Department of Science and Technology
Ministry of Science & Technology
Government of India

NMSHE NATIONAL MISSION FOR SUSTAINING THE HIMALAYAN ECOSYSTEM

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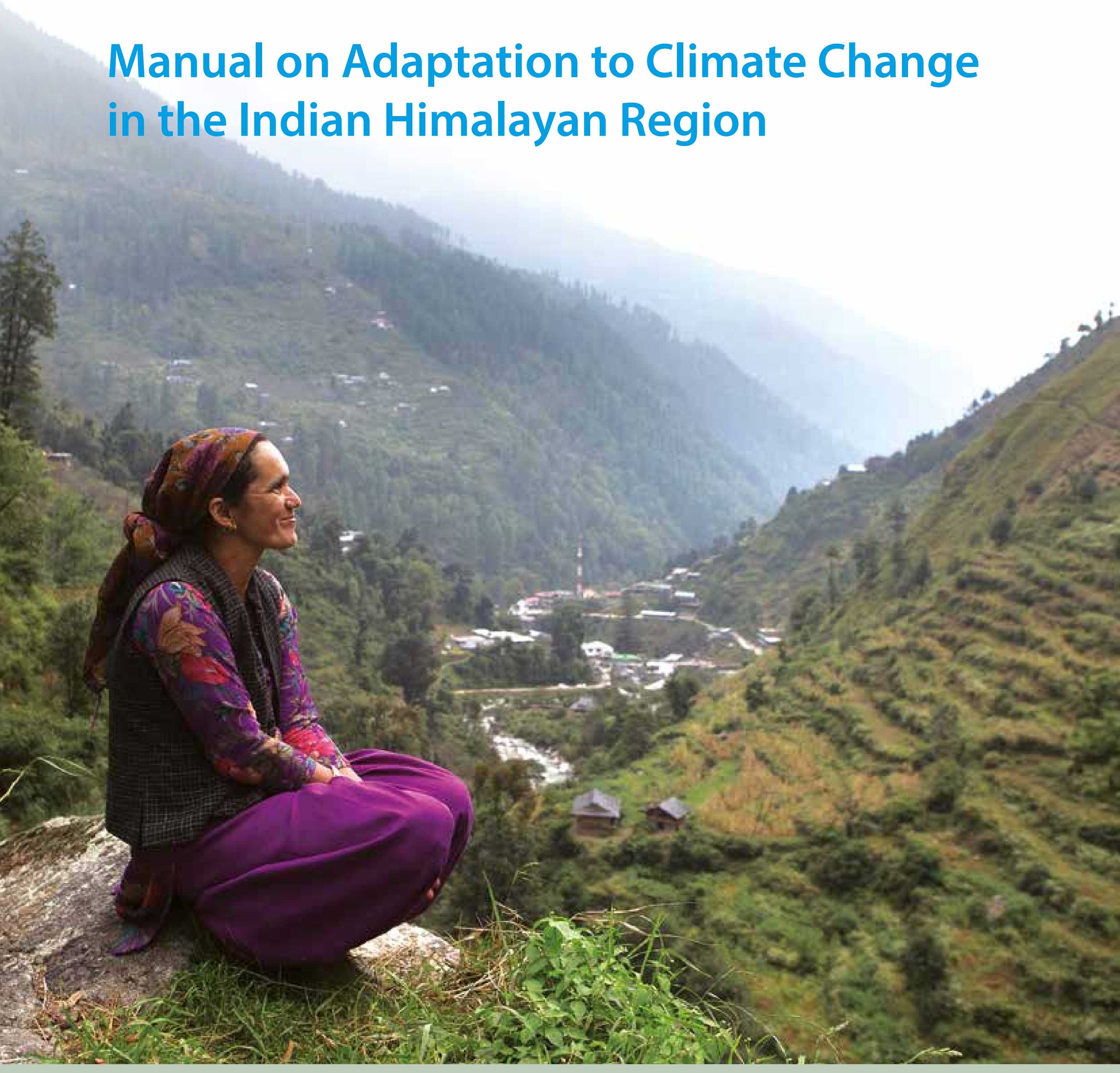
Manual on Adaptation to Climate Change in the Indian Himalayan Region



