conservation and protection activities.

Stakeholder engagement: The entire initiative was based on partnerships with public authorities, religious leaders, local community members and NGOs. It is very important to constructively engage with key stakeholders, especially local authorities, for a project of this scale to succeed. Stakeholder buy-in through engagement, partnership and outreach has resulted in the successful conservation of the cranes and wetlands within Lumbini.

Costs and funding

These initiatives were funded by the ICF and WWF.

Links to SDGs, Aichi Targets and NBTs

SDGs	
Aichi Targets	
National Biodiversity Targets:	5.4.4 i.e. Management of Wetland Biodiversity

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Greening Lumbini

Implementing Nature-based Solutions to restore Lumbini, a city with cultural and historical heritage.

SDGs:

Aichi Targets:

NbS approach: Infrastructure-related management

Local government	Lumbini Cultural Municipality
Country and state	Nepal, Lumbini
Population	72,497 (2011)
Total area	112.21 km^2
Main geography type	Lowland

1994
Establishment of Lumbini Crane Sanctuary

1997
Lumbini declared as a World Heritage Site

2005
Lumbini's farmlands identified as an Important Bird Area

2009
828 km^2 in Rupandehi District and Kapilavastu District declared a Lumbini Protected Zone

2010
Project Green Lumbini initiated by WWF Nepal & LDT

2011
One Million Trees in 10 Years Launched

The first batch of **108,000** trees was planted, which eventually resulted in the planting of over **600,000** tree saplings.

2014
Lumbini declared a Cultural Municipality

2019
Instilling Green Lumbini initiative

Impacts

- Restored and created new wetlands through rainwater impoundments.
- Established raised nesting grounds for sarus cranes to minimise the impacts of flooding during heavy rainfall events.
- Created dykes and embankments to reduce sedimentation.
- Planted native varieties of rice, which are both flood and drought-resistant and provide a food source for cranes.

Re-introduced Kala Namak rice

Endnotes

1 IUCN. (2020) *Guidance for using the IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of Nature-based Solutions*. First Edition. Gland, Switzerland:IUCN.

2 Intergovernmental Panel on Climate Change. (2021). 'Summary for Policymakers', A1. In: Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., Zhai, P. Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R. and Zhou, B. (eds.)]. In Press. See A.1.2.

3 IPCC. (2021). Summary for Policymakers. Table SPM.1.

4 European Academies Science Advisory Council. (2018). Negative emission technologies: What role in meeting Paris Agreement targets? Teutschenthal: The European Academies Science Advisory Council.

5 Nesshöver, C., Assmuth, T., Irvine, K.N., Rusch, G.M., Waylen, K.A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Külvik, M., Rey, F., van Dijk, J., Vistad, O.I., Wilkinson, M.E. and Wittmer, H. (2017). 'The science, policy and practice of Nature-based Solutions: An interdisciplinary perspective'. Science of the Total Environment 579: 1215–1227.

6 Nesshöver, C., Prip, C., and Wittmer, H. (2015). 'Biodiversity governance: A global perspective from the Convention on Biological Diversity' in: Gaspartos, A. and Willis, K.J. (Eds.). In: Biodiversity in the green economy. London: Routledge, pp. 289–308.

7 United Nations. (1992). *Report of the United Nations Conference on Environment and Development*. Rio Janeiro. Vol 1: 3–14. Retrieved from: http://legal.icsf.net/icsflegal/uploads/pdf/instruments/rio0201.pdf.

8 United Nations (2005). *Millennium ecosystem assessment: Ecosystems and human well-being*. Washington, D.C: Island Press.

9 Carpenter, S. R., Mooney, H.A., Agard, J., Capistrano, D., Defries, R.S., Diaz, S., Dietz, T., Durraiappah, A.K., Pereira, H.M., Perrings, C., Reid, W.V., Sarukhan, J., Scholes, R.J. and Whyte, A. (2009). 'Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment'. *Proceedings of the National Academy of Sciences of the United States of America* 106 (5): 1305–1312.

10 United Nations Framework Convention on Climate Change (UNFCCC) (2016). Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015. Retreived from: https://unfccc.int/resource/docs/2015/cop21/eng/10.pdf

11 Eggermont, H. et al. (2015). Op cit.

12 Cohen-Shacham, E., Walters, G., Janzen, C, and Maginnis, S. (Eds.) (2016). *Nature-based Solutions to address global societal challenges*. Gland, Switzerland: IUCN. xiii + 97pp.

13 Ibid.

14 Mittermeier, R.A., Totten, M., Pennypacker, L.L., and Boltz, F. (2008). *A climate for life: Meeting the global challenge*. Arlington, VA: International League of Conservation Photographers.

15 International Union for Conservation of Nature. (2020). 'United Nations Framework Convention on Climate Change (UNFCCC).' Global Policy. Retrieved from: https://www.iucn.org/theme/global-policy/our-work/united-nations-framework-convention-climate-change-unfccc

16 International Union for Conservation of Nature. (2009). *No time to lose: Make full use of Nature-based Solutions in the post-2012 climate change regime*. Position paper on the Fifteenth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change.

17 International Union for Conservation of Nature. (2012). 'The IUCN Programme 2013–2016'. Retrieved from: https://portals.iucn.org/library/node/10320.

18 United Nations (2017). 'UN Climate Change Conference 2017 aims for further, faster ambition together'. UN Climate press release. Retrieved from: https://unfccc.int/news/un-climate-change-conference-2017-aims-for-further-faster-ambition-together

19 https://ipbes.net

20 Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., Hill, R., Chan, K.M.A, Baste, I.A., and Brauman, K.A. (2018). 'Assessing nature's contributions to people'. *Science* 359: 270–272.

21 Pascual U., Balvanera P., Díaz S., Pataki G., Roth E., Stenseke M., Watson R.T., Başak Dessane, E., Islar, M., Kelemen, E. (2017). 'Valuing nature's contributions to people: the IPBES approach'. *Current Opinion in Environmental Sustainability* 26–27: 7–16.

22 Cohen-Shacham, E. et al. (Eds.). (2016). Op cit.

23 European Commission (2016). 'European Commission communication: Next steps for a sustainable European future.' Retrieved from: https://www.emcdda.europa.eu/drugs-library/european-commission-communication-next-steps-sustainable-european-future-com20160739-final_da

24 Wild, T., Freitas, T., and Vandewoestijne, S. (Eds.) (2020). 'Nature-based solutions: State of the art in EU-funded projects'. The European Commission. Retrieved from: https://ec.europa.eu/info/publications/nature-based-solutions-state-art-eu-funded-projects_en

25 Nature Editorial (2017). 'Nature-based Solutions' is the latest green jargon that means more than you might think'. Nature 541 (7636): 133–134.

26 Eggermont, H. et al. (2015). Op cit.

27 Ibid.

28 Faivre, N., Fritz, M., Freitas, T., de Boissezon, B. and Van de Woestijne, S. (2017). 'Nature-based solutions in the EU: Innovating with nature to address social, economic and environmental challenges.' *Environmental Research* 159: 509–518.

29 World Wildlife Fund for Nature (n.d.) 'Nature-based Solutions'. Retrieved from: https://wwf.panda.org/discover/our_focus/climate_and_energy_practice/what_we_do/nature_based_solutions_for_climate/?

30 Eggermont, H. et al. (2015). Op cit.

31 Almenar, J.B., Elliot, T., Rugani, B., Philippe, B., Navarrete Gutierrez, T., Sonnemann, G. and Geneletti, D. (2021). 'Nexus between Nature-based Solutions, ecosystem services and urban challenges'. *Land Use Policy* 100: 104898.

32 Kabisch, N., Frantzeskaki, N., Pauleit, S., Naumann, S., Davis, M., Artmann, M., Haase, D., Knapp, S., Korn, H., Stadler, J., Zaunberger, K. and Bonn, A. (2016). 'Nature-based Solutions to climate change mitigation and adaptation in urban areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action'. *Ecology and Society* 21 (2): 39.

33 Cook, J. (2020). 'Three steps to scaling up Nature-based Solutions for climate adaptation'. World Resources Institute. Retrieved from: https://www.wri.org/blog/2020/05/3-steps-scaling-nature-based-solutions-climate-adaptation

34 Cohen-Shacham, E. et al. (Eds.). (2016). Op cit.

35 Faivre, N., Fritz, M., Freitas, T., de Boissezon, B. and Van de Woestijne, S. (2017). Op cit.

36 Albert, C., Brillinger, M., Guerrero, P., Gottwald, S., Henze, J., Schmidt, S., Ott, E. and Schro, B. (2020). 'Planning Nature-based Solutions: Principles, steps and insights'. *Ambio*. doi: 10.1007/s13280-020-01365-1

37 Maes, J. and S. Jacobs, S. (2017). 'Nature-based Solutions for Europe's sustainable development'. *Conservation Letters* 10 (1): 121–124.

38 Seddon, N., Chausson, A., Berry, P., Girardin, C.A.J., Smith, A. and Turner, B. (2020). 'Understanding the value and limits of Nature-based Solutions to climate change and other global challenges.' *Philosophical Transactions of the Royal Society B: Biological Sciences* 375 (1794).

39 Hamann, F., Blecken, G.T., Ashley, R.M. and Viklander, M. (2020). 'Valuing the multiple benefits of blue-green infrastructure for a Swedish case study: Contrasting the economic assessment tools B£ST and TEEB'. *Journal of Sustainable Water in the Built Environment* 6 (4): 05020003. doi: 10.1061/JSWBAY.0000919

40 Secretariat of the Convention on Biological Diversity. (2004). *The ecosystem approach* (CBD Guidelines). Montreal: Secretariat of the Convention on Biological Diversity.

41 Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C.R., Renaud, F.G., Welling, R. and Walters, G. (2019). 'Core principles for successfully implementing and upscaling Nature-based Solutions'. *Environmental Science and Policy* 98: 20–29.

42 International Union for Conservation of Nature (IUCN) (n.d.) 'CEM work on Nature-based Solutions'. Retrieved from:

43 Subramanian, K. (2020). 'WWF Global Futures pushes 'Nature-based Solutions' agenda'. *Down To Earth*. Retrieved from: https://www.downtoearth.org.in/blog/climate-change/wwf-global-futures-pushes-nature-based-solutions-agenda-69320

44 Cohen-Shacham, E. et al. (Eds.). (2016). Op cit.

45 Faivre, N., Fritz, M., Freitas, T., de Boissezon, B. and Van de Woestijne, S. (2017). Op cit.

46 European Commission (2015). *Towards an EU research and innovation policy agenda for Nature-based Solutions and re-naturing cities*. Final report of the Horizon2020 expert group on Nature-based Solutions and re-naturing cities. Brussels.

