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Nature-based Solutions for Reducing Disaster Risks

A Guidebook for District Disaster Management Planning

Wetlands INTERNATIONAL

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A Guidebook for District Disaster Management Planning

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Contributors

Guidance
- Prof. Anil K Gupta, Professor & Head ECDRM Division, NIDM
- Dr Ritesh Kumar, Director, WI-SA

Authors
- Mr Dhruv Verma, Senior Technical Officer and Project Lead, Eco-DRR, WI-SA
- Ms Pritha Acharya, Research Associate, NIDM
- Ms Suchita Awasthi, National Project Coordinator, IMWBES Project, WI-SA
- Ms Nehha Sharma, Technical Officer – Socio-economics, WI-SA
- Dr Satish Prasad, Technical Officer – Landscape Planning, WI-SA

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National Institute of Disaster Management
(Ministry of Home Affairs, Govt. of India)
Sector-29, Rohini, Delhi -110042
WEBSITE: https://nidm.gov.in

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National Institute of Disaster Management
Ministry of Home Affairs, Government of India

nidm
Resilient India - Disaster Free India

ताज हसन, भा.पु.से.
कार्यकारी निदेशक

Taj Hassan, IPS
Executive Director

सत्यमेव जयते

राष्ट्रीय आपदा प्रबंधन संस्थान
National Institute of Disaster Management
(गृह मंत्रालय, भारत सरकार)
Ministry of Home Affairs, Govt. of India
प्लॉट नं. 15, ब्लॉक-बी, पॉकेट-3,
सेक्टर-29, रोहिणी, दिल्ली-110042
Plot No. 15, Block-B, Pocket-3,
Sector-29, Rohini, Delhi - 110042

75 आज़ादी का अमृत महोत्सव

Foreword

India is one of the most hit countries in terms of climate change and related disasters. Challenges like water scarcity, drought, heat wave, dust storm etc are all aggravated by climate change and wetlands are identified to play a critical role in maintaining and moderating these. Environmental degradation is a key driver of disaster risk and is also exacerbated by climate change. With disaster management going through a paradigm shift in India from 'response and relief' to "prevention-mitigation and preparedness" centric approach, mitigating and managing disasters calls for proactive solutions. Ecosystems play a vital role in promoting effective risk reduction strategies. Nature-based Solution (NbS) harnesses the benefits of ecosystems to provide numerous societal benefits. Nature-based solutions also provide prime examples of how they can be used to address the challenges of climate change and disaster risk reduction and mitigation. Wetlands are one of the most important ecosystems that can help in disaster risk reductions with their ability to buffer cyclonic storms, soak up flood waters and release water slowly during drought and offer multiple advantages. They also provide livelihood opportunity, food, water and fibre along with helping adapt to the climate while remaining cost effective.

However, these benefits will remain isolated and will not be reaped to their full potential until there is an upscaled implementation of Nature-based Solutions through inclusion within disaster policy and planning. Districts being key units of administration in our country, mainstreaming ecosystems services approach in district level planning, particularly in district level DRR is of vital importance.

This manual has been designed jointly by Wetland International India and NIDM to recognise the benefits of ecosystems and their management for DRR and CCA and provides guidance to plan and implement Nature-based Solutions and climate change adaptation. It also helps in understanding NbS entry points by the district level officers, policy makers, practioners, research personnel, academicians, NGOs etc.

With the publication we aim to draw attention to the role of ecosystems in disaster risk reduction, with valuable insights from Wetlands International South Asia. The manual is a result of learnings under the Partners for Resilience programme in India, led by Wetland International South Asia, has been very effective in building community climate resilience through Integrated Risk Management (IRM), which combines adaptation with DRR and Nature-based Solutions such as wetland restoration. I am sure that the contents of this report will be useful for the readers.

Taj Hassan

Foreword

Building resilience in all forms, including resilience to water-mediated disasters, is imperative for sustainable development. Human civilisations, wetlands and water systems have co-evolved as a coupled system. Significant parts of water systems and wetlands were transformed and regulated to meet human needs for survival and sustenance. While degradation of wetlands has made landscapes and societies vulnerable, it is also true that a significant part of the human population and economic assets currently dwell in highly dynamic, hydrologically variable and ecologically fragile parts of andscapes, such as river floodplains, wetlands shorelines and coastal zones. It is, therefore, natural that conservation and wise use of ecosystems such as wetlands form an integral part of solutions for buffering disaster risks and building resilient societies.

The gradual shift in focus over the last three decades from an emphasis on disaster response to com rehensive disaster management, specifically disaster risk reduction, has opened new possibilities for considering Nature-based Solutions for disaster risk reduction and, more recently, climate change mitigation and adaptation. In the aftermath of several water-mediated disasters, a considerable body of research highlights the increasing vulnerability of landscapes wherein wetlands have been degraded or lost. This is especially true for major urban areas in India, wherein large swathes of wetlands have been converted to give way for housing and other infrastructure. If the floods have brought floodplain and urban wetlands to the limelight, so have tropical cyclones and storm surges to the coastal wetlands, such as mangroves and estuaries.

Integrating wetlands in disaster risk reduction programmes needs programming innovations, particularly in how wetlands are identified and prioriised, collaborative planning is conducted, and governance for the two sectors is bridged. Implementing nature-based solutions, such as considering wetlands as buffers of water-mediated risks, cannot be treated as an additive process wherein the policies and programmes of wetlands conservation and disaster risk reduction sector are joined together but require a more sophisticated and nuanced collaborative and beyond sectoral disciplinary approaches.

This guidebook on Nature-based Solutions, prepared jointly by the National Institute of Disaster Management and Wetlands International South Asia, is an effort to embed Nature-based Solutions in District Disaster Management Plans, the most fundamental units of disaster governance in India. We look forward to feedback on the uptake of this guidebook from various stakeholders.

Dr Ritesh Kumar
Director
Wetlands International South Asia

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राष्ट्रीय आपदा प्रबंधन संस्थान
National Institute of Disaster Management
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Ministry of Home Affairs, Govt. of India
प्लॉट नं. 15, ब्लॉक बी, पॉकेट 3,
सेक्टर 29, रोहिणी, दिल्ली
Plot No. 15, Block B, Pocket 3,
Sector 29, Rohini, Delhi -110042

डॉ. अनिल कुमार गुप्त
आचार्य एवं अध्यक्ष
ANIL K. GUPTA (Prof./Dr.)
Head of Division, I/c. International Cooperation & Advisory Services
Head-Online Training & Continuous Learning
Director of Projects & Centre of Excellence
Professor of Policy & Strategies

Preface

Climate change is increasing frequency, intensity and complexity of water-related risks. Such changes are taking place in the backdrop of increasing water challenges such as declining per-capita availability, pollution, conflicts over various usages, and deterioration of ecosystems which moderate water regimes. There is increasing evidence that ecosystem degradation, such as rapid loss of natural wetlands, is a significant underlying driver of increasing water-related risks. Similarly, data suggests that nearly 86% of disaster events and 98% of damages from disasters in India were hydro-meteorological extreme events.

Nature sustains all life on earth and supports human well-being through a range of ecosystem services. Consequently, disaster risk-reduction (DRR) approaches that incorporate Nature-based Solutions (NbS) have the potential to support achievement of societal development goals, safeguard human well-being and enhance resilience of ecosystems. The global policies including SFDRR, SDGs and the Paris Climate Agreement have significantly prioritized the use of NbS in disaster risk reduction and ecosystem restoration. Thus the international and national priority accorded to NbS in reducing water-related risks can be effectively reinforced and operationalized by embedding in the District Disaster Management Plans. Disaster Management in India is going through a paradigm shift, focusing on relief-centric approaches to response- centric approach, thus, mainstreaming NbS through localization at district level is an integral part part of this transition, in securing development gains.

NIDM has been actively working with Wetland International (WI) South Asia on various issues of capacity building in wetland and ecosystem restoration. This guidebook has also been developed as part of the CAP-RES (DST Funded) and Eco-DRR (European Commission Funded). I hope this guidebook is helpful to the district authorities to understand the importance of NbS and prioritizing it for reducing water related risks.

Anil K Gupta

Acknowledgements

On behalf of the team, we extend our sincere thanks to Shri Taj Hassan, Executive Director, National Institute for Disaster Management and Dr Sidharth Kaul, President, Wetland International South Asia for their constant guidance and encouragement in bringing out this publication.

The guidebook for District Disaster Management Planning on Nature-based Solutions for Reducing Water-related Risks has been jointly prepared by National Institute for Disaster Management (NIDM) and Wetland International South Asia (WI-SA) under the aegis of project 'Climate Adaptive Planning for Resilience and Sustainable Development in Multi-Hazard Environment (CAP-RES)' (supported by Department of Science & Technology - DST), Government of India and 'Upscaling community resilience through Ecosystem based Disaster Risk Reduction' (funded by European Commission and implemented by UN Environment Programme and Partners for Resilience).

A special note of thanks to Dr Akhilesh Gupta (Sr Advisor & Head PCPM, DST, GoI) and Dr Nisha Mendiratta (Head, Climate Change Programme, and WISE-KIRAN Division, DST, GoI) and Dr Susheela Negi (Scientist E, Climate Change Programme, DST, GoI) for entrusting NIDM with the opportunity to take up and work on the project CAP-RES for bring-in the considerations of ecosystem management and restoration in DRR.

We appreciate the support and guidance of the advisory board of the Wetlands International South Asia, Dr Ajit K. Pattnaik (Vice President) and Dr J.K. Garg (Honorary Treasurer) in preparation of this guidebook. We also acknowledge the guidance and expert inputs provided by Mr Dushyant Mohil, Program Manager - PfR at WI-SA in conceptualisation and development of this guidebook. We also thank Mr Harsh Ganapathi, Sr Technical Officer and Ms Namita Sharma, Technical Officer – Communications in supporting the development of this publication.

We also extend our sincere gratitude to Dr Manu Gupta (Founder, SEEDS India), an eminent Disaster Risk Reduction and NbS professional for reviewing and providing expert inputs throughout the development of this guidebook.

Dr Ritesh Kumar
Director
Wetlands International South Asia

Prof Anil K Gupta
Project Director, CAP-RES Project
Head, ECDRM, NIDM

Contents

About this Guidebook

Water-related risks, which are attributed to complex interactions in the ocean-atmosphere-land process cascade, cause extensive damage to lives and assets as well as to life-sustaining ecosystems. As per the International Disaster Database (EMDAT), during 1970–2019, nearly 86% of disaster events and 98% of damages due to disasters in India were caused by hydro-meteorological extreme events (Figure 1). This trend is likely to persist and intensify in the coming times due to climate change and anthropogenic factors such as ecosystem degradation and poor land use planning.