NABCONS

IHCAP Indian Himalayas Climate Adaptation Programme

Manual on Adaptation to Climate Change in the Indian Himalayan Region

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Message

The risks of climate change are challenging sustainable development through direct and indirect impacts on natural resources and socio-economic sectors. Owing to its fragility and sensitivity to global and local anthropogenic changes, the Himalayan region is likely to be affected much more than the plain areas. The livelihoods of the communities of the Himalayan region are at risk due to climate change. In response to the serious threats posed by climate change to the development process and the limitations that Indian Himalayan Region (IHR) is facing, the Government of India as part of its comprehensive National Action Plan on Climate Change has a dedicated mission for the Himalayan region, namely the National Mission for Sustaining the Himalayan Ecosystem (NMSHE).

NMSHE emphasizes on building capacities at the sub-national level. For this purpose, State Climate Change Cells/Centres have been established in the Himalayan States. NMSHE is in its progressive phase, and I am sure in the future, it will develop into a pool of knowledge on which future policy and programmes will rely. I would like to thank the State Climate Change Cells in the Himalayan states who are working under NMSHE for making significant efforts in achieving the objectives of the mission.

NMSHE is being coordinated by the Climate Change Programme (CCP) of the Department of Science and Technology (DST). This manual has been developed as part of the capacity building initiative under NMSHE and is aimed to enhance the understanding of stakeholders on climate change and its impacts, vulnerability, risk, adaptation, and related issues in the IHR. I hope that it will contribute towards the capacity building efforts of the Government of India in the Himalayan region.

I wish to compliment the efforts made by the Climate Change Programme, SPLICE Division, DST and the State Climate Change Cells in the Himalayan States for bringing out this manual on climate change adaptation in the Himalayan Region. Let me also take this opportunity to thank the Swiss Agency for Development and Cooperation for partnering with India for building resilience in the Himalayas.

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Message

Dr. Andreas Baum
Ambassador of Switzerland to India and Bhutan

The Indian Himalayan Region is highly vulnerable to climate change and needs immediate attention. The Swiss Agency for Development and Cooperation (SDC), as part of the Indian Himalayas Climate Adaptation Programme (IHCAP), has been strengthening the resilience of vulnerable communities in the Himalayas and enhancing the knowledge and capacities of research institutions and decision-makers. IHCAP is a bilateral programme of the Government of Switzerland and the Government of India, supporting the implementation of the National Mission for Sustaining the Himalayan Ecosystem (NMSHE).

Climate change results in risks and uncertainties for natural resources and communities threatening the socio-economic development in the Himalayan Region. A comprehensive understanding of these risks and impacts can enable planning and implementation of robust adaptation measures. Under IHCAP, SDC has been sensitizing the state Governments in the Himalayan Region on the risks of climate change, supporting adaptation planning and implementation. This initiative contributes towards the objectives of NMSHE while enhancing the capacities of the state administrations.

This manual has been developed as a guidance document to facilitate the integration of climate change adaptation in the overall development process of the region. The manual is aimed at enhancing the understanding of stakeholders on adaptation through modules on climate change and its impacts in the Himalayan region, concepts of vulnerability, risk and adaptation, and methods related to adaptation planning and implementation.

I would like to congratulate the authors of the manual for developing a guidance document that helps integrate climate change adaptation into existing planning processes and institutions.

Switzerland is pleased to contribute to the development and resilience of the mountain regions and communities in India and is confident that this document will help achieve that objective.

Message

K Venkateswara Rao
Managing Director, NABCONS

Earth's climate is now changing faster than at any point in the history of modern civilization, primarily as a result of anthropogenic activities. The Himalayas is one of the world's most sensitive hotspots of global climate change. Melting glaciers, rising sea levels, erratic and unpredictable weather conditions, changing patterns of rainfall and rising temperatures are impacting people, wildlife and all natural resources of the region. As a large part of the population of the Indian Himalayan Region is engaged in various climate sensitive activities of agriculture, forestry, water conservation, forest management and eco-tourism sectors, it becomes extremely important to protect and conserve the fragile Himalayan ecology and build resilience of vulnerable communities and enhance the capacities of research institutions and policy makers.