47 International Union for Conservation of Nature (2012). Op cit.

48 WWF. n.d. 'Nature-based Solutions'. Op cit.

49 The Nature Conservancy (n.d.). 'Nature-based solutions'. Retrieved from: https://www.nature.org/en-us/about-us/where-we-work/united-states/missouri/stories-in-missouri/nature-based-solutions/

50 International Union for Conservation of Nature (2012). Op cit.

51 Seddon, N., Sengupta, S., Hauler, I. and Rizvi, A.R. (2019). *Nature-based Solutions in Nationally Determined Contributions: Synthesis and recommendations for enhancing climate ambition and action by 2020*. Gland, Switzerland and Oxford, UK: IUCN and University of Oxford.

52 United Nations Development Programme (2019). Pathway for increasing nature-based solutions in NDCs. Retrieved from: https://www.undp.org/publications/pathway-increasing-nature-based-solutions-ndcs

53 United Nations Framework Convention on Climate Change (2016). Op cit.

54 United Nations Framework Convention on Climate Change (2021). Nationally determined contributions under the Paris Agreement: Synthesis report by the secretariat. Retrieved from: https://unfccc.int/documents/306848

55 https://unfccc.int/topics/climate-finance/events-meetings/scf-forum/the-scf-forum-on-finance-for-nature-based-solutions-part-i

56 United Nations. (2019).' UN Climate Action Summit 2019'. Retrieved from: https://www.un.org/en/climatechange/un-climate-summit-2019.shtml

57 United Nations Environment Programme (2019). 'Nature-based solutions for climate'. Retrieved from: https://www.unep.org/nature-based-solutions-climate

58 University of Oxford (n.d.). 'What is the Nature-based Solutions Initiative?' Retrieved from: https://www.naturebasedsolutionsinitiative.org/what-is-the-nature-based-solutions-initiative/

59 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

60 Society for Ecological Restoration (2004) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

61 Sudding, K.N. (2011) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

62 Odum, H. (1996) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

63 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

64 Mansourian, S. et al. (2005) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

65 Maginnis, S. et al. (2014) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

66 Convention on Biological Diversity (2009) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

67 Convention on Biological Diversity (2010) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

68 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

69 Pedrr in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

70 Lavorel, S. et. al. (2015) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

71 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

72 European Commission (2013) in Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

73 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

74 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

75 Roy, D., Barr, J., and Venema, H. (2011). *Ecosystem approaches in Integrated Water Resources Management (IWRM): A review of transboundary river basins*. United Nations Environment Programme and the International Institute for Sustainable Development.

76 Cohen-Shacham, E. et al. (Eds.) (2016). Op cit.

77 International Union for Conservation of Nature (n.d.) 'OECMs'. World Commission on Protected Areas. Retrieved from: https://www.iucn.org/commissions/world-commission-protected-areas/our-work/oecms

78 National Geographic. (2020). 'Nature-based solutions essential for climate mitigation'. National Geographic Society Newsroom. Retrieved from: https://blog.nationalgeographic.org/2020/12/11/nature-based-solutions-essential-for-climate-mitigation/

79 Goldsmith, Z. (2020). 'COVID-19 can be a wake-up call for Nature-based Solutions'. *Down To Earth*. Retrieved from: https://www.downtoearth.org.in/blog/environment/covid-19-can-be-a-wake-up-call-for-nature-based-solutions-73585

80 World Wildlife Fund for Nature (2020). 'Nature-based Solutions and the post-COVID recovery'. Retrieved from: https://wwf.panda.org/?364346/Nature-based-solutions-post-COVID-19-recovery

81 Ibid.

82 Portugal, D., Pino, D., Opperman, J., Stevens, A., Weber, C., Fabricius, C., Escobar, N., Aceituno, E., Llewellyn, G., Close, C., Putt, S., Wright, H., Pacheco, P., Leonard, P., Harsdorff, S., Gutierrez, M.T., Tsukamoto, M. and Morales, V. (2020). *Nature hires: How nature-based solutions can power a green jobs recovery*. Retrieved from: www.panda.org or www.ilo.org

83 International Union for Conservation of Nature (2021). 'Nature's future, our future: The world speaks.' Retrieved from: https://www.iucn.org/news/protected-areas/202102/natures-future-our-future-world-speaks

84 Eggermont, H. et al. (2015). 'Nature-based Solutions: New influence for environmental management and research in Europe'. *GAIA - Ecological Perspectives on Science and Society* 24(4): 243-248.

85 United Nations for Disaster Risk Reduction (2020). Words into action: *Nature-based Solutions for disaster risk reduction*. Retrieved from: https://www.undrr.org/publication/words-action-nature-based-solutions-disaster-risk-reduction

86 Lechner, A. M., Gomes, R.L., Rodrigues, L. and Ashfold, M.J. (2020). 'Challenges and considerations of applying Nature-based Solutions in low- and middle-income countries in Southeast and East Asia'. *Blue-Green Systems* 2 (1): 331–351.

87 Ibid.

88 Wamsler, C., Pauleit, S., Zölch, T., Schetke, S. and Mascarenhas, A. (2017). 'Mainstreaming nature-based Solutions for climate change adaptation in urban governance and planning'. In: *Theory and Practice of Urban Sustainability Transitions*. Springer. Cham.

89 Davis, M., Abhold, K., Mederake, L. and Knoblauch, D. (2018). *Nature-based solutions in European and national policy frameworks*. Deliverable 1.5, Naturvation. Horizon 2020 Grant Agreement Number 730243, European Commission

90 Government of India. (1927). *The Indian Forest Act,* 1927. New Delhi, India. Retrieved from: https://www.indiacode.nic.in/bitstream/123456789/15385/1/the_indian_forest_act%2C_1927.pdf

91 Government of India (1991). *The Wildlife (Protection) Amendment Act*, 1991. New Delhi, India. Retrieved from: http://nbaindia.org/uploaded/Biodiversityindia/Legal/15.%20Wildlife%20(Protection)%20Act,%201972.pdf

92 Government of India. (1974). *The Water (Prevention and Control of Pollution) Act,* 1974. New Delhi, India. Retrieved from: https://cpcb.nic.in/upload/home/water-pollution/WaterAct-1974.pdf

93 Government of India. (1980). *The Forest (Conservation) Act*, 1980. New Delhi, India. Retrieved from: https://www.indiacode.nic.in/bitstream/123456789/1760/1/198069.pdf

94 Government of India. (1981). *The Air (Prevention and Control of Pollution) Act*, 1981. New Delhi. India. Retrieved from: https://legislative.gov.in/sites/default/files/A1981-14.pdf

95 Government of India. (1986). *The Environment (Protection) Act*, 1986. New Delhi. India. Retrieved from: https://parivesh.nic.in/writereaddata/ENV/eprotect_act_1986.pdf

96 Ministry of Environment and Forests. (1990). *The Circular Concerning Joint Forest Management*. New Delhi: Government of India. Retrieved from: http://faolex.fao.org/docs/texts/ind21949.doc

97 Ministry of Environment and Forests. (2011). *Coastal Regulation Zone Notification*. New Delhi: Government of India. Retrieved from: http://www.environmentwb.gov.in/pdf/CRZ-Notification-2011.pdf

98 Kumar, S.V. and Bharat, G.K. (2014). *Perspectives on a water resource policy for India*. TERI Discussion Paper. Retrieved from: http://www.teriin.org/policybrief/docs/persp.pdf

99 National Biodiversity Authority (2004). *The Biological Diversity Act, 2002 and Biological Diversity Rules*, 2004. New Delhi: Government of India.

100 Government of India (2005). *Disaster Management Act*, 2005. New Delhi, India. Retrieved from: https://legislative.gov.in/sites/default/files/A2005-53.pdf

101 Government of India. (2006). *The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act*, 2006. New Delhi, India. Retrieved from: https://legislative.gov.in/sites/default/files/A2007-02.pdf

102 Ministry of Environment and Forests. (2010). *Wetlands (Conservation and Management) Rules*, 2010. New Delhi: Government of India. Retrieved from: https://www.indiawaterportal.org/sites/default/files/iwp/Wetlands_Rules_New_Delhi_MoEF_November_2010.pdf

103 Government of India. (2016). *The Compensatory Afforestation Fund Act*, 2016. New Delhi, India. Retrieved from: http://www.indiaenvironmentportal.org.in/content/447846/the-compensatory-afforestation-fund-act-2016/

104 Ministry of Environment, Forest and Climate Change. (2018). *Draft National Forest Policy*. New Delhi: Government of India.

105 Agarwal., S. (2018). 'National Forest Policy Draft 2018 takes one step forward, two steps back'. The Wire. Retrieved from: https://thewire.in/environment/national-forest-policy-draft-2018-takes-one-step-forward-two-steps-back

106 Ministry of Environment and Forests. (1992). *National Conservation Strategy and Policy Statement on Environment and Development*. New Delhi: Government of India. Retrieved from: http://moef.gov.in/wp-content/uploads/2017/07/introduction-csps.pdf

107 Ministry of Environment and Forests. (2012). 'Green Schemes'. ENVIS Newsletter. January-March. New Delhi: Government of India.

108 Ministry of Environment and Forests. (1999). National Forestry Action Programme. New Delhi: Government of India.

109 Ministry of Agriculture. (2000). *National Agriculture Policy,* 2000. New Delhi: Government of India.

110 Ministry of Environment and Forests. (2006). *National Environment Policy,* 2006. New Delhi: Government of India.

111 Department of Agriculture and Cooperation, Ministry of Agriculture. (2007). *National Policy for Farmers*, 2007. New Delhi: Government of India.

112 Government of India. (2008). *National Action Plan on Climate Change*. Prime Minister's Council on Climate Change. Retrieved from: https://envt.kerala.gov.in/wp-content/uploads/2019/05/National-Action-Plan-on-Climate-Change.pdf

113 Ministry of Environment and Forests. (2008). National Biodiversity Action Plan. New Delhi: Government of India.

114 Ministry of Environment, Forests and Climate Change. (2014). Addendum, 2014 to NBAP, 2008. New Delhi: Government of India.