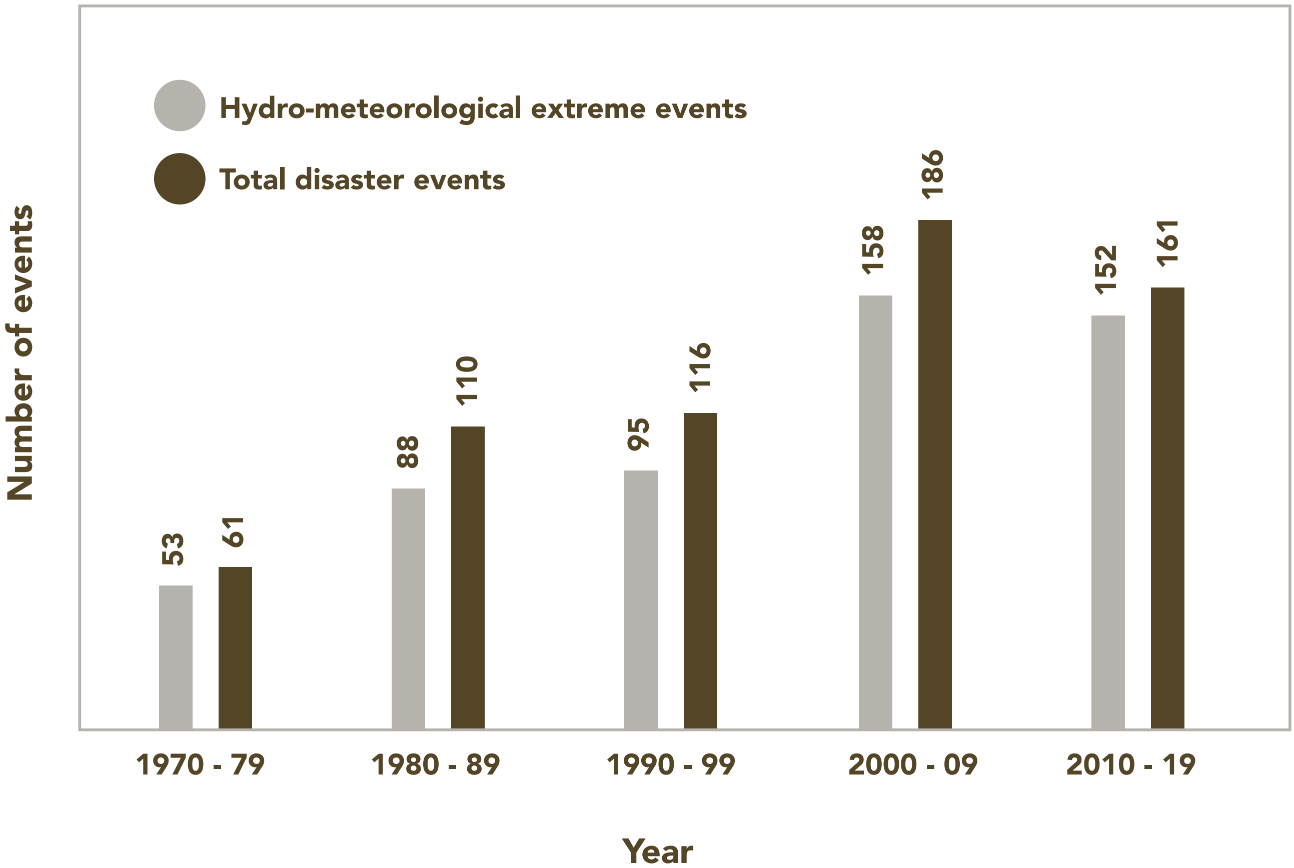


Figure 1: Increasing share of hydro-meteorological extreme events in India during 1970 - 2019 (Source: EMDAT)

There is increasing evidence that ecosystem degradation, such as rapid loss of natural wetlands, is a significant underlying driver of increasing water-related risks. Consequently, disaster risk-reduction (DRR) approaches that incorporate Nature-based Solutions (NbS) have the potential to support achievement of societal development goals, safeguard human well-being and enhance resilience of ecosystems.

The significance of NbS has been recognised by several international agreements. The Sendai Framework for Disaster Risk Reduction (2015- 2030) recognises the need to shift from primarily post-disaster planning and recovery to the proactive risk reduction strategies that should consider integration of ecosystem-based solutions. The Paris Agreement on Climate Change calls on the Parties to acknowledge 'the importance of ensuring the integrity of all ecosystems, including oceans, and the protection of biodiversity, recognised by some cultures as Mother Earth'. The United Nations Convention for Biological Diversity at its 14th Conference of the Parties decided to integrate climate change issues into national biodiversity strategies and vice versa, bringing important interdependencies to light.

The Ramsar convention on Wetlands recommends that policy makers recognise the role of wetlands in disaster risk reduction, emphasising the value of their wise use as a significant and cost-effective component of DRR strategies. NbS contributes to multiple Sustainable Development Goals (SDGs) and helps with challenges related to development by providing livelihoods and playing an important role in climate change adaptation and mitigation.

India's National Disaster Management Plan (2019) recommends shifting focus from relief-centric approaches to proactive DRR measures. Adopting locally-relevant NbS is an important part of this transition, and can significantly help in securing development gains, reduce vulnerabilities to future risks, and increase access to sectoral resources to implement risk-reduction measures.

India has a decentralized framework for implementing disaster risk reduction actions, in which district administration plays a crucial role. The Disaster Management Act, 2005 mandates District Disaster Management Authorities (DDMA), headed by the Collector/ District Magistrate with elected representative of the local authority as co-chairperson, as the planning, coordinating and implementing body for disaster management at the district level. The DDMAs are also entrusted with preparation of the District Disaster Management Plans (DDMP) in accordance with national and state level guidelines.

The international and national priority accorded to NbS in reducing water-related risks can be effectively reinforced and operationalized by embedding in the DDMP. This manual has been drafted to assist the DDMA in this task.

Destruction caused by flash floods in Uttarakhand

IMAGE CREDIT Jan Vikas Sansthan

Mangroves help mitigate storm surges at Bhitarkanika Conservation Area, Odisha

IMAGE CREDIT Dhruv Verma

Target Audience

This guidebook is primarily targeted for use by the DDMA. The document will also be useful for

- Non-government and civil society organizations who support the formulation and implementation of DDMP.
- Panchayat members involved in planning and implementing DDMP.
- Disaster management professionals engaged in capacity development and research on the application of nature-based solutions.

Structure of the guidebook

This guidebook has four sections

- Section 1
  Understanding water-related risks - introduces the concept of water-related risks and their causative factors and the need for planning at the level of hydrological units.
- Section 2
  NbS for addressing water-related risks - discusses the concept of Nature based solutions (NbS), their typology and application principles.
- Section 3
  Integrating NbS into DDMP - provides a framework for assessing water-related risks and identifying appropriate NbS. The section also indicate ways in which NbS can be reflected in the model DDMP format.
- Section 4
  Creating an enabling environment - makes recommendation for amending the model DDMP planning process to enable incorporation of NbS.

Further readings

- Sendai Framework for Action
  https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
- National Disaster Management Plan
  https://reliefweb.int/sites/reliefweb.int/files/resources/ndmp-2019.pdf
- Wetlands for Disaster Risk Reduction: Effective choices for resilient communities
  https://www.ramsar.org/sites/default/files/documents/library/rpb_wetlands_and_drr_e.pdf

SECTION 1

Understanding water-related risks

1.1 What are water-related risks?

Water is the life-blood of our biosphere. Water sustain economic activities and nourishes ecosystems. Human development has been made possible by harnessing water available in nature and diverting it for various usages such as agriculture, building water supply systems, and providing input to industries.

Yet, water is also a source of disaster risk – when it is in such quantity (too much or too little), quality (being polluted) and timing that it can no longer play a beneficial role – rather becoming a threat to lives and assets. In cases where planning and infrastructure development is not aligned with the way water naturally moves in the landscape in its various forms, water becomes a hazard, and in combination with factors which increase exposure and reduce capacity, translates into water-related risks.
Water-related risks can be primary or secondary. Primary water-related risks are the direct results of hydro-climatic interference. Some examples are:

- Floods
- Droughts
- Cyclones

Secondary water-related risks are brought upon or initiated by the primary risks. Some examples are:

- Landslides
- Cyclone-induced floods
- Waterborne diseases
- Desertification

1.2 What creates water-related risks?

Disaster risk is widely recognized as the consequence of the interaction between a hazard and the characteristics that make people, places and ecosystems exposed and vulnerable. Owing to their geographical location and biophysical characteristics, certain areas are at high risk of impacts of hydro-climatic events. Developmental activities that do not take cognizance of these factors contribute to heightened risks, which when juxtaposed with these events lead to disasters. Climate change is increasing frequency, intensity and complexity of water-related risks. Such changes are taking place in the backdrop of increasing water challenges such as declining per-capita availability, pollution, conflicts over various usages, and deterioration of ecosystems which adversely affect water regimes.

Loss and degradation of extensive network of wetlands in Jhelum valley led to extreme flooding in 2014

IMAGE CREDIT Wetlands International South Asia

Box 1

Key concepts

Satabhaya beach in Odisha bore the brunt of Super cyclone of 1999 due to destruction of dense Mangrove belt

IMAGE CREDIT Bijoy

Disaster risks	Disaster risks are the potential loss of life, injury, destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, and vulnerability. Disaster risk reduction is the concept and practice of reducing disaster risks through systematic efforts to analyse and reduce the causal factors.
Disasters	Disasters are the outcomes of continuously present conditions of risk. Parts of disaster risks may be acceptable or tolerable depending on existing social, economic, political, cultural, technical and environmental conditions, whereas for the residual, emergency disaster response and recovery capacities must be maintained. It is well-established that there is no such thing as 'natural' disasters, only natural 'hazards'. Disasters follow natural hazards due to the choices we make for development and environment, and this is applicable to water-related disaster risks as well. Water-related disaster risks are a manifestation of three major factors, namely hazard, exposure and vulnerability.

School in Ganjam district, Odisha submerged by Cyclone induced floods

IMAGE CREDIT Partners for Resilience, Wetlands International South Asia

Hazards

Hazard are the possible, future occurrence of natural or human-induced physical events that may have adverse effects on exposed and vulnerable elements. Water-related hazards may be attributed to a range of factors such as:

- Geomorphological - Factors attributed to physical features of the landscapes (such as coastal deltas are more prone to cyclonic flooding).
- Hydrological - The drainage pattern significantly determines the quantity, timing and quality of water in landscape. For example, the impervious surface greatly increases the rate and volume of runoff therefore increasing the risk of flooding.
- Ecological - Presence of ecosystems, such as wetlands, forests and grasslands influence the movement of water in a landscape.
- Climate and weather related - Climatic patterns such as rainfall influence the seasonality of floods and droughts in a landscape. For example, the east coast of India is highly prone to cyclonic disturbances due to wind patterns in Bay of Bengal.

The intensity or recurrence of water-related hazard events are highly influenced by environmental degradation and human intervention in natural ecosystems, such as construction in wetlands.

Water-related hazards which are attributed to natural settings of the landscape are **systemic hazards**. For example, flood pulses in river floodplains are systemic, and enable exchange and transport of water, sediment, nutrients and species. Hazards that are induced by alteration to the landscape are **non-systemic hazards**. Thus, water logging caused by embankments along a river are an outcome of engineering intervention in the landscape. Similarly, while formation of glacial lakes in high-altitude areas is a natural landscape process, faulty land use planning such as settlements below such lakes or in their natural drainage may turn these into hazards such as GLOF. This distinction is important as systemic hazards relate to natural landscape processes, mitigation of which may have highly adverse consequences.

Exposure

Exposure refers to concentration of people and their assets in an area in which hazard events may occur. If people and assets were not located in hazard-prone spaces, no problem of disaster risk would exist. Normally, exposure is considered from an anthropogenic perspective, but to be able to address water-related risks, it is important to include ecosystems in this definition. This is in consideration of the fact that the ecosystem services (particularly those supporting DRR and resilience building) are key assets for people in the landscape.