The Indian Himalayan Region covering twelve states of India - Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, West Bengal, Assam, Meghalaya, Nagaland, Arunachal Pradesh, Manipur, Mizoram and Tripura have reasons to be concerned about these changes in the climatic phenomena due to concentration of GHGs in the atmosphere. We express our concern and anxiety when natural disaster events happen, but by and large depend on the concerned stakeholders to do the needful, who on the other hand, have a reactive rather than pro-active approach to address the issues of climate change.

Against this backdrop, the Government of India had launched National Mission for Sustaining the Himalayan Ecosystem (NMSHE), which is one of the eight core "National Missions" of the National Action Plan on Climate Change (NAPCC). Indian Himalayas Climate Adaptation Programme (IHCAP) of Swiss Agency for Development and Cooperation (SDC) is supporting the implementation of NMSHE as a knowledge and technical partner. The overall goal of IHCAP is to strengthen the resilience of vulnerable communities in the Himalayas and to enhance and connect the knowledge and capacities of research institutions, communities and decision-makers. NABARD Consultancy Services (NABCONS) is partnering with SDC in organizing training and capacity building programmes through the State Climate Change Cells (SCCCs) by setting up an institutional mechanism, understanding training needs, and organizing orientation and training programmes on climate change adaptation. Training manuals and modules are also being developed and is envisaged to help institutionalise the training programmes and ensure sustainability of the capacity building initiatives.

This training manual developed by NABCONS focuses on the knowledge building, skill and attitudinal changes on the various facets of climate change adaptation in a step by step manner. It emphasizes the role and relevance of decision makers, state government functionaries at various levels and representatives at the grassroots level. The need for community understanding and participation in climate change adaptation effort has been emphasised. The manual also summarizes the significant knowledge gathered around climate change and its impact on the marginalised, vulnerable communities of the Indian Himalayan Region in the form of case studies.

I am confident that this manual will be of great value to stakeholders & functionaries and will serve its purpose effectively. I congratulate the entire team of SDC and NABCONS for their efforts in preparing this training manual.

Acknowledgements

This manual has been developed as part of a capacity building programme on climate change adaptation in the Indian Himalayan Region under the National Mission for Sustaining the Himalayan Ecosystem (NMSHE). The development of this manual has been supported by the Indian Himalayas Climate Adaptation Programme (IHCAP), a project of the Swiss Agency for Development and Cooperation (SDC), which is being implemented as a bilateral cooperation programme with the Department of Science and Technology (DST), Government of India. IHCAP has been supporting the implementation of NMSHE as a knowledge and technical partner.

NABARD Consultancy Services (NABCONS) expresses its sincere gratitude to Dr. Akhilesh Gupta, Adviser/Scientist-G & Head, Strategic Programmes, Large Initiatives and Coordinated Action Enabler (SPLICE) and Climate Change Programme, Department of Science and Technology (DST), Government of India and Dr. Nisha Mendiratta, Scientist-G & Associate Head, SPLICE and Climate Change Programme, DST, Government of India for their continuous support and invaluable insights provided during the course of the development of this manual.

It also expresses its sincere thanks to Ms. Marylaure Crettaz, Head, Swiss Cooperation Office India and Dr. Shirish Sinha, Ex-Deputy Head, Swiss Cooperation Office India, for their encouragement, guidance and firm support for the development of this manual. Special thanks are due to Dr. Mustafa Ali Khan, Team Leader and Ms. Divya Mohan, Science Policy Officer, Programme Management Unit of IHCAP for their continued contribution at various stages of preparation of this manual.

We are especially thankful to NABARD and Faculty Members of Bankers Institute of Rural Development for providing necessary help and support.

The cooperation received from the State Climate Change Cells (SCCCs), established under NMSHE in Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, Uttarakhand and West Bengal in the Indian Himalayan Region is duly acknowledged.

NABCONS would like to acknowledge its scientific team members for authorship contribution particularly, Dr. Suraj Pandey, Mr. Siddharth Bhatia, Ms. Alka Patwal for preparing this manual led by Mr. Sanjoy Ghosh, Project Leader & Vice President.

We greatly appreciate the contribution of expert reviewers for their invaluable insights that have been crucial for the development of this manual.