115 National Disaster Management Authority, Ministry of Home Affairs. (2009). *National Policy on Disaster Management*. New Delhi: Government of India.

116 Ministry of Water Resources (2012). *National Water Policy*, 2012. New Delhi: Government of India. Retrieved from http://jalshakti- dowr.gov.in/sites/default/files/NWP2012Eng6495132651_1.pdf

117 Ministry of Environment, Forest and Climate Change. (2019). *National Plan for Conservation of Aquatic Ecosystems*. New Delhi: Government of India.

118 Department of Land Resources, Ministry of Rural Development. (2013). *Draft National Land Utilisation Policy Framework for Land Use Planning & Management*. New Delhi: Government of India.

119 Department of Agriculture and Cooperation and Ministry of Agriculture. (2014). *National Agroforestry Policy*. New Delhi: Government of India. Retrieved from: https://agricoop.gov.in/sites/default/files/National_agroforestry_policy_2014.pdf

120 National Disaster Management Authority. (2016). *National Disaster Management Plan*. New Delhi: Government of India.

121 Ministry of Water Resources, River Development and Ganga Rejuvenation. (2016). *Guidelines for Integrated Water Resources Development and Management*. New Delhi: Government of India.

122 Ministry of Environment, Forest and Climate Change. (2017). *National Wildlife Action Plan (2017-2031)*. New Delhi: Government of India.

123 Bawa, K.S., Sengupta, A., Chavan, V., Chellam, R., Ganesan, R., Krishnaswamy, J., Mathur, V.B., Nawn, N., Olsson, S.B., Pandit, N., Quader, S., Rajagopal, P., Ramakrishnan, U., Ravikanth, G., Sankaran, M., Shankar, D., Seidler, R., Uma Shanker, R. and Vanak, A.T (2021). 'Securing biodiversity, securing our future: A national Mission on biodiversity and human well-being for India'. *Biological Conservation*,253 (2021): 108867.

124 Ministry of Housing and Urban Affairs. (2020). *National Urban Policy Framework Strategic Intent*. New Delhi: Government of India.

125 Central Pollution Control Board and Ministry of Environment, Forest and Climate Change. (2020). *Guidelines for Setting up of Biodiversity Parks in Floodplains of Rivers of India, including River Ganga*. New Delhi: Government of India.

126 Government of the People's Republic of Bangladesh. (1927). *The Forest Act*, 1927. Dhaka, Bangladesh.

127 Government of the People's Republic of Bangladesh. (1995). *The Bangladesh Environment Conservation Act,* 1995. Dhaka, Bangladesh.

128 Government of the People's Republic of Bangladesh. (2010). *Playgrounds, Open Spaces, Parks and Natural Reservoirs in all Municipal Areas of the Country, including Municipalities in Metropolitan, Divisional Cities and Districts Act*, 2000. Dhaka, Bangladesh.

129 Government of the People's Republic of Bangladesh. (2012). *Wildlife (Conservation and Security) Act*, 2012. Dhaka, Bangladesh.

130 Ministry of Shipping. (2013). The National River Conservation Commission Act, 2013. Dhaka: Government of the People's Republic of Bangladesh.

131 Government of the People's Republic of Bangladesh. (2013). *Bangladesh Water Act,* 2013 (Act No. 14 of 2013). Retrieved from: http://www.fao.org/faolex/results/details/en/c/LEX-FAOC154320/

132 Sajal, I.A. (2016). 'Managing ecologically critical areas in Bangladesh'. *IUCN Ejournal* 8: 65–72. Retrieved from: https://www.researchgate.net/profile/Imtiaz-Sajal/publication/325471666_Managing_Ecologically_Critical_Areas_in_Bangladesh/links/5b0feb17a6fdcc80995c6d325b0feb17a6fdcc80995c6d32/Managing-Ecologically-Critical-Areas-in-Bangladesh.pdf

133 Sajal, I.A. (2017). 'Bangladesh Biological Diversity Act 2017: An appraisal'. *IUCN Academy of Environmental Law* 334:132–141.

134 Bangladesh Forest Department, Ministry of Environment and Forests. (2018). *Co-management and benefit-sharing from coastal afforestation*. Dhaka: Government of the People's Republic of Bangladesh.

135 Rahman, S. (2020). 'Bengali forests: Towards more nature protection?'. European Forest Institute. Retrieved from: https://efi.int/articles/bengali-forests-towards-more-nature-protection

136 Ministry of Finance. (1992). *Environment Policy*, 1992. Dhaka: Government of the People's Republic of Bangladesh, Retrieved from: http://nda.erd.gov.bd/en/c/publication/environment-policy-1992

137 Ministry of Water Resources. (1999). *National Water Policy*. Dhaka: Government of the People's Republic of Bangladesh.

138 Ministry of Water Resources. (2005). *Coastal Zone Policy,* 2005. Dhaka: Government of the People's Republic of Bangladesh.

139 Ministry of Environment and Forests. (2009). *Bangladesh Climate Change and Action Plan 2009*. Dhaka: Government of the People's Republic of Bangladesh. xviii+. pp. 76.

140 Ministry of Agriculture. (2013). *National Agriculture Policy 2013*. Dhaka: Government of the People's Republic of Bangladesh. Retrieved from: http://dae.portal.gov.bd/sites/default/files/files/dae.portal.gov.bd/page/452f_9774_8c23462ab73a/NAP.pdf

141 Ministry of Local Government, Rural Development and Cooperatives. (2014). *National Strategy for Water Supply and Sanitation 2014*. Dhaka: Government of the People's Republic of Bangladesh.

142 Ministry of Environment Forest and Climate Change. (2021). *Nationally Determined Contributions (NDCs) 2021*. Dhaka: Government of the People's Republic of Bangladesh. Retrieved from: https://unfccc.int/sites/default/files/NDC/2022-06/NDC_submission_20210826revised.pdf

143 Bangladesh Forest Department, Ministry of Environment and Forests. (2016). *National Forestry Policy, 2016*. Dhaka: Government of the People's Republic of Bangladesh.

144 Ministry of Environment and Forests. (2016). *National Biodiversity Strategy and Action Plan of Bangladesh 2016–2021*. Dhaka: Government of the People's Republic of Bangladesh.

145 Bangladesh Planning Commission, General Economics Division. (2020). *8th Five-Year Plan July 2020–June 2025*. Dhaka: Government of the People's Republic of Bangladesh.

146 Bangladesh Planning Commission, General Economics Division. (2018). *Bangladesh Delta Plan 2100*. Dhaka: Government of the People's Republic of Bangladesh.

147 Nepal Law Commission. (1982). *Soil and Watershed Conservation Act, 2039 (1982)*. Kathmandu: Government of Nepal.

148 Nepal Law Commission. (1992). *Water Resources Act*, 2049 (1992). Kathmandu: Government of Nepal.

149 Nepal Law Commission. (1993). *Forest Act, 2049*. Kathmandu: Government of Nepal.

150 Nepal Law Commission. (1973). *National Parks and Wildlife Conservation Act, 2029 (1973)*. Kathmandu: Government of Nepal.

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

152 Environment Protection Council. (1993). *Nepal Environmental Policy and Action Plan*. Kathmandu: Government of Nepal.

153 Water and Energy Commission Secretariat. (2002). Water Resources Strategy. Kathmandu: Government of Nepal.

154 Ministry of Agriculture and Cooperatives. (2004). *National Agricultural Policy, 2004*. Kathmandu: Government of Nepal.

155 Ministry of Science and Technology. (2005). *Science and Technology Policy, 2061 (2005 A.D.)*. Kathmandu: Government of Nepal.

156 Water and Energy Commission Secretariat. (2005). *National Water Plan: Nepal.* Kathmandu: Government of Nepal.

157 Ministry of Agricultural Development. (2007). *National Agro Biodiversity Policy of Nepal.* Kathmandu: Government of Nepal.

158 Ministry of Environment. (2010). *National Adaptation Programme of Action (NAPA) to Climate Change*. Kathmandu: Government of Nepal.

159 Ministry of Environment. (2011). *Climate Change Policy, 2011*. Kathmandu: Government of Nepal.

160 Ministry of Environment. (2011). *National Framework on Local Adaptation Plans for Action.* Kathmandu: Government of Nepal.

161 Pradhan, N. M., Khatri, T. and Pandey, M. (2018). *Mainstreaming the conservation and sustainable use of wetlands and their resources into key national planning processes in Nepal*. Ministry of Forests and Soil Conservation and Ramsar Secretariat.

162 Ministry of Federal Affairs and Local Development. (2013). *Environment-friendly Local Governance Framework, 2013*. Kathmandu: Government of Nepal.

163 Ministry of Forests and Soil Conservation. (2014). *National Biodiversity Strategy and Action Plan: 2014–2020*. Kathmandu: Government of Nepal.

164 Paudel, G., Adhikari, S. and Bhusal, P. (2019). 'Integration of Forest and Climate Change Policies in Nepal'. *Journal of Forest and Natural Resource Management* 1 (1): 1–13.

165 Ibid.

166 Ministry of Forests and Soil Conservation. (2015). *Strategy and Action Plan 2015–2025*, Terai Arc Landscape, Nepal. Kathmandu: Government of Nepal.

167 Ministry of Forests and Soil Conservation. (2016). *Forestry Sector Strategy (2016–25)*. Kathmandu: Government of Nepal.

168 Ministry of Forests and Soil Conservation. (2015). *Strategy and Action Plan 2016–2025, Chitwan-Annapurna Landscape*. Kathmandu: Government of Nepal.

169 Government of Nepal. (2020). *Second Nationally Determined Contribution (NDC)*. Kathmandu: Government of Nepal. https://unfccc.int/sites/default/files/NDC/2022-06/Second%20Nationally%20Determined%20Contribution%20%28NDC%29%20-%202020.pdf

170 Ministry of Forest and Environment. (2018) *National Ramsar Strategy and Action Plan, Nepal (2018–2024)*. Kathmandu: Government of Nepal.

171 National Planning Commission. (2020). *The Fifteenth Plan (Fiscal Year 2019/20–2023/24)*. Kathmandu: Government of Nepal.

172 Ministry of Agriculture and Livestock Development. (2019). *National Agroforestry Policy 2019*. Kathmandu: Government of Nepal.