Exposure to the water-related hazards is mainly an outcome of:

- Improper land-use planning
- Environmental degradation
- Demographic changes
- Promotion of unsustainable livelihood options

Vulnerability

Vulnerability refers to the propensity of exposed elements (such as people, livelihoods and assets, ecosystems) to suffer adverse effects when impacted by hazard. High vulnerability of communities to water-related risks may be due to:

- High susceptibility: due to physical predisposition of people and their assets to be affected due to a water-related hazard event. For example, housing with weak foundations is very likely to collapse in floods. Similarly, specially-abled people may not be able to evacuate quickly in the case of sudden storm surge.
- Low coping and adaptive capacities: Low capacities to cope (ability to react to adverse hazard events) or adapt (ability to anticipate risks and take timely measures to better survive hazards) makes a community highly vulnerable to water-related hazards.

These capacities may relate to

Anticipating water-related risks:
through measures such as early-warning systems.

Responding to water-related risks:
through planning and investment in disaster-preparedness, and conservation and management of ecosystems that buffer communities against water-related risks.

Recovering and changing in the face of increasing water-related risks:
by making conscious conservation and development choices that avoid concentration of people and assets in fragile and exposed parts of landscapes, and building overall resilience.

Figure 2: Elements of water-related risks

Vulnerability

Factors which reduce or limit coping and adaptive capacities to water-related risks

- Capacity to anticipate
- Capacity to respond
- Capacity to recover and change

Hazard

Natural properties of landscape which influence and condition movement of water

- Geomorphology
- Climate and weather
- Hydrological regimes
- Ecosystems

Exposure

Concentration of people andassetsinwater-hazard prone spaces

- Physical dimensions
- Social dimensions
- Economic dimensions
- Institutions and governance dimensions

1.3 Reducing water related risks

Water is a dynamic resource. In a landscape, water may express itself in various physical forms (such as ice, snow, liquid water and moisture), in different flow conditions (such as flowing in rivers, while relatively stagnant in wetlands); plentiful in certain parts (such as river floodplains and deltas) yet very less in others (such as deserts); highly destructive in some areas (such as when moving through high hill slopes) or very tame in others (such as when moving through plains); highly invisible (such as in marshes and swamps where water is barely at surface round the year), and can be efficient carriers and transporters of materials and genetic resources.

As water moves in landscape, it is influenced by its different parts, for example, forests and wetlands moderate flows and enable groundwater recharge; cropped areas convert liquid water (also called blue water) into vapour (or green water); and constructed surfaces increase the water flow rates and reduce groundwater recharge.

Seldom do development choices factor in an understanding of water and the role different ecosystems play in influencing movement of water in a landscape. This is at the core of creating water-related risks. Reducing these risks requires actions for reducing exposure and vulnerability. This can be achieved by DRR planning which:

- Incorporates an understanding of the way water manifests and moves in the landscape
- Adopts hydrological unit (basin, sub basin or coastal zone) as a unit of planning
- Prevents or regulates concentration of people and assets in parts of the landscape which are prone to water-related hazards
- Incorporates the role healthy ecosystems play in buffering water-related risks (through NbS- discussed in the following sections)
- Builds individual as well as community level capacity to anticipate and respond to water-related risks

Marshes are excelent natural sponges in a landscape

IMAGE CREDIT Wetlands International South Asia

Further readings

Landscape Approach - Care and Wetlands International
Understanding Disaster Risks - https://www.preventionweb.net/disaster-risk/

Box 2

Kashmir Deluge: Reconsidering wetlands as natural flood defence

The city of Srinagar was struck by devastating floods in September 2014. Nearly 500 lives were lost, 22,000 injured, and over 0.12 million houses were damaged. This flooding episode is touted as being the worst to affect Srinagar since 1902. A closer look, however, underlines Kashmir Valley's increasing vulnerability to extreme events as its natural buffers, the extensive network of wetlands, have been rapidly destroyed and degraded.

The City of Srinagar has evolved on the floodplains of River Jhelum. Wetlands, through their ability to moderate flow regimes, are its natural and primary flood defence. However, the urban sprawl has engulfed large chunks of these fragile ecosystems. Floodplains of River Jhelum and its channels have been encroached and constructed upon. At the same time, concretized surfaces with high surface run-off during precipitation events have increased exponentially. Wular, the largest wetland of Kashmir, presents a classic case of anthropogenic modification of natural landscape. Studies undertaken during the course of work in the Wular Wetland indicated that during the last century, the area of the wetland and its associated marshes has shrunk by over fifth (from 217 km^2 in 1911 to 178 km^2 in 2007). The marshes associated with Wular have been extensively converted for agriculture and settlements. Construction of embankments to protect the agriculture fields has reduced connectivity of the wetland with the Jhelum River and inflowing streams. Extensive degradation of catchments and plantation of willow inside the wetland have resulted in rapid siltation and reduced water holding capacity.

The September 2014 deluge is a grim reminder of the ways in which societies are rendered vulnerable due to the loss of wetlands. As measures of urban reconstruction and flood risk reduction are being identified and implemented for Kashmir Valley, it is important that the role of wetlands is brought to the fore, and integrated as 'natural solutions'.

IMAGE CREDIT Wetlands International South Asia

SECTION 2

Nature-based Solutions for addressing water-related risks

2.1 What are Nature-based Solutions?

Nature sustains all life on earth and supports human well-being through a range of ecosystem services. For example, wetlands act as a source of freshwater and buffer floods and droughts. Forests help maintain soil moisture, prevent soil erosion and sequester carbon. NbS are solutions that use nature, or are inspired by nature to address societal challenges such as reduction of water-related risks.

The International Union for Conservation of Nature (IUCN) has adopted the following definition of NbS: 'Nature-based Solutions are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.'

Nature conservation has been the focus of several government and non-government programmes in India. Some notable examples are programmes for conservation of forests, rivers, and wetlands, and laws and regulations put in place for the environment (such as the Environment Protection Act, 1986 and the Biological Diversity Act, 2002). These actions are directed at nature conservation.

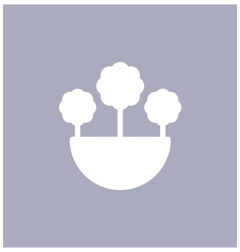
Community members cleaning wetland for augmenting water storage and groundwater recharge

IMAGE CREDIT Wetlands International South Asia

NbS are distinguished from strict nature conservation actions in the following ways

Challenge orientation

The NbS are directed at meeting a specific development challenge, such as disaster risk reduction, building water security or climate change adaptation.



Ecosystem process utilization

The NbS use or mimic ecosystem processes, such as the ability of wetlands to moderate floods.

Embeddedness

The NbS are embedded within the existing governance models and implementation arrangements for conservation or development sectors. These are not stand-alone actions.

These characteristics make NbS

Deliver co-benefits

A well-designed NbS can deliver societal benefits as well as benefits to nature. A healthy forest for example, improves soil moisture, but also provides a habitat for several species.

Cross-sectoral

NbS requires actors from different sectors to collaborate for successful implementation.

Cost-effective

NbS may be more cost-effective than conventional physical infrastructure solutions.

2.2 Nature-based Solutions for reducing water-related risks

Much of the conventional approaches to address water-related risks have been structural in nature - by putting in place infrastructure to control and regulate movement of water in a landscape. Attempts have been made to tame floods by embankments and control landslides by building concrete retaining walls. However, over time it has been realized that such solutions come with their inherent limitations, especially when the frequency and severity of extreme events are on a rise.

Embankments and flood walls that are constructed to protect human society and their assets from floods, in most of the cases, do not take into account the dynamics of water pulses under changing climate. This results in the failure of such infrastructure to cope with the impacts of extreme events, taking communities off guard. Contextualised to the landscapes and its character, the NbS are critical to achieving climate-smart and risk-informed DRR and development (Table 1).

Blue-green infrastructure is a boon for mitigating disaster risks in urban landscapes

IMAGE CREDIT Harsh Ganapathi

Table 1

Approches to nature-based solutions

Approaches	Exampleofapplicationforreducingwater-related risks
Restorative approaches Restoration, rejuvenation or enhancement of the structure and functions of a degraded, damaged or destroyed ecosystem	**Rejuvenating wetlands to buffer risk of floods and droughts**
Issue-specific approaches Use of biodiversity and ecosystem services as a solution towards a specific challenge, such as assisting communities to Cope and adapt to climate change Sequester carbon and thus mitigate GHG emissions Reduce disaster risk Improve water security	**Rejuvenating ponds to counter droughts**

Approaches	Exampleofapplicationforreducingwater-related risks
Infrastructure based approaches Using nature to replace or complement built infrastructure	**Mangrove regeneration as a means of shoreline protection, replacing or complementing conventional sea-walls**
Management based approaches Integrated, science-based approaches for the management of natural resources to balance the goals of conservation and sustainable use	**Integrated watershed management to reduce the risk of droughts**
Protection approaches In-situ nature conservation through legal or any other effective means	**Declaration of upstream forests as protected area so that the communities living downstream have perennial streams**

NbS can range from being minimalist (such as monitoring), moderate management approaches for optimization of chosen ecosystem functions and services (such as habitat management and sustainable agriculture) and highly intensive management approaches which include creation of new ecosystems (such as development of green-blue spaces).

2.3 Implementing Nature-based Solutions

Successful implementation of NbS requires consideration of following principles for planning and implementing processes.

Place-specificity

Both societal challenges (such as recurrence of floods or droughts) and their potential NbS are context specific. What works in one landscape may not work in another, due to differences in characteristics of landscapes, ecosystems, societal values, governance arrangements and a range of other factors. It is therefore recommended that the local contexts and the feasible choices of applying NbS are carefully explored.

IMAGE CREDIT Dhruv Verma

GLOFs occur specifically in high altitude mountainous regions of Himalayas

The ability of ecosystems to provide different functions especially those related with reduction of water related risks is closely linked with landscape settings. A particular NbS cannot be generically applied to all landscapes, rather it is important to consider the landscape settings and the potential of ecosystems to deliver an ecosystem function relevant for reducing water related risks. For example, the ability of a wetland to moderate water regimes is closely linked with soil condition, in particular, extent of saturation and relative location within a landscape. Wetlands located in highly saturated headwaters may actually become a source of floods, rather than acting as a sponge as is widely believed.

The solutions should build upon existing ecosystems within the landscapes in which the district is situated through actions aimed at rejuvenating and managing these ecosystems in a holistic way as well as reducing threats. Historical presence of certain species and habitats provide a good indication of the success of ecosystem rejuvenation and management efforts. For example, mangrove plantation may fail to establish when the required ecological conditions are not met (such as salinity gradient and tidal regime required for establishment and propagation of saplings). Similarly, introduction of Prosopis juliflora, an exotic species to control desertification in Indian drylands was counterproductive to the native species while also aggravating invasion threats in other landscapes owing to gregarious behaviour of the species.

Evidence-based

Consideration of available information and knowledge prior to implementation of a particular NbS can reduce wastage of human and financial resources. For example, while wetlands are often referred to as sponges in landscape, their ability to absorb flows and gradual release is dependent on a number of factors such as soil conditions and local topography.

The storm buffering capacity of mangroves and coastal ecosystems is closely related to their structure (such as density, height, species composition). Extreme cyclones with very high-water levels and wind speed may actually end up damaging mangroves, rendering their coastal protection value less effective. Similarly, monoculture tree plantations do not provide ecosystem services similar to natural forests in the short and medium term. In situations where limited 'hard' evidence is available, expert judgements may be used.