List of Abbreviations

Accredited Entity	AE
Adaptation Fund	AF
Adaptive Water Management	AWM
Asian Cities Climate Change Resilience Network	ACCCRN
Atmosphere-Ocean General Circulation Model	AOGCM
Centre for Environment Education	CEE
Certified Emission Reduction	CER
Clean Development Mechanism	CDM
Climate Action Group	CAG
Climate Resilience Strategy	CRS
Climate-Smart Agriculture	CSA
Community Based Eco-Tourism	CBET
Community-Based Adaptation	CBA
Community-Based Tourism	CBT
Conference of Parties	COP
Dangerous Anthropogenic Interference	DAI
Department of Science and Technology	DST
Direct Access Entity	DAE
Disaster Risk Management	DRM
Ecosystem Services	ES
Ecosystem-based Adaptation	EbA
Forest Survey of India	FSI
General Circulation Model	GCM
Geological Survey of India	GSI
Glacial Lake Outburst Flood	GLOF
Global Change in Mountain Regions	GLOCHAMORE
Global Programme Climate Change and Environment	GPCCE
Government of India	GoI
Green Climate Fund	GCF
Greenhouse Gas	GHG
Gross Domestic Product	GDP
Gross State Domestic Product	GSDP
Himachal Pradesh State Knowledge Cell on Climate Change	HPKCCC

Hindu-Kush Himalayan region	HKH
ICLEI-ACCCRN Process	IAP
Improved Cook Stoves	ICS
Indian Council of Agricultural Research	ICAR
Indian Himalayan Region	IHR
Indian Himalayas Climate Adaptation Programme	IHCAP
Indian Network for Climate Change Assessment	INCCA
Indian Space Research Organisation	ISRO
National Communication to the United Nations Framework Convention on Climate Change	NATCOM
Integrated Organic Farming System	IOFS
Integrated Research and Action for Development	IRADe
Integrated Water Resource Management	IWRM
Intended Nationally Determined Contribution	INDC
Intergovernmental Panel on Climate Change	IPCC
International Centre for Integrated Mountain Development	ICIMOD
International Year of Mountains	IYM
Jammu & Kashmir	J&K
Joint Forest Management	JFM
Knowledge Management Group	KMG
Mahatma Gandhi National Rural Employment Guarantee Act	MGNREGA
Ministry of Environment, Forest and Climate Change	MoEF&CC
Ministry of New and Renewable Energy	MNRE
Mizoram Science, Technology and Innovation Council	MISTIC
Monitoring and Evaluation	M&E
Mountain Research Initiative	MRI
NABARD Consultancy Services	NABCONS
National Action Plan on Climate Change	NAPCC
National Adaptation Fund for Climate Change	NAFCC
National Bank for Agriculture and Rural Development	NABARD
National Disaster Response Force	NDRF
National Implementing Entity	NIE
National Initiative on Climate Resilient Agriculture	NICRA
National Institution for Transforming India	NITI
National Mission for Sustaining the Himalayan Ecosystem	NMSHE
National Mission on Himalayan Studies	NMHS
Nationally Determined Contribution	NDC
Non-Timber Forest Products	NTFPs

North-Eastern Himalayas	NEH
Pradhan Mantri Ujjwala Yojana	PMUY
Protected Areas	PA
Providing Regional Climates for Impact Studies	PRECIS
Reducing Emissions from Deforestation and forest Degradation	REDD+
Regional Circulation Model	RCM
Representative Concentration Pathway	RCP
Rural Management and Development Department	RMDD
Sectoral Working Groups on Climate Change	SWGCC
Self Help Group	SHG
Shimla Municipal Corporation	SMC
Short Lived Carbon Pollutants	SLCP
State Action Plan on Climate Change	SAPCC
State Climate Change Centre/Cell	SCCC
Strategic Knowledge Mission	SKM
Sustainable Agriculture and Rural Development in Mountains	SARD-M
Sustainable Development Goals	SDG
Swiss Agency for Development and Cooperation	SDC
Training Needs Assessment	TNA
Training of Trainers	ToT
Travel & Tourism	T&T
United Nations	UN
United Nations Development Programme	UNDP
United Nations Environment Programme	UNEP
United Nations Framework Convention on Climate Change	UNFCCC
United Nations General Assembly	UNGA
United Nations Human Settlement Programme	UN-HABITAT
United Nations International Strategy for Disaster Reduction	UNISDR
Van Panchayats	VP
Van Suraksha Samiti	VSS
Vulnerability and Risk Assessment	VRA
Watershed Organisation Trust	WOTR
Western Disturbances	WD
World Health Organisation	WHO
World Meteorological Organization	WMO
World Wide Fund for Nature	WWF