173 IQAir. (2020). *World Air Quality Report: Region and City PM2.5 Ranking*. Retrieved from: https://www.iqair.com/world-air-quality-report

174 Babu, C.R., Kumar, P., Prasad, L., and Agrawal, R. (2012). *Valuation of ecological functions and benefits: A case study of wetland ecosystems along the Yamuna River corridors of Delhi region. Theme:* Wetlands and Biodiversity. EERC Working Paper Series: Ministry of Environment and Forests and Indira Gandhi Institute of Development Research. Retrieved from: https://irade.org/eerc/pdf/WB_FR_LallanPrasad.pdf

175 Malik, D., Singh, S., Thakur, J., Singh, R.K., Kaur, A. and Nijhawan, S. (2014.) *Heavy metal pollution of the Yamuna River: An introspection*. Retrieved from: http://www.ijcmas.com

176 Misra, A.K. (2010). 'A river about to die: Yamuna'. *Journal of Water Resource and Protection 2:* 489–500. doi: 10.4236/jwarp.2010.25056

177 Babu, C.R. et al. (2012). Op cit.

178 Ibid.

179 Central Pollution Control Board. (2006). *Water quality status of Yamuna River (1999–2005)*. Retrieved from: www.cpcb.nic.in

180 Chandra, S., and Sajwan, B.S. (2020). *Final report of the Yamuna Monitoring Committee for the rejuvenation of the River Yamuna and abatement of pollution*. Retrieved from: https://yamuna-revival.nic.in/wp-content/uploads/2020/07/Final-Report-of-YMC-29.06.2020.pdf

181 Malik, D. et al. (2014). Op cit.

182 Niangthianhoi, S. L. and Khudsar, F. A. (2016). 'The nesting success of the Oriental Darter Anhinga melanogaster (Aves: Suliformes: Anhingidae) in the Yamuna Biodiversity Park, New Delhi, India'. *Journal of Threatened Taxa 7:* 8148–8153.

183 Aerts, R., Honnay, O., and Nieuwenhuyse, A. V. (2018). 'Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces'. *British Medical Bulletin* 127 (1): 5–22. doi: 10.1093/bmb/ldy021

184 Junior, D.P.M., Bueno, C., and da Silva, C.M. (2022). 'The effect of urban green spaces on reduction of particulate matter concentration'. *Bulletin of Environmental Contamination and Toxicology* 108: 1104–1110. doi: 10.1007/s00128-022-03460-3

185 Prudencio, L., and Null, S.E. (2018). 'Stormwater management and ecosystem services: a review'. *Environmental Research Letters* 13 (3).

186 Sun, Y., Xie, S., Zhao, S. (2019).' Valuing urban green spaces in mitigating climate change: A city-wide estimate of aboveground carbon stored in urban green spaces of China's capital'. *Global Change Biology* 25 (5): 1717–1732. doi: 10.1111/gcb.14566

187 Oliveira, S., Andrade, H., and Vaz, T. (2011). 'The cooling effect of green spaces as a contribution to the mitigation of urban heat: A case study in Lisbon'. *Building and Environment* 46 (11): 2186–2194. doi: 10.1016/j.buildenv.2011.04.034

188 Santos, M.N., Delabie, J.H.C. and Queiroz, J.M. (2019). 'Biodiversity conservation in urban parks: a study of ground-dwelling ants (Hymenoptera: Formicidae) in Rio de Janeiro City'. *Urban Ecosystems 22:* 927–942. doi: 10.1007/s11252-019-00872-8

189 Derr, V. (2017). 'Urban green spaces as participatory learning laboratories'. *Urban Design and Planning* 171 (1): 1–9. doi: 10.1680/jurdp.17.00009

190 Hoyle, H. (2021). *Futureproofing urban parks and greenspaces for climate resilience, people and wildlife.* Technical Report: University of the West of England, Bristol. doi: 10.13140/RG.2.2.33278.72004

191 Delhi Development Authority (2021). *Biodiversity Park: Nature reserves of Delhi.* New Delhi, India.

192 Central Pollution Control Board and Ministry of Environment, Forest and Climate Change (2020). *Guidelines for setting up of Biodiversity Parks in floodplains of rivers of India, including River Ganga.* New Delhi, India.

193 Singh, M., Gautam, S., Srivastava, D. P., Jain, P., Sirohi, U., Singh, H., Arjun, and Khudsar, F. A. (2021). 'First leopard picture in the Yamuna Biodiversity Park, India'. *Cat News* 72: 19.

194 Ruth, H., and Eugenia. M. (2019). *Bangladesh poverty assessment: Facing old and new frontiers in poverty reduction.* Washington DC: World Bank Group. Retrieved from: http://documents.worldbank.org/curated/en/793121572582830383/Bangladesh-Poverty-Assessment-Facing-Old-and-New-Frontiers-in-Poverty-Reduction

195 Bangladesh Bureau of Statistics, Ministry of Planning. (2014). *Bangladesh Population and Housing Census 2011.* Government of the People's Republic of Bangladesh.

196 Bangladesh Bureau of Statistics. (2017). *Household Income and Expenditure Survey 2016–2017.* Retrieved from: https://catalog.ihsn.org/index.php/catalog/7399/related- materials

197 ACAPS. (2020). 'Cox's Bazar *Upazila* profiles'. Retrieved from: https://www.acaps.org/sites/acaps/files/products/files/20200917_acaps_coxs_bazar_analysis_hub_upazila_profiles.pdf

198 Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, (2013). District statistics 2011: Cox's Bazar. Government of the People's Republic of Bangladesh.

199 ACAPS. (2020). Op cit.

200 Chowdhary, T.H. (2012). *'Ukhia Upazila'*. Banglapedia: National Encyclopaedia of Bangladesh. Asiatic Society of Bangladesh.

201 Ministry of Environment and Forests, UNDP Bangladesh, and UN Women (2018). *Report on the environmental impact of the Rohingya influx.* Retrieved from: https://www.undp.org/bangladesh/publications/report-environmental-impact-rohingya-influx

202 Local Government Engineering Department, and Ministry of Local Government Rural Development and Cooperatives. (2018). 'Bangladesh: Emergency Assistance Project: Construction of 4 nos. school cum cyclone shelter for affected people, 3 storied LGED Prototype, in Ukhiya'. Asian Development Bank. ADB Project 52174-001 | Grant 0582-BAN. Retrieved from: https://www.adb.org/sites/default/files/project-documents/52174/52174-001-iee-en_1.pdf

203 ACAPS (2020). Op cit.

204 Inter Sector Coordination Group Bangladesh. (2019). *Joint Multi-Sector Needs Assessment (J-MSNA): Host communities in Teknaf and Ukhiya Upazilas. Cox's Bazar.* European Union Civil Protection and Humanitarian Aid and UNHCR. Retrieved from: https://reliefweb.int/report/bangladesh/joint-multi-sector-needs-assessment-j-msna-host-communities-teknaf-and-ukhiya

205 Ministry of Environment and Forests, UNDP Bangladesh and UN Women Bangladesh. (2018). Op cit.

206 Chowdhury, K.R. (2018). 'Rohingya find a precarious perch on deforested hills'. The Third Pole. Retrieved from: https://www.thethirdpole.net/en/nature/rohingya-find-a- precarious-perch-on-deforested-hills

207 UN Refugee Agency. (2019). 'Rohingya emergency'. Retrieved from: https://www.unhcr.org/en-%20in/rohingya-emergency.html

208 Inter Sector Coordination Group Bangladesh. (2020). *Joint Response Plan Rohingya humanitarian crisis.* Retrieved from: https://reliefweb.int/sites/reliefweb.int/files/resources/jrp_2020_final_in-design_280220.2mb_0.pdf

209 ACAPS. (2020). Op cit.

210 Ibid.

211 Ministry of Environment and Forests, UNDP Bangladesh, and UN Women. (2018). Op cit.

212 Alam, A., Sammonds, P. and Ahmed, B. (2019). 'Cyclone risk assessment of the Cox's Bazar district and Rohingya refugee camps in southeast Bangladesh'. *Science of the Total Environment* 704. doi: 10.1016/j.scitotenv.2019.135360.

213 Local Government Engineering Department, and Ministry of Local Government Rural Development and Cooperatives. (2018). Op cit.

214 Ministry of Environment and Forests, UNDP Bangladesh, and UN Women. (2018). Op cit.

215 Ministry of Environment and Forests, UNDP Bangladesh, and UN Women. (2018). Op cit.

216 Inter Sector Coordination Group Bangladesh. (2019). Op cit.

217 Koema (2012). Retrieved from: https://knoema.com/NITI_DGAGRBACPFTUP2019/districtwise-gdp-and-growth-rate-based-at-current-price-2004-05-from-2004-05-to-2011-12-uttar-prades?district=1000320-gorakhpur

218 Gorakhpur Environmental Action Group. (2013). *City Resilience Strategy Summary*. Retrieved from: https://geagindia.org/sites/default/files/2018-08/151.-City-Resilience-Strategy-Gorakhpur.pdf

219 Opitz-Stapleton, S. and Hawley, K. (2013). *Gorakhpur: Extreme rainfall, climate change, and flooding*. Policy Brief. Retrieved from: https://www.i-s-e-t.org/publications-and-resources-1/gorakhpur%3A-extreme-rainfall%2C-climate-change%2C-and-flooding-%28policy-brief%29

220 Gorakhpur Development Authority. (2010). *Gorakhpur Master Plan 2021*. Gorakhpur. Retrieved from: http://www.gdagkp.org/userfiles/Gorakhpur Master Plan 2021.pdf

221 Farmers' unions part of a national LSKM network

222 Mani, N. Singh, A. and Wajih,S. (2014).' Promoting Periurban Agriculture in Flood-Prone Areas of Gorakhpur, India'. *Urban Agriculture* 28: 72-76.

223 Rai, S. (2006). 'Is the next silicon valley taking root in Bangalore?'. *The New York Times*. Archived from the original on 13 October 2011.

224 Ahmed, F. (2017). *To flow, or to fortify? Water, development, and urbanism in building a deltaic metropolis*. Retrieved from: https://digital.library.adelaide.edu.au/dspace/handle/2440/109736

225 Roy, S., Sowgat, T. and Mondal, J. (2019). 'City profile: Dhaka, Bangladesh'. *Environment and Urbanisation Asia* 10 (2): 216–232. doi: 10.1177/0975425319859126

226 Kabir, M.H., Sato, M., Habbiba, U. and T. Bin Yousuf, T. (2018). 'Assessment of urban disaster resilience in Dhaka North City Corporation (DNCC), Bangladesh'. *Procedia Engineering* 212: 1107–1114. doi: 10.1016/j.proeng.2018.01.143.