Integration

Integrating insights and methods from different approaches such as green and blue infrastructure, ecosystem-based management, ecological restoration can assist in implementation of NbS. As ecosystems deliver ecosystem services at different scales (for example, a wetland can provide fish and water to the immediate community, but can provide flood buffering only to the community living downstream), it is important to integrate scale dimensions in planning and management. Some NbS can be effective at addressing small-scale societal challenges (for example, restoring a village pond can improve water availability locally), and some at larger scales (such as restoring degraded watersheds can improve flood buffering to the entire watershed). Accordingly, some solutions need a shorter implementation time-frame, while others may need a longer time-frame and involvement of multiple sectors.

NbS often require cross sectoral and participative institutional structures. This is in difference with siloed sectoral arrangements that is used for implementing various conservation and developmental interventions. The feasibility of such institutional structures must be considered before making a choice for suitable NbS alternatives.

Systematic involvement of diverse knowledge holders in co-design, planning and implementation of NbS improves the chances of success. Different knowledge systems, formal (such as emerging from disciplines as engineering and ecology and informal (such as those rooted in local and indigenous systems) can provide significant insights into selection of appropriate NbS for a given societal problem.

Urban wetlands buffer floods, recharges groundwater and abates heat island effect

IMAGE CREDIT Harsh Ganapathi


Community led mangrove plantation in Odisha aimed at buffering storm surges

IMAGE CREDIT Partners for Resilience, Wetlands International South Asia

Equity

NbS should recognize the rights, values and interests of different actors, while also ensuring inclusive and effective participation of all relevant stakeholders. Top-down solutions, such as creation of a protected forest upstream of a village, without taking into account rights and privileges of local communities, may lead to the NbS being highly contested and lacking local ownership and support.

Buy-in of the envisaged NBS by the local communities especially those directly dependent on natural resources is critical for intervention success. While planning for implementing NbS, it is important to factor in community rights and privileges, gender & cultural dimensions, traditional knowledge, and views and capacities within decision making framework. For example, designation of Keshopur marshes in Gurdaspur, Punjab, an important groundwater recharge source and a waterbird habitat, as a Protected Area met with stiff resistance from the local farmer community. Only after a series of consultations, Keshopur was designated as the country's first community reserve where natural resources are managed by a committee with representatives from the State Forest Department and Sarpanch from the villages in which the wetland is located.

Box 3

Mangroves and Cyclones

The Super Cyclone Kalinga which hit Odisha in 1999 with a landfall wind velocity of 256 km/hr devastated the entire coastline. Of the 30 districts, 12 were severely hit, killing nearly 10,000 people. Among the five coastal districts, Kendrapada district witnessed fewer casualties. This was attributed to the presence of mangroves on their shoreline. Before the cyclone, the district had around 190 km^2 of mangroves belt with more than 93% dense and well protected mangroves. Also, villages with wider mangroves along the coast witnessed fewer deaths than those with narrower or no mangroves. The projections revealed that human casualties would have been nearly 12% lesser with 10% wider mangrove forest cover.

Cyclone Kalinga impacted village Satabhya in Odisha is being lost to sea due to coastal erosion

IMAGE CREDIT Bijoy

Suggested readings

- IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NbS
  https://portals.iucn.org/library/sites/library/files/documents/2020-020-En.pdf

- Ecosystem Approach to Disaster Risk Reduction
  https://nidm.gov.in/PDF/pubs/Ecosystem%20Approach.pdf

- Evaluating the impact of nature-based solutions
  https://op.europa.eu/en/publication-detail/-/publication/d7d496b5-ad4e-11eb-9767-01aa75ed71a1

IMAGE CREDIT Wetlands International South Asia

SECTION 3

Integrating Nature-based Solutions into District Disaster Management Plan

3.1 The District Disaster Management Plan

A river gauge installed in Bihar for providing early warning of floods.

IMAGE CREDIT Seeds-India

The District Disaster Management Plan (DDMP) is a planning tool which enables duty bearers and stakeholders to take actions for risk preparedness and mitigation, and in a disaster event, take coordinated response and rehabilitation actions. The overarching aim is to make the district resilient to disaster using sustainable development pathways. As per the model DDMP development framework recommended by NDMA the plan caters to the following objectives:

- Identification of areas vulnerable to major hazards types in the district
- Identification of measures to be taken for prevention and mitigation of disaster
- Recommending planning measures to reduce the loss of public and private property, especially critical facilities and infrastructure
- Development of response plans and procedures, in the event of a disaster, providing details on:
    - Constitution of an Emergency Operations Centre to function effectively in search, rescue and response
    - Development of a standardized mechanism for disaster response
    - Allocation of responsibilities to various government departments and local authorities during pre-disaster and post-disaster phases of the disaster
    - Setting up an early warning system (EWS) for disaster preparedness and response
    - Adoption of disaster resilient construction mechanism
    - Dissemination of information to the public using media
- Recommending rehabilitation plan and reconstruction measures for the affected people
- Recommending measures for managing future development so as to mitigate the impact of natural hazards
- Suggesting capacity building measures for disaster resilience
- Specifying annual review and process to address emerging climate risks

3.2 Identifying and mapping water-related risks

Robust identification and mapping of water-related risks is the foundational step for identifying the possibility of using NbS for addressing these risks. The risk mapping enables determination of spatial and temporal extent of risk and their prioritization, taking into account hazard propensity, exposure and vulnerabilities.

A framework for identifying and mapping water-related risks is presented in Figure 3. The first step involves determining the hydrological setup of the basin (sub-basin or coastal zone) in which the district is located, delineating the natural settings as well as human modifications of the landscape. In step 2, this provides the basis for characterising the systemic water-related hazards (those attributed to natural hydrological setup) and the non-systemic hazards (resulting from human induced modification to the landscape and development choices). In Step 3, exposure of the district elements to water-related hazards is determined. This is followed by assessing vulnerability in Step 4, which combines information on susceptibility and coping capacities of the elements exposed to water-related hazards. In Step 5, the information is finally synthesised in the form of a water-related risk map of the district which provides spatially explicit risk ranking.

Figure 3: A framework for water-related risk assessment

Context Setting	Hazard Assessment	Exposure Assessment	Vulnerability Assessment	Risk Prioritization
Situating the district within hydrological unit Defining key hydrological features	Characterizing systemic hazards Characterizing non-systemic hazards	Physical factors Social factors Economic factors Ecological factors	Physical disposition Coping capacities (Individual, collective) Adaptive capacities (Individual, collective)	Relative ranking incorporating hazards, exposure and vulnerability

Method for water-related risk assessment

Step 1

Context setting

Creating an understanding of key landscape elements and processes which define the hydrological set up of the district and influence water-related risks

Key questions

1. Which hydrological unit (basin, sub-basin or coastal zone) is the district located in? What is the relative position of the district in this unit (close to the water sources, middle segments, or towards the lower end)?
2. In the hydrological unit, which features influence water-related hazards:
   a. Presence of aquatic ecosystems through which water flows (such as rivers and streams) or is stored (such as wetlands)
   b. Climatic settings and its influence on local hydrology (such as rainfall variations and timing of floods)
   c. Geological and topographical features which influence presence and movement of water (such as location of topographic depressions prone to flooding)
   d. Presence of ecosystems which regulate movement and storage of water (such as forests, wetlands, grasslands and others)
   e. Structural modifications (such as dams, barrages, roads, embankments) which impede or alter water storage and movement (for example embankments and linear structures often create waterlogging)
3. What are the climate change projections for the hydrological unit and their consequences for water-related hazards?

Information needs

- Location of river basins, sub-basins or coastal zones to which the district corresponds
- Spatial datasets for the corresponding hydrological unit on:
  - Drainage pattern indicating upstream and downstream hydrological connectivity, and hydraulic structures
  - Inundation regime (seasonal variation of inundated area)
  - Land degradation or groundwater table map
  - Geology and geomorphology, soils
  - Land use and land cover (specifically demarcating ecosystems which influence hydrological regimes such as rivers, wetlands, forests, and human modified areas used for economic activities such as housing, agriculture, industries and others)
- Projected climate risks map showing areas susceptible to floods, droughts and other extreme events
- Statistical trend data on climate parameters

Available datasets

- India Water Resource Information System (https://indiawris.gov.in/wris/#/about)
- Bhuvan satellite data for Land use land cover and Geomorphology (https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php)
- Digital Elevation Model (https://earthexplorer.usgs.gov/)
- Indian Meteorological Department or NASA Power for climate data (http://dsp.imdpune.gov.in/ and https://power.larc.nasa.gov/data-access-viewer/)
- National Wetlands Atlas (https://vedas.sac.gov.in/vcms/en/National_Wetland_Inventory_and_Assessment_(NWIA)_Atlas.html)
- Hazard Atlas(https://www.nrsc.gov.in/KR_Atlas_FloodHazardZonation?language_content_entity=en)
- Flood Information Management System
- Statistical abstracts

Step 2

Hazard assessment

Characterising systemic and non-systemic water-related hazards

Key questions

1. What are the systemic water-related hazards in the district (such as flood pulses within river floodplains)?
2. What are the non-systemic water-related hazards in the district (such as waterlogged areas created by embankments)?
3. What are the key characteristics of these hazards?
   a. What is their seasonality?
   b. What is their frequency?
   c. Which area is likely to get affected?

Information needs

- Interpreting and downscaling the data collected in Step 1 to determine the systemic and non-systemic water-related hazards in the district
- Determining the areas likely to be affected by these hazards considering historical data as well as climate projections on seasonality and frequency

Available datasets

- Datasets mentioned in Step 1
- Existing HVCR Assessments

Step 3

Exposure assessment

Identifying communities, economic assets and ecosystems likely to be affected by water-related hazards

Key questions

1 What elements of the district are exposed to (likely to be affected by) water-related hazards?
   a communities
   b economic assets
   c ecosystems

Information needs

- Interpret spatial dataset on LULC of the district to indicate:
  - built-up areas (area constructed upon for residential and allied purposes)
  - production landscapes (areas under agriculture, industries, aquaculture and others)
  - ecosystems (such as rivers, forests, wetlands, grasslands and others)
- Overlay of district hazard map (step 2) on the LULC map to indicate areas of the district likely to be exposed to water-related hazards

Available datasets

In addition to data collected in Step 1, following datasets can accessed:

- Bhuvan for district land use and land cover (https://bhuvan-app1.nrsc.gov.in/thematic/thematic/index.php)
- District Statistical Handbook for data on economic assets and production landscapes

Exposed community members repairing breached embankment to stop flood water intrusion

IMAGE CREDIT Seeds-India

Step 4

Vulnerability assessment

Estimating vulnerabilities of exposed people and their assets to cope and adapt to water-related hazards

Key questions

1 What is the propensity of exposed elements to suffer adverse effects when impacted by water-related hazards due to their:
   a Physical location (for example, landslide prone slopes, downstream reaches of expanding glacial lakes and water impounding structures, river floodplains, coastal areas)
   b Asset quality (for example, quality of housing, access to water and sanitation infrastructure, status of natural resources)
   c Social and economic conditions (for example, income inequalities, occupational diversity, access to markets and communication)
   d Environmental conditions (for example, location with respect to degraded ecosystems providing disaster buffering services, pollution)
2 What are the mechanisms used by individuals and communities to cope with water-related hazard events?
   a Awareness of water related risks and their impacts
   b Access to risk transfer mechanism (Life and asset insurance, crop insurance)
   c Membership of local networks such as Resident Welfare Associations, Village Development Committees, local NGOs
3 What are the prevalent mechanisms used for adapting to water-related hazard, particularly systemic hazards?
   a Availability of early warning systems
   b Emergency preparedness measures such as mock drills
   c Response capabilities
   d Presence of natural resources management committees
4 Synthesize the information into vulnerability map - creating a relative ranking of communities from low to high

Information needs

Data (at Block, Urban Local Body, Panchayat and Village level) on

- Demographic features (Population, Sex, Occupation, Education, Schedule castes and tribes, institutional population)
- Economic features (Employment patterns & sectors, Income and expenditure, Access to financial institutions)
- Social infrastructure (Access to health centres, safe sanitation and drinking water facilities, fair weather roads and markets)
- Ecosystem profile (status and trends, ecosystem health)

Available datasets

- Existing District Disaster Management Plan
- District Statistical Handbook for data on economic assets and production landscapes

- District level data from State Wetland Atlas
- Minor Irrigation Census (http://jalshakti-dowr.gov.in/6th-minor-irrigation-census-2017-18-and-water-bodies-census)
- Swachh Bharat Dashboard (https://sbm.gov.in/sbmdashboard/)
- MGNREGA (https://nrega.nic.in/netnrega/mgnrega_new/Nrega_home.aspx)
  Jal Jeevan Mission

Step 5

Risk prioritization

Defining level of water-related risks in different parts of the district

Key questions

1 What is the relative risk ranking of different parts of the district taking into account the information on hazard, exposure and vulnerability?