Preface

In 2008, the Government of India launched the National Action Plan on Climate Change (NAPCC) taking into consideration the recommendations from the Fourth Assessment Report of IPCC (AR4, 2007) and India's First National Communication on Climate Change to United Nations Framework Convention on Climate Change (UNFCCC) (2002). The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) is one of the eight core "national missions" of the NAPCC. It is the only mission with a regional focus.

The most crucial and primary objective of the mission is to:

- develop a sustainable national capacity to continuously assess the health status of the Himalayan ecosystem;
- enable policy bodies in their policy-formulation functions; and
- assist states in the Indian Himalayan Region (IHR) with the implementation of actions selected for sustainable development.

The Department of Science and Technology (DST) under the Ministry of Science and Technology, Government of India is the nodal agency for coordinating the implementation of NMSHE.

The Indian Himalayas Climate Adaptation Programme (IHCAP) was launched in 2012 by the Swiss Agency for Development and Cooperation (SDC) in partnership with DST under its Global Programme Climate Change and Environment (GPCCE). IHCAP is supporting the implementation of NMSHE as a knowledge and technical partner. The overall goal of IHCAP is to strengthen the resilience of vulnerable communities in the Himalayas and to enhance and connect the knowledge and capacities of research institutions, communities and decision-makers. The first phase of IHCAP (2012-15) focussed on a number of initiatives including an Indo-Swiss collaborative research and capacity building activities in Himachal Pradesh. During the second phase (2016-19), the scope of implementation was expanded to include all the 12 Himalayan states.

As part of NMSHE activities, State Climate Change Centres/Cells (SCCCs) have been established in 11 out of the 12 Himalayan States including Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, West Bengal, Meghalaya, Manipur, Tripura, Mizoram, Nagaland and Arunachal Pradesh. These SCCCs are responsible for the implementation of the activities that align the State Action Plans on Climate Change with NMSHE priorities.

The SCCCs are responsible to undertake the following activities with the technical support of DST at various levels -

- Conduct vulnerability and risk assessment;
- Development and implementation of training programmes on climate change adaptation;
- Conduct public awareness training programmes;
- Undertake initiatives for building institutional capacity

One of the key objectives of the SCCCs is to strengthen capacities of state government officials and legislators through orientation and training programmes at different levels on adaptation planning and implementation to respond to climate change risks. Training programmes are also organised from time to time with an objective to create a pool of master trainers for autonomous replication in each Himalayan state. IHCAP is supporting the organization of these training programmes in the Himalayan States under NMSHE. *Read more about the trainings at www.ihcap.in.*

For the implementation of training programmes in all Himalayan states, IHCAP is facilitating design and organization of orientation and training programmes through NABARD Consultancy Services (NABCONS). NABCONS is a wholly owned subsidiary of NABARD, primarily engaged in the consultancy and advisory services in the field of agriculture and rural development. NABCONS is supporting the organization of training programmes through the SCCCs by setting up institutional mechanism, understanding the knowledge gaps, developing a training manual, and organizing orientation and training programmes on climate change adaptation.

With this background, Training Need Assessment (TNA) was conducted by NABCONS for all the Himalayan states of India *(Please refer to the summary of TNA in Annexure 1).* A series of consultations were undertaken with the key nodal department and other relevant stakeholders in each state. The structure of the training programmes and the indicative duration as finalized in consultation with the SCCCs is as follows:

- Level 1 - Orientation programme for legislators and senior officials (Half day programme)
- Level 2 - Training programme for state level officials (One day programme)
- Level 3 - Training programme for district level officials (3 to 4 days programme)
- Level 4 - Training of trainers programme (3 to 4 days training programme)

Exposure visits are part of the training programmes to gain understanding of the field scenario.

To ensure the sustainability of the capacity building initiatives, SCCC will require identifying and collaborating with the state training institutes or universities, designated for conducting and implementing the training programmes. Regular training programmes conducted periodically, development of training manuals and calendars will help institutionalise the training programmes at the state level contributing towards sustained action on adaptation planning and implementation.