227 Ibid.

228 Ibid.

229 Ahmed, F. (2017). Op cit.

230 Ibid.

231 Islam, M.S., Rahman, M.R., Shahabuddin, A. and Ahmed, R. (1970). *Changes in wetlands in Dhaka City: Trends and physico-environmental consequences*. Journal of Life and Earth Sciences. 5: 37–42. doi: 10.3329/jles.v5i0.7348..

232 Roy, S. (2019). Op cit.

233 Ahmed, S., Bramley, G., and Dewan, A. (2012). 'Exploratory growth analysis of a megacity through different spatial metrics: A case study on Dhaka, Bangladesh (1960–2005)'. *Urban and Regional Information Systems Association Journal* 24: 9–24. Retrieved from: https://www.researchgate.net/publication/244989545_Exploratory_growth_analysis_of_a_megacity_through_different_spatial_metrics_A_case_study_on_Dhaka_Bangladesh_1960-2005

234 Dewan, A.M. and Yamaguchi, Y. (2009). 'Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanisation'. *Applied Geography* 29 (3): 390–401. doi: 10.1016/j.apgeog.2008.12.005.

235 Kabir, M.H. et al. (2018). Op cit.

236 World Bank. (2015). Climate and disaster resilience of Greater Dhaka area: *A micro level analysis*. Bangladesh development series, paper no. 2;. Dhaka, Bangladesh. Retrieved from: https://openknowledge.worldbank.org/handle/10986/23235

237 Kabir, M.H. et al. (2018) Op cit.

238 World Bank. (2015). Op cit.

239 World Wildlife Fund for Nature. (2009). *Mega-stress for mega-cities: A climate vulnerability ranking of major coastal cities in Asia*. Retrieved from: https://wwfeu.awsassets.panda.org/downloads/mega_cities_report.pdf

240 Jahan, F. and Khasrul Alam Quddusi, K. S. (2013). 'Climate change and Bangladesh: Geographical and socio-economic impacts'. *Dhaulagiri Journal of Sociology and Anthropology* 7: 113-132.

241 Ahmed, F. (2017). Op cit.

242 SENES Consultants Limited and Techno Consult International Limited. (2007). *Dhaka Metropolitan Development Plan Strategic Environmental Assessment.* The World Bank, Washington, DC. Retrieved from: https://documents1.worldbank.org/curated/en/945651468003307657/pdf/750620WP0P10210C00Dhaka0Development.pdf

243 Nijhum, F.Q., Rahaman, S.T., Hossain, M.J. and Islam, I. (2019). 'Participatory democracy or state-induced violence? Resettling the displaced people of Hatirjheel in Dhaka'. *South Asia Research* 39 (2): 202–217. doi: 10.1177/0262728019843715

244 Mazid, M.A. (2013). 'How it came into being '. Daily Star. Retrieved from: https://www.thedailystar.net/news-detail-263437

245 United Nations Department of Economic and Social Affairs Population Division. (2018). *World Urbanisation Prospects: The 2018 Revision.* Retrieved from: https://population.un.org/wup/publications/Files/WUP2018-Report.pdf

246 Gamesby, R. (2013). 'Mumbai case study'. Coolgeography. Retrieved from: https://www.coolgeography.co.uk/A-level/AQA/Year 13/World Cities/Mumbai/Mumbai.htm

247 District Disaster Management Authority. (2019). *District disaster management plan: Mumbai city district.* Retrieved from: https://dm.mcgm.gov.in/disaster-management-plan-city

248 Sarkar, L.H. (2021).' Mangroves in Mumbai'. *International Journal of Creative Research Thoughts* 5:(4). Retrieved from: https://www.ijcrt.org/papers/IJCRT1704193.pdf

249 Everard, M., Jha, R.R. and Russell, S. (2014). 'The benefits of fringing mangrove systems to Mumbai'. *Aquatic Conservation: Marine and Freshwater Ecosystems* 24 (2): 256–274.

250 Sarkar, L.H. (2021). Op cit.

251 Everard, M. et al. (2014). Op cit.

252 Ibid.

253 Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac, and Z. Sebesvari. (2019). 'Sea level rise and implications for low-lying islands, coasts and communities', Executive Summary. In: *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge and New York: Cambridge University Press, pp. 321-445. https://doi.org/10.1017/9781009157964.006

254 Deshpande, L. and Joshi, T. (2020). 'Pirojshanagar: An illustration of co-existence and biodiversity conservation since seven decades'. In: *Corporate Biodiversity Management for Sustainable Growth.* Springer Nature Publications, pp193–211.

255 Naumann, S., Davis, M., Kaphengst, T., Pieterse, M. and Rayment, M. (2011). *Design, implementation and cost elements of green infrastructure projects.* Final report to the European Commission, DG Environment, Contract no. 070307/2010/577182/ETU/F. 1. Ecologic Institute and GHK Consulting.

256 Zakaria, N.B. (2019).' A green workspace – Karupannya factory'. *Showcase Magazine.* Retrieved from: https://www.showcase.com.bd/architect-column/a-green-workspace-karupannya-factory/

257 Nakshabid Architects (n.d). 'Green field unit Karupannya'. Retrieved from: https://www.nakshabid.com/work/green-field-unit-karupannya-rangpur-limited/

258 Haque, A. (2019). 'Weaving dreams'. *Prothomalo.* Retrieved from: https://en.prothomalo.com/bangladesh/Weaving-dreams

259 Textile Focus (2020). 'Green "Karuponnyo Rangpur Limited", pride of Bangladeshi handicraft industries'. Retrieved from: https://textilefocus.com/green-karuponnyo-rangpur-limited-pride-bangladeshi-handicraft-industries/

260 Ibid.

261 Tuba, N. (2020). 'Karupannya: A factory that breathe'. Context. Retrieved from: https://contextbd.com/karupannya-factory-breathe/

262 Nakshabid Architects. (n.d.). Op cit.

263 Tuba, N. (2020). Op cit.

264 Thapa, R.B. Murayama, Y. and Ale, S. (2008). 'Kathmandu'. *Cities* 25 (1): 45–57.doi: 10.1016/j.cities.2007.10.001

265 The World Bank. (2013). *Lalitpur Sub-Metropolitan City Environmental and Social Management Framework*. Lalitpur, Nepal

266 City-wide Inclusive Sanitation Technical Assistance Hub, Environment and Public Health Organisation, and Kathmandu Valley Water Supply Management Board (2020). SFD Lite Report: Lalitpur metropolitan city, Nepal. Retrieved from: https://www.susana.org/_resources/documents/default/3-3816-7-1615281641.pdf

267 United Nations Department of Economic and Social Affairs. (2014). *World Urbanization Prospects*. The 2014 Revision. New York. Retrieved from: https://population.un.org/wup/publications/files/wup2014-report.pdf

268 Bakrania, S. (2015). *Urbanisation and urban growth in Nepal*. Retrieved from: http://www.gsdrc.org/wp-content/uploads/2015/11/HDQ1294.pdf

269 The World Bank (2013). Op cit.

270 Ishtiaque, A. Shrestha, M. and Chhetri, N. (2017). 'Rapid urban growth in the Kathmandu Valley, Nepal: Monitoring land use land cover dynamics of a Himalayan city with Landsat imageries'. *Environments* 4 (4): 1–16, doi: 10.3390/environments4040072

271 Worpole, K. and Knox, K. (2008). *The social value of public spaces*. Joseph Rowntree Foundation. Retrieved from https://www.jrf.org.uk/sites/default/files/jrf/migrated/files/2050-public-space-community.pdf

272 Timalsina, K.P. (2020). 'Public open spaces in crisis: Appraisal and observation from metropolitan Kathmandu, Nepal'. *Journal of Geography and Regional Planning* 13 (4): 77–90. doi: 10.5897/jgrp2020.0797

273 Ishtiaque, A. et al. (2017). Op cit.

274 Blake. A. (2016). 'Pocket parks'. *Urban Park*. Retrieved from: http://depts.washington.edu/open2100/Resources/2_OpenSpaceTypes/Open_Space_Types/pocket_parks.pdf

275 Timalsina, K.P. (2020). Op cit.

276 Blake. A. (2016). Op cit.

277 Bruce, A. (2017). 'Pocket parks: Rich experiences, small spaces'. Retrieved from: https://sourceable.net/pocket-parks-rich-experiences-small-spaces/

278 Ibid.

279 Ojha, A. (2020). *Lalitpur Launches 'Green Fence Transparent Project' to Promote Greenery and Green Space*. The Kathmandu Post. [Online]. Available: https://kathmandupost.com/valley/2020/11/26/lalitpur-launches-green-fence-transparent-project-to-promote-greenery-and-green-space. Accessed 1 April 2021..

280 Oxford Economics (2018). Global cities: *The future of the world's leading urban economies to 2035*. Retrieved from: https://resources.oxfordeconomics.com/global-cities-2035

281 https://manikondamunicipality.telangana.gov.in/

282 Ramachandraiah, C. and Prasad, S. (2004). *Impact of urban growth on water bodies: The case of Hyderabad*. Working Paper Number 60. Centre for Economic and Social Studies.

283 Chigurupati, R. (2008). 'Urban growth, loss of water bodies and flooding in Indian cities'. In: *Water and Urban Development Paradigms*. CRC Press. pp: 121–125.