Information needs

- Synthesising information on exposure and vulnerability to assign risk categories to different part of the district

Fostering community participation through awareness and capacity building is key to DRR

IMAGE CREDIT Wetlands International South Asia

Case study

Assessing and Mapping Water-related Risk in Ganjam, Odisha

Ganjam, a thickly populated coastal district of Odisha, has two major geographical divisions: the coastal plains in the east and the hills and tablelands towards the west, forming a part of the Eastern Ghats chain of mountains. Risk of water-related hazards is very high due to several factors such as: (a) differential warming of land and sea causing frequent formation of cyclones and extreme rainfall causing flooding and waterlogging; (b) exposed plains beneath hills and long coastal stretch which are subject to inundation, and (3) presence of vulnerable human, economic and natural elements in the district. The sea side villages, primarily engaged in fishing, are vulnerable to sea surge and tsunami, the narrow plains between the hills of Eastern Ghats and Coast having agricultural lands are subject to sudden floods and water logging. Semi-pucca and thatched houses in the district are susceptible to fire and wind gust. Presence of wetlands along the course of the River Rishikulaya, and the coastline; and forests (though mostly open) tend to influence the movement of water in the landscape. Embankments have been constructed along the Rishikulaya floodplains, as a flood control measure, however these have tended to aggravate waterlogging in several parts of the district. Towards the coast, the hydrological connectivity between wetlands, channels and the Bay of Bengal has been impeded by construction of roads and buildings over the channels.

In light of differential geo-hydrological features and vulnerability of communities, assessment of water-related risks using satellite-based imageries and secondary data from government sources is summarised below:

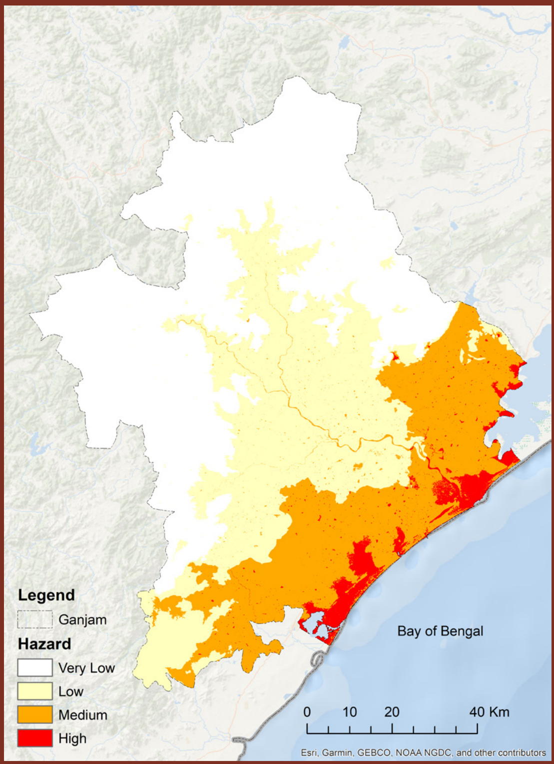
Step 1 Context setting: River and coasts are the two key hydro-geographical features of the district. In order to contextualise, catchment of Rushikuliya River was overlaid on the district administrative boundary.

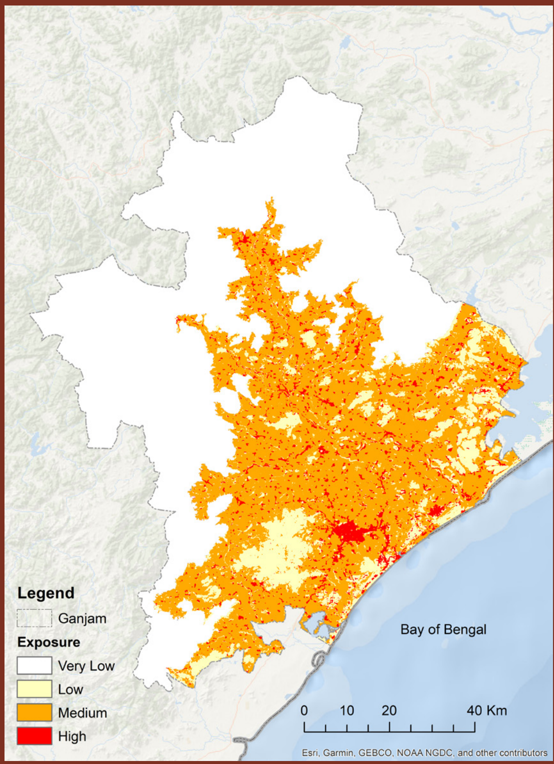
Step 2 Hazard assessment: Based on the available literature and spatial datasets (discussed in the existing DDMP), areas affected by cyclones, storm surges and maximum water inundation were mapped. These hazard prone areas were overlaid for preparing hazard map.

Step 3 Exposure Assessment: Spatial distribution of human, their assets (such as township, villages, highways, agriculture, ports) and natural ecosystems (such as wetlands, forests) were mapped by developing a land-use land cover map of the Ganjam district. The LULC classes were overlaid with the hazard map to demarcate populations, ecosystems and physical assets exposed to water related risks.

Step 4 Vulnerability Assessment: A decision making on relative contribution of factors (as discussed in the box 1 and section 3.2) towards vulnerability (slope, elevation, proximity to cyclone shelters and coast line, literacy, kutcha/pucca house, BPL) and coping capacities (community institutions, healthcare infrastructure and environmental features) of the elements exposed to water-related hazards was made using AHP. Within these parameters, the attributes of these parameters were ranked to develop a composite vulnerability map of the district.

Step 5 Risk prioritisation: Aggregation of hazard, exposure and vulnerability maps to develop a water-related risk map showcasing low to high-risk areas in the district.