On the basis of TNAs, key sectors were identified to prioritize areas for capacity building for climate change adaptation in the states. This manual on climate change adaptation in IHR has been developed by taking inputs from the TNAs done in the Himalayan states. The manual is aimed to enhance the understanding of stakeholders on climate change and its impacts, vulnerability, risk, adaptation, and related issues in IHR. This manual is envisaged to be a guidance document for the government officials in order to facilitate integration of climate change adaptation in the overall development process in the state. It is aimed at promoting, planning and implementation of adaptation solutions towards climate change risks in the Himalayan region.

The manual and capacity building initiatives will enable mainstreaming of climate change adaptation in decision making and preparation of developmental plans in IHR. The manual will also help create a pool of master trainers in the Himalayan states to facilitate capacity building in climate change adaptation.

The contents of the manual are categorised into four parts:

i) **Climate change in IHR (Module 1):** This section provides the observed and projected climate change trends for IHR.
ii) **Response to climate change risks at Global and National Level (Module 2):** This section explains the response mechanisms in the form of plans, policies, and programmes at international, national and sub-national level.
iii) **Vulnerability and Risk Assessment (Module 3):** This section talks about vulnerabilities in IHR and explains a framework for doing a vulnerability and risk assessment.

iv) **Adaptation to Climate Change in IHR (Module 4):** This section explains the approaches for planning and implementation of adaptation in IHR. The section addresses the topic of adaptation in two broad categories:

a. **Sectoral adaptation** (Agriculture, Water, Forest, Health, Urban Risk Resilience, Disaster Management, Energy and Tourism) **(Module 5-12)**
b. **Cross-sectoral topics related to climate change adaptation** (Gender, Access to finance for climate change adaptation, Monitoring and Evaluation) **(Module 13-15)**

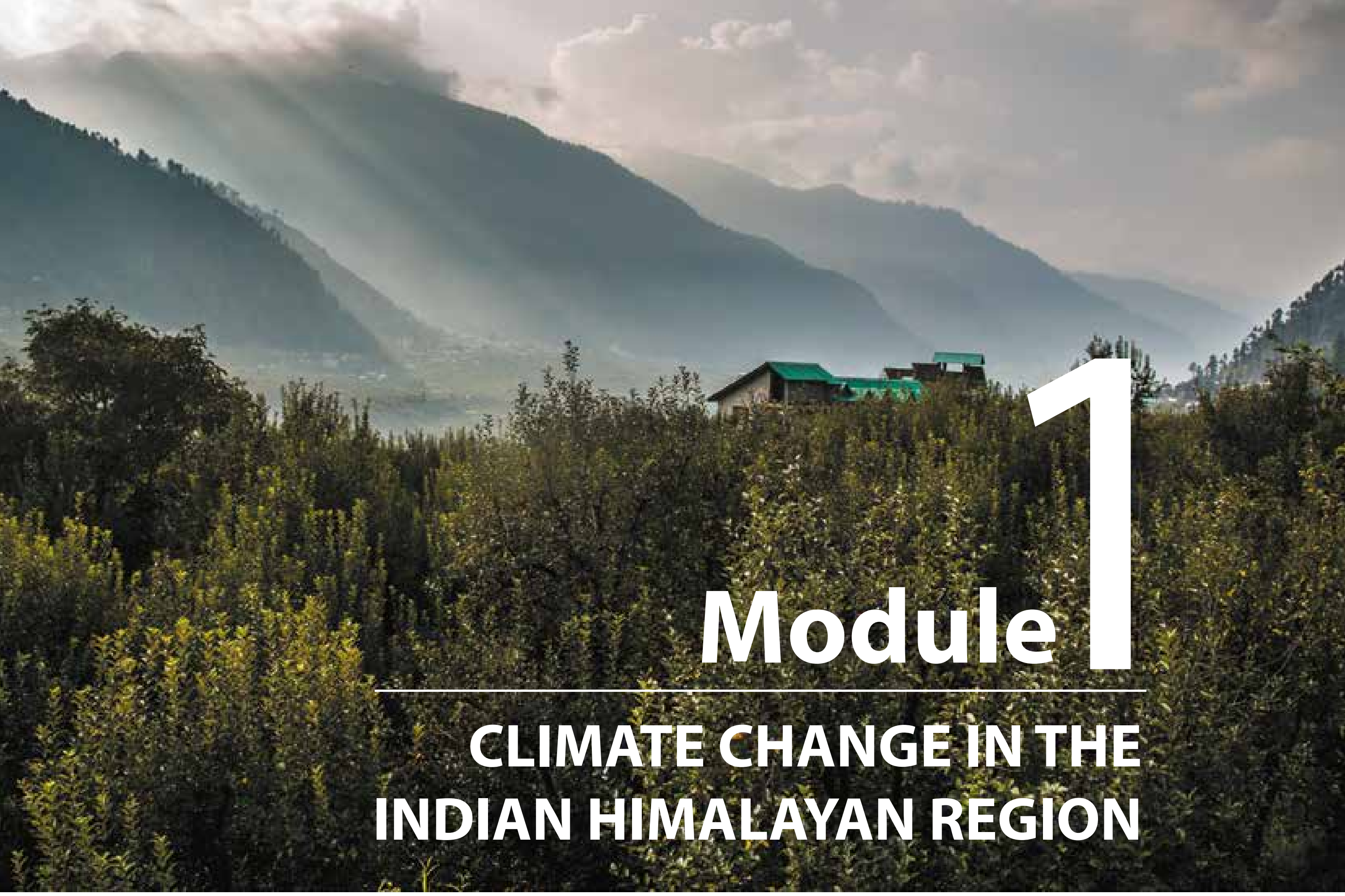
Each of the sectoral modules is structured in a way to give an introduction about the topic, its linkage with climate change and the adaptation solutions which may be adopted.