284 Ramachandraiah, C. and Prasad, S. (2004). Op cit.

285 Chigurupati, R. (2008).Op cit.

286 Singh, S. (2011). Water security in peri-urban South Asia adapting to climate change and urbanization scoping study report: Hyderabad. Retrieved from: www.saciwaters.org/periurban

287 Ramachandraiah, C. and Prasad, S. (2004). Op cit.

288 Singh, S. (2011). Op cit.

289 SaciWATERs (2012). Lakes of Hyderabad. Retrieved from: http://www.saciwaters.org/lakes/about.html

290 Ali, S., Abbas, Z., Rizwan, M., Zaheer, I.E., Yava, I., Unay, A., Abdel, M.M., Bin-Jumah, M., Hasanuzzamam, M. and Kalderis, D. (2020). 'Application of floating aquatic plants in phytoremediation of heavy metals polluted water: A review'. *Sustainability,* 12(5): 1–33. doi: 10.3390/su12051927

291 Negri, M.C. and Hinchman, R.R. (1996). *Phytoremediation: Using green plants to clean up contaminated soil, groundwater, and wastewater.* Argonne National Laboratory technical women's symposium, Argonne, IL, USA. Retrieved from: https://www.osti.gov/biblio/231975-phytoremediation-using-green-plants-clean-up-contaminated-soil-groundwater-wastewater

292 Solitude Lake Management. (2014). 'How to restore lake and pond water quality through nutrient management'. Retrieved from: https://www.solitudelakemanagement.com/how-nutrient-management-restores-water-quality?hsCtaTracking=df372f00-3013-406a-8cfb-a76f5cd68b22%7C097267e9-04a2-42cb-8a5e-8ba9099f42c4

293 Minnesota Pollution Control Agency. (n.d). 'Sediment control practices - Sediment traps and basins'. *Minnesota Stormwater Manual.* Retrieved from: https://stormwater.pca.state.mn.us/index.php?title=Sediment_control_practices_-_Sediment_traps_and_basins

294 Martin Ecosystems. (2017). 'How do floating treatment wetlands work?' Retrieved from: http://martinecosystems.com/how-do-floating-treatment-wetlands-work/

295 White, S.A. and Cousins, M. M. (2013). 'Floating treatment wetland aided remediation of nitrogen and phosphorus from simulated stormwater runoff'. *Ecological Engineering* 61. 207–215. doi: 10.1016/j.ecoleng.2013.09.020

296 A state sponsored greening programme

297 Banerji, A. (2019). 'Bengaluru water crisis: More work, less water in India's "silicon valley"'. *Bloomberg*. Retrieved from: https://www.livemint.com/news/india/bengaluru-water-crisis-more-work-less-water-in-india-s-silicon-valley-1559718058529.html

298 Government of Nepal. (2019). Integrated Urban Development Plan of Dhulikhel Municipality.

299 Khatri, D., Neupane, K.R. and Devkota, K. (2021). 'Dhulikhel's journey towards water security: Insights for policy and practice'. In: *Dhulikhel's journey towards water security: Insights for policy and practice.* Retrieved from: https://www.researchgate.net/profile/Kamal-Devkota-3/publication/349648057_Pani_Chautari_as_a_Tool_for_Evidence_-_Informed_Policy_and_Practice_Experiences_from_Dhulikhel/links/603a5658299bf1cc26f4a9ea/Pani-Chautari-as-a-Tool-for-Evidence-Informed-Policy-and-Practice-Experiences-from-Dhulikhel.pdf

300 Ojha, H., Neupane, K.R., Pandey, C.L., Singh, V.,Bajracharya, R., and Dahal, N. (2020).'Scarcity amidst plenty: Lower Himalayan cities struggling for water security'. *Water* (Switzerland) 12(2). doi: 10.3390/w12020567

301 Government of Nepal. (2019). Op cit.

302 Ojha, H., Neupane, K.R., Pandey, C.L., Singh, V.,Bajracharya, R., and Dahal, N. (2020).Op cit.

303 Shrestha, S., Devkota, K., Dahal, N., and Neupane, K.R. (2021). 'Application of recharge ponds for water management: Explaining from Nature Based Solution Perspective'. In: *Dhulikhel's journey towards water security: Insights for policy and practice.*

304 Sonneveld, B.G. J.S., Merbis, M.D., Alfarra, A., Ünver, O. and Arnal, M.F. (2018). *Nature-based solutions for agricultural water management and food security.* Rome: Food and Agricultural Organization of the United Nations. Retrieved from: https://www.preventionweb.net/publications/view/62867

305 Shrestha, S., Devkota, K., Dahal, N., and Neupane, K.R. (2021). Op cit.

306 Devkota, K., Maskey, G.,and Khatri, D. (2021). 'Pani Chautari as a tool for evidence-informed policy and practice: Experiences from Dhulikhel'. In: *Dhulikhel's journey towards water security: Insights for policy and practice.*

307 Khatri, D., Neupane, K.R. and Devkota, K. (2021). Op cit.

308 Ojha, H., Neupane, K.R., Pandey, C.L., Singh, V.,Bajracharya, R., and Dahal, N. (2020). Op cit.

309 Shrestha, S., Devkota, K., Dahal, N., and Neupane, K.R. (2021). Op cit.

310 Devkota, K., Maskey, G.,and Khatri, D. (2021). Op cit.

311 Neupane, K.R.,Shrestha, A., and Joshi, T. (2021). 'Upstream-downstream interdependencies and water security in Dhulikhel'. In: Dhulikhel's journey towards watersecurity: Insights for policy and practice.

312 Shrestha, S., Devkota, K., Dahal, N., and Neupane, K.R. (2021).Op cit.

313 Khatri, D., Neupane, K.R. and Devkota, K. (2021). Op cit.

314 Ojha, H., Neupane, K.R., Pandey, C.L., Singh, V.,Bajracharya, R., and Dahal, N. (2020). Op cit.

315 Shrestha, S., Devkota, K., Dahal, N., and Neupane, K.R. (2021). Op cit.

316 Devkota, K., Maskey, G.,and Khatri, D. (2021). Op cit.

317 Neupane, K.R.,Shrestha, A., and Joshi, T. (2021). 'Upstream-downstream interdependencies and water security in Dhulikhel'. In: *Dhulikhel's Journey Towards Water Security: Insights for Policy and Practice.*

318 Sundriyal, S., Shridhar, V., Madhwal, S., Pandey, K. and Sharma, V. (2018).' Impacts of tourism development on the physical environment of Mussoorie, a hill station in the lower Himalayan range of India'. *Journal of Mountain Science* 15 (10): 2276–2291. https://doi.org/10.1007/s11629-017-4786-0

319 Ramola, A. (2019). 'Threats to Mussoorie's ecology due to overexploitation, demographic changes'. *Hindustan Times*. Retrieved from: https://www.hindustantimes.com/dehradun/threats-to-mussoorie-s-ecology-due-to-overexploitation-demographic-changes/story-EILY4AO85Wu8nQyrZg1uVI.html

320 Bharti, N., Khandekar, N., Sengupta, P., Bhadwal, S., and Kochhar, I. (2020). 'Dynamics of urban water supply management of two Himalayan towns in India'. *Water Policy* 22. 65–89. https://doi.org/10.2166/wp.2019.203

321 Madan, S. and Rawat, L. (2000). 'The impacts of tourism on the environment of Mussoorie, Garhwal Himalaya, India'. *Environmentalist* 20 (3): 249–255. https://doi.org/10.1023/A:1006760015997

322 Sidhu, A.K. (2011). 'View of changing biodiversity scenario in the Himalayan ecosystem: Mussoorie, Uttarakhand, India, as revealed by the study of blue butterflies (Lycaenidae)'. *Journal of Threatened Taxa:* 3 (2): 1559–1563. Retrieved from: https://threatenedtaxa.org/index.php/JoTT/article/view/608/1059

323 Madan, S. and Rawat, L. (2000). 'The impacts of tourism on the environment of Mussoorie, Garhwal Himalaya, India'. *Environmentalist*. 20 (3): 249–255. https://doi.org/10.1023/A:1006760015997

324 Ibid.

325 Nand Pant, D., Groten, S.M.E. and Sarthi Roy, P. (2000). 'Forest vegetation/land use change detection and impact assessment in part of Western Himalaya'. *International Archives of Photogrammetry and Remote Sensing,* XXXIII (Part B3): 950–957.

326 Ibid.

327 The history of the management of the property including ownership has been accessed from http://jabarkhetnature.com/history.php

328 Ibid.

329 Forest, Environment and Wildlife Management Department. (2011). *Sacred groves of Sikkim*. Government of Sikkim. Retrieved from: http://www.sikkimforest.gov.in/sacredgroves.htm

330 Ghosh, S. (2021). 'Sikkim's urban sacred groves mitigate double the carbon compared to a natural rural forest'. *Mongabay* 4. Retrieved from: https://india.mongabay.com/2021/04/urban-sacred-groves-forests-in-sikkim-act-as-carbon-sinks/

331 Forest, Environment and Wildlife Management Department. (2011). Op cit.

332 Ibid.

333 Devi, N.B., Lepcha, N.T., Mahalik, S.S., Dutta, D., and Tsanglao, B.L. (2020). 'Urban sacred grove forests are potential carbon stores: A case study from Sikkim Himalaya'. Environmental Challenges 4 (November): 100072. doi: 10.1016/j.envc.2021.100072.

334 Escobedo, F.J. et al. (2011). 'Urban forests and pollution mitigation: Analyzing ecosystem services and disservices'. Environmental Pollution 159 (8–9): 2078–2087. doi: 10.1016/j.envpol.2011.01.010.

335 Escobedo, F.J., Kroeger, T. and Wagner, J.E. (2011). Op cit.

336 Neopaney, Y., Ghose, M.K. and Paul, S. (2016). 'Survey paper on effect of urban sprawling on deforestation and encroachment of land using RS and GIS: A case study of Gangtok City'. *International Journal of Computer Applications* 133 (4): 40–42. doi: 10.5120/ijca2016907790.

337 Temperate Plants Database. (n.d.). '*Betula alnoides*': Useful temperate plants. Retrieved from: http://temperate.theferns.info/plant/Betula+alnoides

338 Tropical Plants Database. (n.d.). '*Schima wallichii*'. Useful tropical plants. Retrieved from: http://tropical.theferns.info/viewtropical.php?id=Schima+wallichii

339 Ray, S. and Paria, N.D. (2018). 'Seed and seedling morphology of two near threatened Indian species: *Cryptomeria japonica* and *Cupressus cashmeriana* (*Cupressaceae sensu lato*)'. Annals of Plant Sciences 7 (4): 2179. doi: 10.21746/aps.2018.7.4.3.

340 Jactel, H., Koricheva, J. and Castagneyrol, B. (2019). 'Responses of forest insect pests to climate change: Not so simple'. *Current Opinion in Insect Science* 35: 103-108. doi: 10.1016/j.cois.2019.07.010.

341 Grebner, D.L., Bettinger, P. and Siry, J.P. (2013). 'Urban forestry'. In: *Introduction to forestry and natural resources*. Elsevier. pp. 385–405.