Legend
Ganjam
Hazard
Very Low
Low
Medium
High
Bay of Bengal
0 10 20 40 Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors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Ganjam
Exposure
Very Low
Low
Medium
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Bay of Bengal
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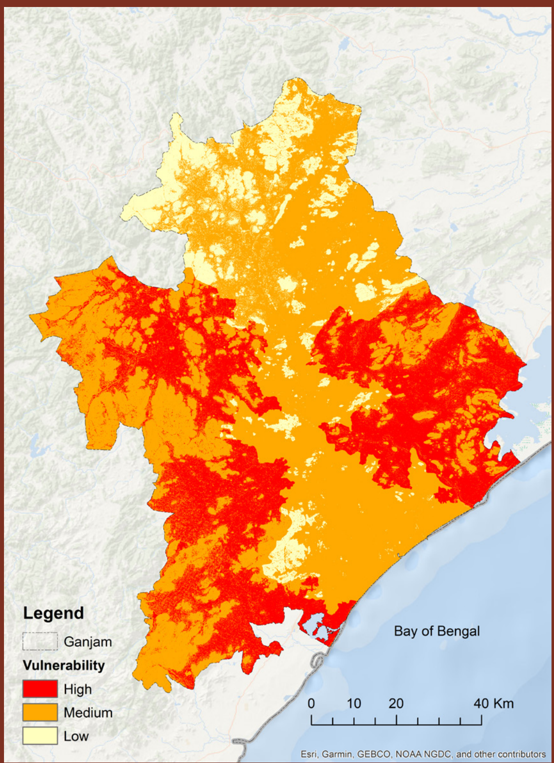
Legend
Ganjam
Vulnerability
High
Medium
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Bay of Bengal
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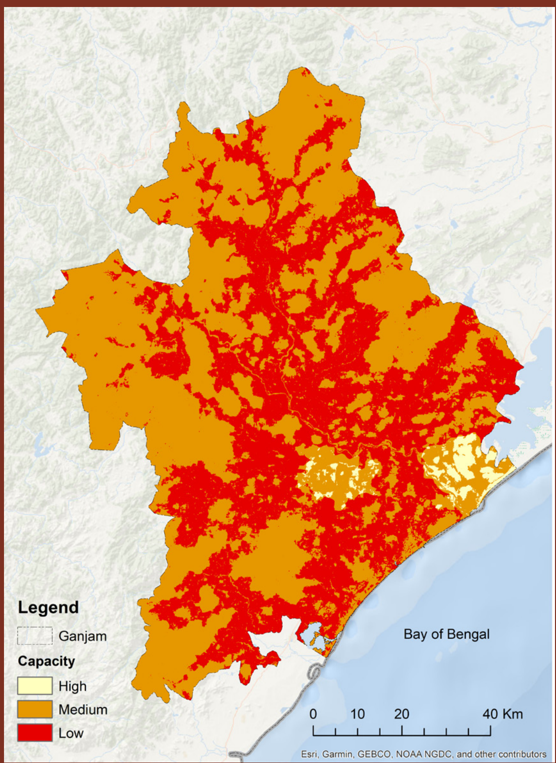
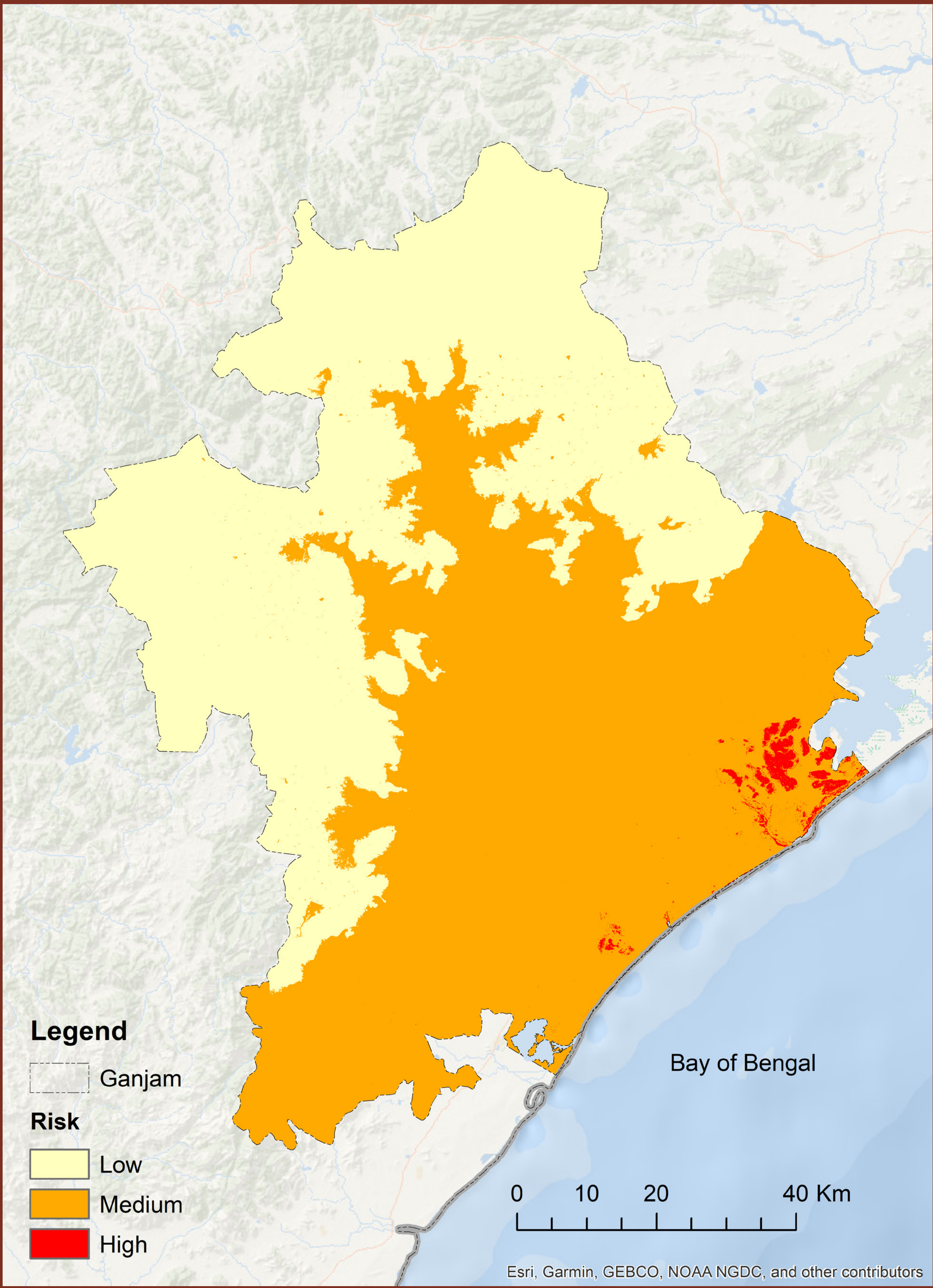
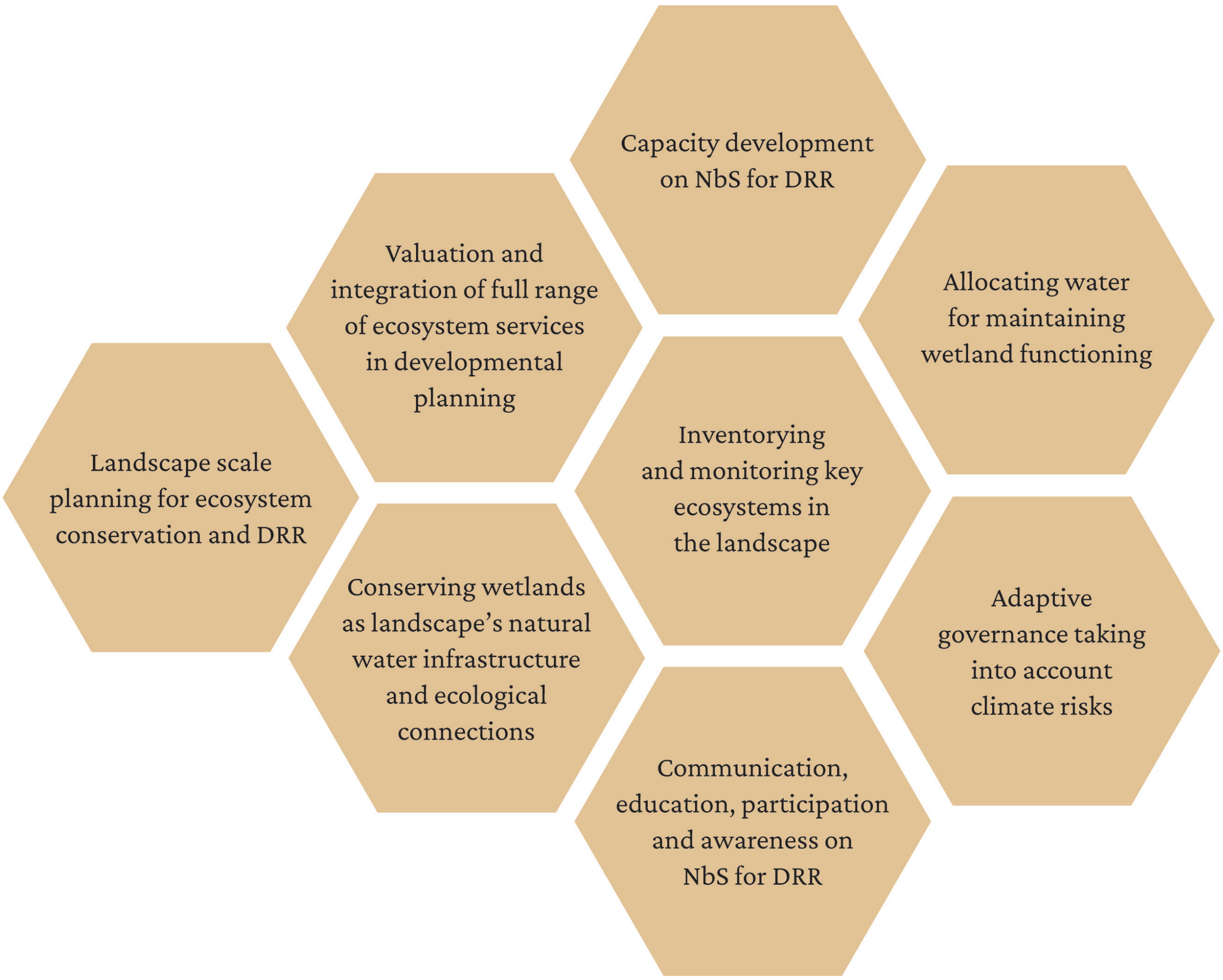

Legend
Ganjam
Capacity
High
Medium
Low
Bay of Bengal
0 10 20 40 Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

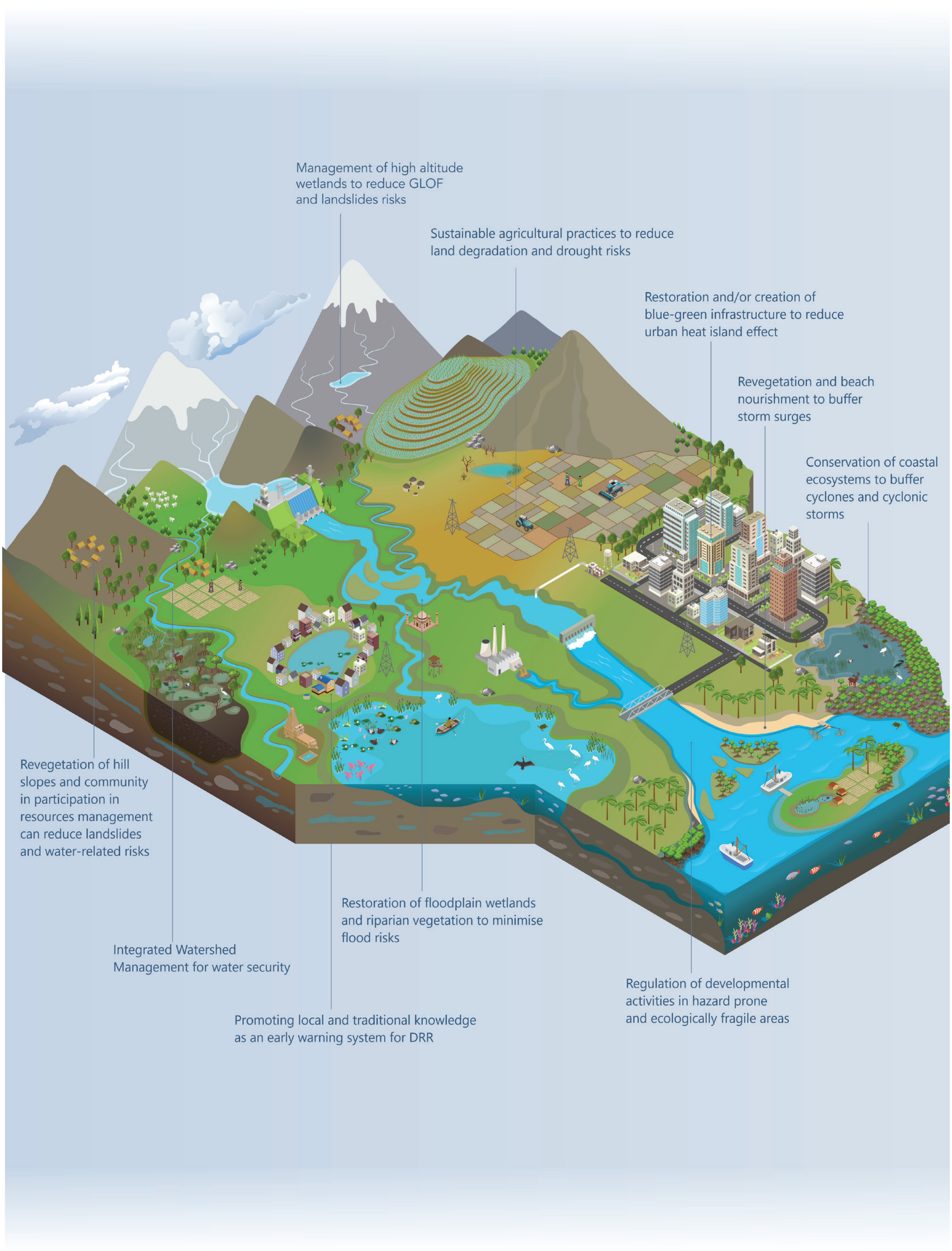

Legend
Ganjam
Risk
Low
Medium
High
Bay of Bengal
0 10 20 40 Km
Esri, Garmin, GEBCO, NOAA NGDC, and other contributors

3.3 Identifying and selecting Nature-based Solutions

Having identified areas of the district in terms of level of water-related risks, the next step is to identify appropriate NbS as a risk reduction measure. In further sections, some examples of the NbS that can be applied to address various water-related risks are presented.