The modules are designed to help the readers (particularly training participants) in getting more information and guidance on the topics being covered during the training. In the manual, readers need to refer to Modules 1 to 4 to get an understanding on climate change, vulnerability and risk assessment and adaptation in IHR. Readers may refer to the respective sectoral modules for getting detailed understanding (Modules 5-12). Modules 13 to 15 may be referred for getting understanding on planning and implementation of adaptation. Readers may refer to the glossary given in Annexure 5 for understanding the key terms and concepts related to climate change, vulnerability, risk and adaptation.

The modules are broadly contextualized to IHR. The readers may refer to Annexure 4 for getting a snapshot of the key climate change issues and current responses in specific Himalayan states.

This manual does not aim to provide exhaustive literature on the entire set of knowledge available within the domain. However, it attempts to provide the basic information as available from published literature from key international and national sources.

Additionally, a set of guidelines for trainers have been provided in Annexure 2. The guidelines cover aspects on how to deliver the session and the tools to be used for this purpose. It also provides a suggested training schedule. Trainers are also suggested to refer 'TRAINING METHODOLOGY MANUAL: Practical guide for climate change trainings' by Helvetas (2019) (Available at: http://ihcap.in/wp-content/uploads/2019/08/Manual-Training-Methodology-climate-change2019.pdf) and use it as a guidance document to design the sessions for a training on climate change adaptation. These guidelines will be helpful for the training resource persons and the master trainers participating in the training of trainers (ToT) programme to get equipped for conducting training programmes in the future.



Module 1

CLIMATE CHANGE IN THE INDIAN HIMALAYAN REGION

1.1 Introduction

What is climate? How is climate different from weather?

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time, ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system (IPCC, 2013).

Weather describes the conditions of the atmosphere at a certain place and time with reference to temperature, pressure, humidity, wind, and other key parameters (meteorological elements); the presence of clouds, precipitation; and the occurrence of special phenomena, such as thunderstorms, dust storms, tornados and others (IPCC, 2013).

What is Climate Change?

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2013).

According to the Intergovernmental Panel on Climate Change (IPCC)[1], the global average temperature of the period 2003-2012 is 0.78°C higher than the average temperature of the period 1850-1900. This is based on the single longest dataset available. Each of the last three decades has been successively warmer at the earth's surface than any preceding decade since 1850.