342 Devi, N.B., Lepcha, N.T., Mahalik, S.S., Dutta, D., and Tsanglao, B.L. (2020). *Urban sacred grove forests are potential carbon stores: A case study from Sikkim Himalaya*. Environmental Challenges, 4 (November): 100072. doi: 10.1016/j.envc.2021.100072.

343 Forest, Environment and Wildlife Management Department (2011).

344 Government of Nepal, Lumbini Cultural Municipality. Retrieved from: https://lumbinisanskritikmun.gov.np/

345 UNESCO. 'Lumbini: A living World Heritage Site'. Retrieved from: https://en.unesco.org/news/lumbini-living-world-heritage-site

346 Atzori, A. (2006). *Lumbini: Present status and future challenges*. Kathmandu. United Nations Educational, Scientific and Cultural Organisation. Retrieved from: https://unesdoc.unesco.org/ark:/48223/pf0000147105

347 Lewer, N., Lafortune-Bernard, A., Coningham, R., Acharya, K.P. and Kunwar, R.B. (2019). 'Community engagement in the Greater Lumbini area of Nepal: The micro-heritage case study of Dohani'. In: *Archaeology, Cultural Heritage Protection and Community Engagement in South Asia*. Springer Singapore. pp. 59–74.

348 World Wide Fund for Nature. (2012). 'The Green Lumbini Initiative'. WWF Nepal. Retrieved from: https://www.wwfnepal.org/what_we_do/special_projects/lumbini/

349 Ministry of Forests and Soil Conservation. (2015). *Strategy and Action Plan 2015-2025, Terai Arc Landscape*.

350 World Wide Fund for Nature. (2012). Op cit.

351 Birdlife International. (2005). 'Important bird areas factsheet: Farmlands in Lumbini area'. Retrieved from: http://datazone.birdlife.org/site/factsheet/farmlands-in-lumbini-area-iba-nepal

352 UNESCO (2013). The sacred garden of Lumbini: Perceptions of Buddha's birthplace. UNESCO: Paris.

353 Belifuss, R. and Suwal, R.N. (1999). 'Restoring a sacred home for the Sarus crane in Nepal'. The ICF Bugle. International Crane Foundation.

354 Suwal, R.N. (1999a). 'Study of the bird diversity of Lumbini Garden and Lumbini Adarsha VDC'. Tribhuvan University.

355 UNESCO 'Lumbini: A living World Heritage Site'. Op cit.

356 Suwal, R.N. (1999). *Study on the habitat preference, movements, nesting and population dynamics of Sarus of Lumbini Cranes*. Tribhuvan University

357 Suwal, R.N. (2001). *Research activities for protecting wildlife and building up a sustainable rural farm in Rupandehi.*

358 World Wildlife Fund. (2021). 'Creating wetlands and improved nesting sites for Sarus cranes in Nepal'. Retrieved from: https://www.worldwildlife.org/creating-wetlands-and-improved-nesting-sites-for-sarus-cranes-in-nepal

Annexure 1: NbS relevant legislation in Bangladesh, India and Nepal

COUNTRY	RELEVANT LEGISLATION
Bangladesh	Forest Act, 1927, the Bangladesh Environment Conservation Act, 1995; Playgrounds, Open Spaces, Parks and Natural Reservoirs in all Municipal Areas of the Country, including Municipalities in Metropolitan, Divisional Cities and Districts Act, 2000; Wildlife (Conservation and Security) Act, 2012; National River Conservation Commission Act, 2013; Bangladesh Water Act, 2013; Ecologically Critical Area Management Rules, 2016; Bangladesh Biodiversity Act, 2017; Protected Area Management Rules, 2017. Relevant policies include Environment Policy, 1992; National Water Policy, 1999; Coastal Zone Policy, 2005; Bangladesh Climate Change Strategy and Action Plan (BCCSAP), 2009; National Agriculture Policy, 2013; National Strategy for Water Supply & Sanitation, 2014; INDC, 2015; National Forest Policy, 2016; National Biodiversity Strategy and Action Plan (NBSAP) of Bangladesh (2016-2021); Bangladesh Eigth Five Year Plan (2020-2025); and the Bangladesh Delta Plan (BDP), 2100.
India	Indian Forest Act, 1927; Wildlife (Protection) Act (WPA), 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; Environment (Protection) Act, 1986; Joint Forest Management (JFM) Circular, 1990; Panchayati Raj Act, 1992; Biological Diversity Act, 2002 and Biological Diversity Rules, 2004; Disaster Management Act, 2005; Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Compensatory Afforestation Fund Act (CAMPA), 2016; Wetlands (Conservation and Management) Rules, 2017; and the Coastal Regulation Zone Notification, 2019. Relevant policies that can be used as a framework for NbS implementation in India include the National Forest Policy, 1952; National Conservation Strategy and Policy Statement on Environment and Development, 1992; National River Conservation Plan (NRCP), 1995; National Ecotourism Policy and Guidelines, 1998; National Forestry Action Programme, 1999; National Agriculture Policy, 2000; National Environment Policy, 2006; National Policy for Farmers, 2007; National Action Plan on Climate Change (NAPCC), 2008; National Biodiversity Action Plan (NBAP), 2008 and Addendum, 2014; National Policy on Disaster Management, 2009; National Water Policy, 2012; National Land Utilisation Policy (Draft), 2013; National Plan for Conservation of Aquatic Ecosystems (NPCA), 2013; Intended Nationally Determined Contributions (INDC), 2015; Policy on Promotion of City Compost, 2016; National Disaster Management Plan (NDMP), 2016; Guidelines for Integrated Water Resources Development and Management, 2016; National Wildlife Action Plan (2017- 2031); National Urban Policy Framework (NUPF), 2020; Guidelines for Setting up of Biodiversity Parks in Floodplains of Rivers of India, including River Ganga, 2020.
Nepal	Soil and Watershed Conservation Act, 1982; Water Resource Act, 1992; Forest Act, 1993; National Parks and Wildlife Conservation Act, 2017; Environment Protection Act, 2019; Nepal Environmental Policy and Action Plan, 1993; Water Resource Strategy, 2002; National Agriculture Policy, 2004; Science and Technology Policy, 2005; National Water Plan (NWP), 2005; Agrobiodiversity Policy, 2007; National Adaptation Programme of Action (NAPA), 2010; Climate Change Policy, 2011; National Framework on Local Adaptation Plan for Action (LAPA), 2011; National Wetland Policy, 2012; Environment Friendly Local Governance Framework, 2013; Nepal Biodiversity Strategy and Action Plan (NBSAP) (2014-2020); Community Forestry Development Guidelines, 2014; Forest Policy, 2015; Terai Arc Landscape (TAL) Strategy and Action Plan (2015-2025); Forestry Sector Strategy, (2016-2025); Chitwan-Annapurna Landscape (CHAL) Strategy and Action Plan 2016-2025; INDC, 2016; National Ramsar Strategy and Action Plan, Nepal (2018-2024); and Nepal's Fifteenth Three Year Plan, 2019-2024.

Annexure 2: Examples of Nature-based Solutions in urban areas from India, Nepal and Bangladesh – at a glance

NO.	COUNTRY	NAME OF THE INITIATIVE	NBS APPROACHES USED	LOCATION	IMPLEMENTED BY	IMPLEMENTED SINCE	ISSUES ADDRESSED
1.	India	Tropical Forest Re storation in the Auroville Township	Ecosystem-restoration approach	Auroville	Auroville Foundation	1970s	Ecological and habitat degradation, biodiversity loss
2.	India	Aravalli Biodiversity Park	Ecosystem-restoration approach	Gurugram	'IamGurgaon' and Municipal Corporation of Gurugram	2010	Ecological degradation
3.	India	Tilpath Valley Biodiversity Park	Ecosystem-restoration approach	New Delhi	DDA and CEMDE	2015	Ecological and habitat degradation, biodiversity loss
4.	India	Kamala Nehru Biodiversity Park	Ecosystem-restoration approach	New Delhi	DDA and CEMDE	2015	Ecological and habitat degradation, biodiversity loss
5.	India	Tughlaqabad Biodiversity Park	Ecosystem restoration approach	New Delhi	DDA and CEMDE	2015	Ecological and habitat degradation, biodiversity loss
6.	India	Neela Hauz Biodiversity Park	Ecosystem-restoration approach	New Delhi	DDA and CEMDE	2015	Ecological and habitat degradation, biodiversity loss
7.	India	Eco-park at Badarpur Thermal Power Station	Ecosystem-restoration approach	New Delhi	National Thermal Power Corporation	2019	Ecological degradation
8.	India	Pond restoration at Shri Guru Ram Rai Public School	Ecosystem-restoration approach	Dehradun	Shri Guru Ram Rai Mission	2010	Ecological degradation
9.	India	Restoration of Bhatti Mines in Asola Bhatti Wildlife Sanctuary	Ecosystem-restoration approach	New Delhi	CEMDE	2000	Ecological degradation, biodiversity loss

NO.	COUNTRY	NAME OF THE INITIATIVE	NBS APPROACHES USED	LOCATION	IMPLEMENTED BY	IMPLEMENTED SINCE	ISSUES ADDRESSED
10.	India	Lakes of Chennai- Alleri Tank, Madambakkam Lake, Vandalur Lake and Koladi Lake	Ecosystem-restoration approach, Ecosystem-based management approach	Chennai	Environmentalist Foundation of India with support from the Greater Chennai Corporation, Chennai Smart Cities Limited, Public Works Department, Government of Tamil Nadu, Thiruvallur District Administration, Rotary Club of Madras, DXC Technology and AstraZeneca	2015	Drought, ecological degradation, water insecurity
11.	India	Pollinator garden in Subhash Park	Issue-specific ecosystem-related approach	Kochi	ICLEI- Local Governments for Sustainability, South Asia	2020	Climate change, biodiversity loss
12.	India	Oxyzone	Issue-specific ecosystem-related approach	Raipur	District Administration, Raipur	2017	Air pollution, climate change
13.	India	Thane Creek Mangrove Restoration Project	Issue-specific ecosystem-related approach	Mumbai	Mangroves Conservation Unit, Maharashtra Forest Department	2005	Biodiversity loss, ecological degradation
14.	India	Urban Jungle on Terrace	Issue-specific ecosystem-related approach	Bengaluru	Mr. Nataraja Upadhya	2010	Air pollution, climate change