Fig 4 : Accelerating Nature-based Solutions for Disaster Risk Reduction



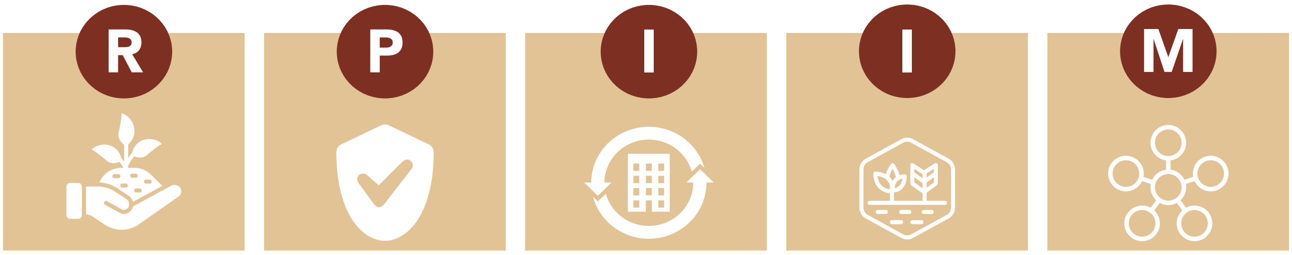


Wetlands are inseparable infrastructure of a landscape: Illustration of Nature-based Solutons

NbS for water-related risks

Having identified areas of the district in terms of level of water-related risks, the next step is to identify appropriate NbS as a risk reduction measure. As indicated in section 2.2, the selected solutions could be from one or more of the five categories of approaches, chosen on the basis of factors like local geomorphology, climatic conditions, soil conditions, land use, past disaster events and socio-economic conditions. Also, these approaches can be used either in isolation or in a combination based on local conditions.

The approaches



Restorative approaches

Protection approaches

Infrastructure based approaches

Issue-specific approaches

Management based approaches

The table 2 below presents some examples of the NbS that can be applied to address various water-related risks, based on these approaches.

A coastal village in Ganjam district flooded due to excess rainfall

IMAGE CREDIT Wardi Kashinath

Table 2

Coastal floods

Possible NbS	Illustrative Examples
R Restoration of coastal vegetation and coastal wetlands Beach nourishment in erosion prone areas Renaturation of creeks and inter-tidal zones **P** Protection of coastal ecosystems under the provisions of Environment Protection Act, 1986 and its notifications such as Coastal Regulation Zone notification, 1991 & its amendments; Island Protection Zone Notification, 2011; Wetlands (Conservation & Management) Rules, 2017; and Wildlife (Protection) Act, 1972; Forest (Conservation) Act 1980. Designating key coastal wetlands as sites of international importance under the Ramsar Convention **I** Creation of blue-green spaces (such as wetland parks) to buffer coastal floods **M** Integrated coastal zone management	Bhitarkanika Conservation Area (a designated Protected Area) having mangroves, estuaries, tidal flats, beaches and other ecosystems protects Rajnagar Block, Kendrapa district, Odisha from the impacts of cyclones and cyclonic floods which are known to frequent this area. Mangrove plantation was raised over 320 ha of Bhadrak and Balasore districts, Odisha for checking cyclonic storms and coastal floods. A community led project 'Haritham Vypeen' aimed at coastal plantation for checking coastal flooding is being implemented in Vypeen Block Panchayat, Kerala.

Riverine floods

Possible NbS	Illustrative Examples
R Restoration of riparian vegetation Restoration of floodplain wetlands Renaturation of drains and streams **P** Floodplain delineation and protection under extant regulatory provisions Protection of floodplain wetlands under the provisions of Environment (Protection) Act, 1986 and its notifications such as Wetlands (Conservation & Management) Rules, 2017; and Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980 and other relevant acts **M** Integrated watershed management	Wular, a floodplain wetland of River Jhelum absorbs floodwaters and secures Srinagar from floods. Kanwar wetland complex in Begusarai district of Bihar functions as a buffer to riverine floods in Burhi-Gandak River. Eco-restoration of Adyar river in Chennai for mitigation of floods.

Brahmaputra in spate due to excess rainfall

IMAGE CREDIT Mridusmita Borah

Unregulated development leads to annual flooding in the Brahmaputra basin

IMAGE CREDIT Mridusmita Borah

Urban floods

Possible NbS	Illustrative Examples
R Restoration of urban and peri-urban wetlands and drainages Restoration of upstream catchments of urban and peri-urban area **P** Delineation and protection of flood buffers such as river floodplain, city forests and urban wetlands under the provisions of Environment Protection Act, 1986 and its notifications such as Wetlands (Conservation & Management) Rules, 2017; and Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980 and other relevant acts **I** Creation of green spaces and constructed wetlands Construction of bioswales, green roofs, permeable pavements **M** Land use zoning Town Planning Integrated Watershed Management	Delhi Development Authority has undertaken demarcation, protection of Yamuna floodplains and removal of debris from the floodplains to mitigate the risks of flooding in the city of Delhi. The Gorakhpur Environmental Action Group undertook an initiative to promote maintenance of open spaces in the form of peri-urban agriculture. This enhances the flood buffering capacity of the city and contributes towards maintaining the food and nutritional security for urban areas.

Glacial Lake Outburst Floods (GLOF)

Possible NbS	Illustrative Examples
R Restoration of hill slopes P Land use zone planning for downstream stretches M Integrated watershed management Management of high-altitude wetlands	The Centre for Development of Advanced Computing (CDAC) using various types of satellite data and time series analysis of Glacial Lake has created an Early Warning GLOF System for the Sikkim Government. The system has led to identification, classification and prioritisation of vulnerable moraine dammed lakes.


Unregulated development exacerbated destruction caused by GLOF in Uttarkashi, 2013

IMAGE CREDIT Jan Vikas Sansthan

Wetlands conservation and spring recharge treatment in cold arid landscapes contribute to water security

IMAGE CREDIT Wetlands International South Asia

Droughts

Possible NbS	Illustrative Examples
R Restoration of degraded wetlands, grazing land and vegetated areas Restoration of degraded agricultural land **P** Prohibition & regulation of livestock grazing in fragile areas **I** Creation of wetlands and farm ponds **M** Integrated watershed management	Restoration of the agricultural systems by rejuvenation of traditional water harvesting structures by Tarun Bharat Sangha in Rajasthan has contributed towards enhanced groundwater levels and thereby mitigating the impacts of droughts on agriculture. Watershed development programmes in the States of Maharashtra and Rajasthan have helped the rural communities in adapting to frequent dry-spells through enhanced soil and water management practices. Parasai-Sind watershed in Jhansi, Uttar Pradesh was developed by joint collaboration of ICAR-Agroforestry Research Institute and ICRISAT for combating drought conditions. Construction of check dams, farm ponds and renovation of existing water structures contributed to an increase in groundwater level by 2-5 meters and rejuvenated 100 acres of land for cultivation. Asian Paints Ltd. and ICRISAT collaborated on a project in Medak district, Telangana where water management practices like check dams, farm ponds achieved groundwater recharge of 91000 cubic meters.

Cyclones

Possible NbS	Illustrative Examples
R Restoration of coastal ecosystems such as wetlands, rivers and forests	Mangrove ecosystems in Sundarbans (a Ramsar site) were able to buffer the impact of Cyclone Bulbul in 2019. A community stewardship program aimed at conservation, restoration and management of mangroves was piloted by Mangroves for Future in 10 villages of Odisha coasts. It helped in restoring 12 ha of mangroves for mitigating the impacts of cyclone and cyclone induced floods.
P Protection of coastal ecosystems under the provisions of Environment Protection Act, 1986 and its notifications such as Coastal Regulation Zone notification, 1991 & its amendments; Island Protection Zone Notification, 2011; Wetlands (Conservation & Management) Rules, 2017; and Wildlife (Protection) Act, 1972; Forest (Conservation) Act, 1980. Designating key coastal wetlands as sites of international importance under the Ramsar Convention	
I Vegetation based geotextiles to check coastal erosion Sand dune construction and stabilisation for coastal protection	
M Integrated coastal zone management	

Landslide

Possible NbS	Illustrative Examples
R Restoration of degraded/barren hill slopes **P** Protection of fragile zones (moraines, reservoirs, wetland complex, hill slopes) **I** Vegetative geo-textile for erosion control Terracing **M** Integrated watershed management	Bio-engineering technology using geo-jute and indigenous species of grasses were applied for rehabilitation of Varunavat landslide region, Uttarkashi, Uttarakhand. Restoration of Landslide zone by vegetated measures at Turung and Donok landslide zones, Sikkim.

Deforestation of hill slopes can lead to landslides and rockfall

IMAGE CREDIT Wetlands International South Asia

Water-borne diseases

Possible NbS	Illustrative Examples
R Removal of invasive species Restoration of hydrological regime in wetlands to ensure stagnant water does not become mosquito breeding ground **I** Constructed wetlands to reduce pollution load in wetlands **M** Bioremediation, biomanipulation, sedimentation basin and green bridge to reduce water pollution	Hunting of waterfowl poses a continuous risk of emergence of zoonotic pathogens such as avian influenza. Protecting and managing habitats of waterbirds, especially in the flyway networks and zones with high poultry density can reduce spread of water-borne diseases. Fateh Sagar lake, Udaipur was cleaned by community led environmental groups like Mohan Singh memorial trust by clearing junk and Water Hyacinth for water quality improvement.

Degradation of wetlands can increase exposure to water-related diseases

Desertification

Possible NbS	Illustrative Examples
R Restoration of degraded wetlands, grazing land and vegetated areas Restoration of degraded agricultural land **P** Prohibition & regulation of livestock grazing in fragile areas **I** Creation of wetlands and farm ponds **M** Integrated watershed management	Gujarat Institute of Desert Ecology, in collaboration with Gujarat Forest department and local communities has restored Banni grasslands. It helped native species of flora to flourish and reduce salinity. Watershed development at Rajasamadhiyala, Gujarat helped in increasing crop and livestock productivity apart from addressing distress migration. Forest restoration was carried out at old Jalukie village JFMC, Nagaland in an area of 370 ha, declaring it as community biodiversity reserve.


IMAGE CREDIT Wetlands International South Asia

Poor water management practices along with removal of native vegetation leads to desertification

3.4 Building Nature-based Solutions in District Disaster Management Plans

A model framework for preparing DDMP has been recommended by the National Disaster Management Authority. The framework recommends a 12-chapter formulation to respond to a hazard, vulnerability, capacity and risk assessment through appropriate prevention and mitigation; response and relief; reconstruction, rehabilitation and recovery, and risk reduction measures. In the table below, the scope for integrating NbS in different chapters is discussed.

Table 3: Embedding NbS in DDMP

Recommended chapter from the model framework	NbS considerations
Chapter 1: Introduction This chapter sets out aims and objectives of the DDMP and defines the line of command, legal authority and stakeholders.	The list of DDMP objectives could include the following: • Identify appropriate NbS to address disaster risks. • Include the role healthy ecosystems play in disaster risk reduction while identifying prevention, preparedness, mitigation, response and recovery measures and actions. • The list of line departments and agencies should include those responsible for ecosystem conservation and management (such as District Wetlands Authority, Forest Department, Environment Department, Water Resources Department and others). • The list of stakeholders should include those concerned with ecosystem conservation and management (such as watershed committees, joint forest management committees, eco-development committees, water user associations, wetland mitras, and others). • The list of datasets consulted should include those corresponding to the landscapes (such as river basin and coastal zones), ecosystems and their ecosystem services particularly those relevant for disaster risk reduction.