NO.	COUNTRY	NAME OF THE INITIATIVE	NBS APPROACHES USED	LOCATION	IMPLEMENTED BY	IMPLEMENTED SINCE	ISSUES ADDRESSED
15.	India	Sabarmati River Front Project	Infrastructure-related approach	Ahmedabad	Sabarmati River Front Development Corporation Ltd	1996	Water scarcity, Water pollution, Limited recreational spaces
16.	India	Indira Paryavaran Bhavan	Infrastructure-related approach	New Delhi	Ministry of Environment, Forest and Climate Change, Government of India	2011	Climate change
17.	India	Ekrukh Lake Constructed Wetlands	Infrastructure-related approach	Solapur	ICLEI- Local Governments for Sustainability, South Asia	2019	Water pollution, water scarcity
18.	India	Campus of Indian Institute of Human Settlements Institution of Eminence (IIHS-IOE)	Infrastructure-related approach	Kengeri, Bengaluru	IIHS-IOE	2020	Climate change
19.	India	Bhakti Park Urban Forest	Infrastructure-related approach	Mumbai	Brihanmumbai Municipal Corporation	2020	Air pollution, biodiversity loss
20.	India	Hamla Urban Forest	Infrastructure-related approach	Mumbai	The Indian Navy and Green Yatra	2020	Air pollution, biodiversity loss
21.	India	Jayaprakash Narayan Biodiversity Park	Infrastructure-related approach	Bengaluru	Bruhat Bangalore Mahanagara Palike (BBMP)	2006	Lack of open green spaces and recreational places
22.	India	East Kolkata Wetlands	Ecosystem-based management approach	Kolkata	East Kolkata Wetlands Management Authority	2002	Ecological degradation, water pollution
23.	India	Adopting Integrated Urban Water Management in Indian cities	Ecosystem-based management approach	Jaisalmer	ICLEI- Local Governments for Sustainability, South Asia	2013	Water pollution, water scarcity
24.	India	Chauganpur Pond Restoration	Ecosystem-based management approach	Chauganpur Tehsil, Dadri	Mr. Ramveer Tanwar	2020	Water scarcity, ecological degradation

NO.	COUNTRY	NAME OF THE INITIATIVE	NBS APPROACHES USED	LOCATION	IMPLEMENTED BY	IMPLEMENTED SINCE	ISSUES ADDRESSED
25.	India	Thane Creek Flamingo Sanctuary	Ecosystem-protection approach	Navi Mumbai	Government of Maharashtra	2018	Biodiversity loss
26.	India	Barapullah Urban Forest	Ecosystem-protection approach	New Delhi	Afforestt and Department of Biotechnology, Government of India	2019	Air pollution, biodiversity loss
27.	India	Raj Bhavan Biodiversity Park	Ecosystem-protection approach	Nagpur	Forest Development Corporation of Maharashtra Limited	2009	Biodiversity loss, climate change
28.	India	Ambazari Biodiversity Park	Ecosystem protection approach	Nagpur	Maharashtra Forest Department	2019	Biodiversity loss, climate change
29.	India	Haldwani Biodiversity Park	Ecosystem-protection approach	Haldwani	Uttarakhand Forest Department	2020	Biodiversity loss, climate change
30.	India	Jorbeer Conservation Reserve	Ecosystem-protection approach	Bikaner	Rajasthan Forest Department	2008	Biodiversity loss
32.	India	Karpoor Chandra Kulish Smriti Van	Ecosystem-protection approach	Jaipur	Government of Rajasthan	2005	Biodiversity loss
33.	Bangladesh	Ecological Rehabilitation of the Korean Export Processing Zone	Ecosystem-restoration approach	Chittagong	Youngone Corporation	1999	Ecological degradation
34.	Bangladesh	Integrated Quality Horticulture Development Project	Issue-specific ecosystem-related approach	Mirpur and Mohammadpur	Department of Agriculture Extension, Government of Bangladesh	2013	Climate change, food insecurity
35.	Bangladesh	Floating Agriculture	Issue-specific ecosystem-related approach	Barisal, Gopalganj, Madaripur and Pirojpur	Local farmers	1800s	Climate change, food insecurity

NO.	COUNTRY	NAME OF THE INITIATIVE	NBS APPROACHES USED	LOCATION	IMPLEMENTED BY	IMPLEMENTED SINCE	ISSUES ADDRESSED
36.	Bangladesh	Urban Biodiversity Conservation project through creating an Eco Museum by the participatory approach of civil society	Infrastructure-related approach	Khulna	Bangladesh Environment and Development Society	2018	Biodiversity loss, climate change
37.	Bangladesh	Kolpona-Talaimari river embankment plantation	Infrastructure-related approach	Rajshahi	ICLEI- Local Governments for Sustainability, South Asia	2020	Biodiversity loss
38.	Bangladesh	National Botanic Garden of Bangladesh	Ecosystem-protection approach	Mirpur	Ministry of Environment and Forests, Government of Bangladesh	1961	Biodiversity loss, climate change
39.	Nepal	Phewa Watershed community-based forest landscape restoration	Ecosystem-restoration approach	South Pokhara	Government of Nepal	1970s	Ecological degradation
40.	Nepal	Ancient Pond restoration	Ecosystem-restoration approach	Ramechhap	Ramechhap Municipality	2020	Ecological degradation, water scarcity
41.	Nepal	Rooftop farming in Kathmandu	Issue-specific ecosystem-related approach	Kathmandu	Mr. Dilip Shrestha	1993	Climate change, food insecurity
42.	Nepal	Sunga Constructed Wetland	Infrastructure-related approach	Madhyapur Thimi	WaterAid Nepal	2005	Water pollution
43.	Nepal	World Peace Biodiversity Garden	Ecosystem-protection approach	Pokhara	Ministry of Forests and Environment, Government of Nepal	2014	Biodiversity loss
44.	Nepal	Community managed Special Conservation Sites in Nepal	Ecosystem-protection approach	Golchha House, Biratnagar	Himalayan Nature	1990s	Biodiversity loss

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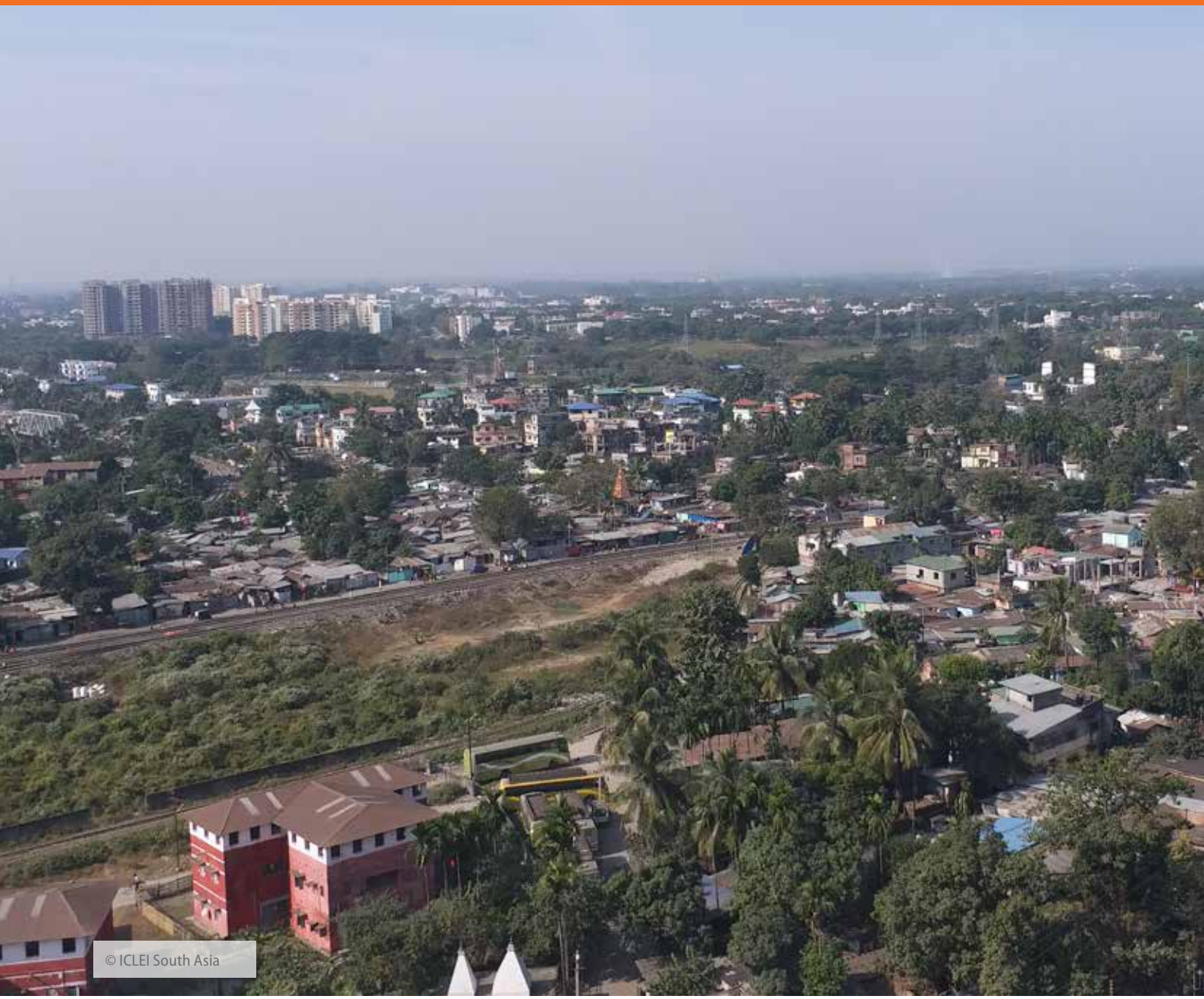

About ICLEI - Local Governments for Sustainability, South Asia

ICLEI South Asia supports South Asian cities on multiple aspects of sustainable development. We aim to build and serve a regional network of local governments to achieve tangible improvements in regional and global sustainability through local initiatives.

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CDKN works to improve the lives of the most climate-affected people in the global South through mobilising knowledge-into-action, capacity and Southern climate leadership from local to global levels. We collaborate with the public, private and non-governmental sectors in support of locally-owned and -led climate-resilient action.

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