Recommended chapter from the model framework	NbS considerations
Chapter 2: Hazard, Vulnerability, Capacity and Risk Assessment The chapter includes a district profile and HVCR assessment.	The water-related risk mapping and the underlying information (discussed in section 3.2 of the manual) should form an integral part of HVCR.
Chapter 3: Institutional arrangements This chapter spells out the relevant rules and regulations and organisations responsible for managing disasters.	• Regulatory framework for environment such as the provisions of the Environment (Protection) Act, 1986; Forest (Conservation) Act, 1980; The Fisheries Act, 1897; Wetlands (Conservation & Management) Rules, 2017, Wildlife (Protection) Act, 1972' and others should be accounted for managing disasters. • Constitution of Inter-Agency groups must include organisations involved in ecosystem conservation and management. • At grassroot level the role of civil society and community-based organisations involved in ecosystem conservation and management (such as Wetland Mitras, Water User Associations, Van Suraksha Samitis, Eco-development Committees, Joint Forest Management committees) should be considered at various stages of disaster management.
Chapter 4: Prevention and Mitigation Measures This chapter summarises the preventive and mitigative measures for disasters.	Appropriate NbS for preventing and mitigating water-related risks must be included here (Refer section 3.3 of this manual).

Strengthening of community members and local bodies in NbS can contribute greatly to resilience building towards disaster risks

IMAGE CREDIT Wetlands International South Asia

Recommended chapter from the model framework	NbS considerations

Chapter 5: Preparedness
This chapter summarises the preparedness measures for disaster.
	• Early warning systems linked with major ecosystem features which are sources of water-related hazards may be included. Some examples are:
	  • Monitoring spread and level of mountain wetlands for GLOF.
	  • Water level indicators for wetlands and rivers prone to flooding.
	  • Slope stability indicators (such as vegetation, solid engineering properties) for landslide prone areas.
	  • Stream-flow, soil moisture, and groundwater parameters for drought risks.
	• Opportunities for leveraging information from existing monitoring systems should be identified and build in the institutional arrangements.

Chapter 6: Capacity building
The chapter includes the capacity building and training measures for disaster management.
	• Actions for building capacity for identifying and applying NbS must be included here. These include specific actions for
	  • Conserving and managing ecosystems to reduce water-related disaster risks.
	  • Monitoring ecosystem health and drivers of ecosystem degradation which compromise capacity to buffer disaster risks.
	• Development of knowledge base on status and trends of ecosystems that provide water-related risk reduction benefits.
	• Inclusion of NbS in disaster management education for schools in villages, to establish a well-informed network of young people/teachers for preparedness and response in times of disasters.

Chapter 7: Response and relief The chapter includes multi-hazards response and relief planning, preparedness and assessments.	Response and relief measures identified should take into account the likely environmental damages (such as avoiding establishment of relief camps in environmentally fragile areas).

Recommended chapter from the model framework	NbS considerations
Chapter 8: Reconstruction, RehabilitationandRecovery measure The chapter spells out the reconstruction, rehabilitation and recovery measures for the disaster affected regions and communities.	• Rejuvenation of disaster impacted ecosystems should be an integral part of overall rehabilitation measures. Specific actions may be included in consultation with concerned line departments and experts. • Proposed rehabilitation and resettlement measures for disaster affected communities should prevent adverse impact on ecosystems (for example by ensuring that resettlement areas are away from environmentally fragile areas such as marshes and grasslands). • Livelihood recovery for disaster affected communities may include opportunities for sustainable use of ecosystems and prevent over exploitation (for example livelihood options involving species introduction should take into account the risk of invasion and transformation of a natural ecosystem to a degraded and irreversible state, losing its potential to provide essential ecosystem services).
Chapter 9: Financial resources for implementation The chapter focuses on the financial allocations for planning and execution of disaster management measures.	• Convergence with existing national and state government schemes that can support NbS can be built in (for example afforestation and forest conservation can be supported under National Afforestation Programme (NAP) and Green India Mission (GIM); wetlands conservation and rejuvenation can be supported under National Plan for Conservation of Aquatic Ecosystems (NPCA). The Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) also provides opportunities for generating employment for implementing NbS. • Funds under Corporate Social Responsibility and Corporate Environment Responsibility can be leveraged for implementing NbS.


Wetland restoration helps in disaster recovery and rehabilitation.

IMAGE CREDIT Wetlands International South Asia

Recommended chapter from the model framework	NbS considerations

Chapter 10: Monitoring, Evaluation and Updation
The chapter summarises the procedure and methods for monitoring, evaluation, updation and maintenance of DDMP.
	• Measures for monitoring effectiveness of NbS should be identified. These may include:
	  • Extent of amelioration of water-related risks (for example reduction in damages from cyclones and floods, reduced land degradation).
	  • Extent of reduction in vulnerability (for example increase in ecosystem services by healthy and well managed ecosystems).
	  • Economic and social benefits arising from implementation of NbS (for example, generation of new employment opportunities).
	• Benefits to objectives such as climate mitigation and adaptation (for example, additional carbon sequestration in the landscape supporting climate mitigation goals).

Chapter 11: Coordination mechanism for implementation The chapter describes the coordination mechanism for implementation of disaster management measures.	• NbS for addressing water-related risks may involve working across several districts (sharing the river basin or coastal zone). Inter district coordination mechanisms must be identified. This may be facilitated by NDMA and the respective SDMAs. • Inter-sectoral coordination arrangements must include the line department and agencies responsible for ecosystem conservation and management at various levels.
Chapter 12: Standard Operating Procedures (SOPs) and checklist The chapter includes SOPs and checklists to be prepared for various stakeholders effective responses.	Ecological considerations as discussed in the previous chapters may be reflected in the SOPs.

Integration of NbS in DDMP requires specific skills related with understanding of landscapes and movement of water and ecosystem functions. To facilitate this integration, it is recommended that the DDMP preparation process:

- Involves experts from the domains of ecology, geography, hydrology, landscape planning, environmental economics, and other related disciplines.
- Involves line departments, agencies and actors involved in ecosystem conservation and management.
- Make effective use of remote sensing and GIS databases bringing on-board information at different spatial and temporal scales.
- Consider all forms of knowledge (scientific, indigenous and local) while assessing disaster risks and identifying risk reduction measures.
- Incorporate sufficient flexibility in the plan to be able to take into account new information on landscapes and ecosystems as they become available in due course of time.

IMAGE CREDIT Wetlands International South Asia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SECTION 4

Creating an enabling environment

Under Section 31 of the Disaster Management Act 2005, the District Disaster Management Authority (DDMA) is responsible for developing the DDMP which acts as an administrative document to guide disaster management programming and actions in the district with support from line departments and other stakeholders. Integration of NbS into DDMP is contingent on setting up an interdisciplinary planning team and using diverse knowledge bases, establishing monitoring and evaluation systems for NbS performance, building convergence with environment and development sector programmes and developing capacities at multiple levels.

4.1 Setting up an interdisciplinary planning team

An NbS interdisciplinary team implementing Eco-DRR activities at Tampara wetland

IMAGE CREDIT Dhruv Verma

The model guidelines for DDMP formulation recommend that the plan is prepared by a core team of representatives of departments and agencies likely to be involved in response and rehabilitation. To ensure incorporation of NbS in the plan, it may be necessary to augment the team with experts from the disciplines of hydrology, geography, landscape planning, ecology, meteorology and climate sciences, sociology and others. Wherever feasible research professionals with regional expertise may be invited to join the planning team.

Consideration of gender and social equity & inclusion should also be factored-in during the setting up of the planing team.

4.2 Use of diverse knowledge bases

IMAGE CREDIT Dhruv Verma

Indigenous knowledge system forms an integral part of planning NbS for reducing disaster risks

Currently much of the data that is used in DDMP preparation pertains to socio-economic features of the district and economic assets likely to be rendered vulnerable due to hazards. To bring NbS into consideration, datasets on ecosystem and their services, land use and land cover, hydrological and geo-morphological setup is required. For several of these, the entire hydrological unit (river basin or sub-basin, or coastal zone) may need to be considered. Spatial datasets generated from satellite images and GIS products are capable of providing information on water risk manifestation at multiple scales. Datasets on ecosystem functions can be generated through expert consultation, field surveys and landscape modelling tools (remote sensing and GIS). Climate scenarios, especially those downscaled for the respective basin or coastal zone can provide information on the impacts and vulnerabilities. Analysis and integration of such data into DDMP can be facilitated by bringing on board experts and research institutions.

4.3 Cross-sectoral institutional collaboration agreements

Engagement of setoral experts can facilitate effective planning and implementation of NbS for DRR

IMAGE CREDIT National Institute of Disaster Management

Enabling environment for NbS implementation can be created by incorporating collaborations with agencies responsible for conservation and management of ecosystems within the institutional architecture of the DDMP. These normally include the Department of Forests, Environment and Climate Change, but also entities such as District Wetland Committees, Joint Forest Management Committee, Biodiversity Management Committees, Watershed Committees and others.

Often NbS may involve working across several districts. For example, mangrove restoration may need to be taken up across several districts to be able to deliver cyclone buffering benefits. In such cases, it may be pertinent to define inter-district working arrangements by engaging members from relevant DDMAs falling under the same hydrological unit (basin or sub-basin or coastal zone) during the planning phase of DDMP formulation. The inter-district working arrangements could be facilitated by SDMA and NDMA.

4.4 Set monitoring, learning and adaptation processes

Community-based monitoring mechanisms provide real time data to measure effectiveness of NbS

IMAGE CREDIT Partners for Resilience, Wetlands International South Asia

The effectiveness of NbS in terms of reduction in vulnerability through provisioning of economic and social benefits, amelioration of water-related risks, and climate change mitigation and adaptation need to be assessed periodically. The outcome of such assessments should inform investment choices and management arrangements. The scope of monitoring arrangements prescribed within DDMP may thus need to be expanded to incorporate monitoring of NbS. The DDMP review and adaptation process may incorporate taking into account results from such monitoring.

4.5 Building development and environment convergence

Field visits by different agencies often facilitate resource building opportunities

IMAGE CREDIT Dr. Satyaprakash

An enabling environment for NbS may be created by building convergence of DDMP with funding streams supporting development and environment conservation programmes. This can be achieved a number of ways, including:

- Promoting NbS in operations of self-help groups and community-based organization to ensure gender and social equity in NbS
- Inclusion of NbS within village and block development plans, and earmarking a percentage of funds allocated at these levels for implementation
- Mobilising funds under Corporate Social Responsibility (CSR) and Corporte Environment Responsibility (CER) for implementing NbS
- Forging collaborations with government and non-government entities implementing schemes having embedded NbS components.

4.6 Capacity development

Capacity building of stakeholders is fundamental to mainstreaming of NbS in developmental plans

IMAGE CREDIT Dr. Satyaprakash

Integrating NbS in disaster risk reduction requires broadening of skills and capacities from the current physical infrastructure dominated thinking to consideration of nuances of nature and its functioning. Building capacities of concerned line departments and agencies and other stakeholders on the concept of NbS is critical. DDMPs may therefore incorporate training workshops, exposure visits and other hand holding mechanisms to support implementation of NbS and sustain the interventions over time. Particular emphasis may need to be given to inclusion of water-related risks within HVCRA which is foundational to identification of appropriate NbS. Capacity development interventions may need to span aspects such as NbS identification, monitoring effectiveness, building convergence with ongoing environmental and developmental schemes, and developing early warning system.

Resilient India - Disaster Free India

National Institute of Disaster Management
(Ministry of Home Affairs, Government of India)
Plot No. 15, Pocket-3, Block-B,
Sector 29, Rohini, Delhi- 110042
https://nidm.gov.in/

Wetlands International South Asia
A-25, Floors 1 & 2, Defence Colony
New Delhi-110 024, India
Tel.: +91-11-24338906, 46038906
https://south-asia.wetlands.org/

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