[1] The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

Observations indicate a change in the trends of many extreme weather and climate events since about 1950. This includes reduction in the number of cold days and nights, and an increase in the number of warm days and nights. A number of regions have observed an increase in the number of heavy precipitation events (IPCC, 2013). These observed changes are largely attributed to human activities including burning of fossil fuels to meet energy demands and large scale deforestation which have led to an increase in Greenhouse Gas (GHG) concentrations in the atmosphere. *(Read more about GHGs in glossary –Annexure 5)*.

The global warming being observed has not been spatially uniform. It has been faster over continents than the oceans. Higher latitudes have been warming faster than the lower ones. For instance, the rates of warming in the Hindu Kush-Himalayan region (HKH) are significantly higher than the global average. Many mountainous regions across the globe have been experiencing higher rates of temperature rise. This has contributed in reduction of the area of glaciers found in these regions with implications on the water reserves for the downstream communities.

What are climate change scenarios and how are they useful?

IPCC has developed scenarios projecting climate change pathways based on a range of calculations as well as adopted four different scenarios that differ in the projected atmospheric CO_2 concentrations in the year 2100. These sample scenarios are termed Representative Concentration Pathways (RCPs). Specifically, the IPCC calls these four trajectories RCP2.6, RCP4.5, RCP6.0, and RCP8.5. The numerical values indicate the degree to which different CO_2 concentrations in the year 2100 will have altered the earth's energy balance. IPCC, more closely, assessed causes and effects and found that the trajectory of climate change and the increase in average global temperatures are determined particularly by the trajectory of population growth and the associated increase in the consumption of fossil fuels. (*Read more about RCPs in the glossary – Annexure 5)*

What are Climate Models?

According to IPCC (2013), climate models are a numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and accounting for some of its known properties. The climate system can be represented by models of varying complexity i.e, for any one component or a combination of components, a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) provide a representation of the climate system that is near or at the most comprehensive end of the spectrum currently available. There is an evolution towards more complex models with interactive chemistry and biology.

Climate models are based on well-documented physical processes to simulate the transfer of energy and materials through the climate system. Also known as General Circulation Models (GCMs), these climate models use mathematical equations to characterize how energy and matter interact in different parts of the ocean, atmosphere and land. Knowledge of the climate comes from modelling the interaction of the global climate with regional physical variables, included in a model as a grid cell. They use both palaeo-data and observational data.

Regional Circulation Models (RCMs) are similar to GCMs, but for a limited area of the earth. RCMs can generally be run more quickly and at a higher resolution than GCMs as they cover a smaller area. It is a model with a high resolution, has smaller grid cells and therefore can produce climate information in greater detail for a specific area. RCMs are one way of "downscaling" global climate information to a local scale as it involves taking information provided by a GCM or coarse-scale observations and applying it to a specific area or region.

What is the difference between climate models and weather models?

Weather models work at resolutions high enough to generate different predictions for neighbouring locations, in some cases, but only over short timescales of about two weeks maximum. Whereas, climate models include more atmospheric, oceanic and land processes than weather models do—such as ocean circulation and melting glaciers. These models are typically generated from mathematical equations that use thousands of data points to simulate the transfer of energy and water that takes place in climate systems.

Understanding climate and adaptation planning through climate models

Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and inter-annual climate predictions (IPCC, 2013). The main goal for climate science and climate models is prediction of future climate. While key physical inputs such as the earth's position relative to the sun can be calculated accurately for the future, we do not know how much carbon dioxide and methane will be released into the atmosphere. Therefore, climate models produce results for different scenarios of GHGs.

Climate models have been proved as robust tools in reducing vulnerability to the impacts of climate change by building adaptive capacity and resilience. They facilitate the integration of climate change adaptation into relevant new and existing policies, programmes and activities. The mainstreaming of climate models into development planning processes and strategies takes place in a coherent manner within all relevant sectors and at different levels.

The Indian Himalayan Region

The Indian Himalayan Region (IHR) spreads across 12 states (administrative regions) namely, Jammu & Kashmir (J&K), Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and hilly regions of Assam and West Bengal. Starting from foot-hills in the south (Siwaliks), the region extends to Tibetan plateau in the north (trans-Himalaya), comprising about 95 districts of India. The region occupies the strategic position of the entire northern boundary (North-West to North-East) of the nation and touches the international borders of seven countries. It covers about 16.2% of India's total geographical area, and is mostly enveloped by snow-clad peaks and glaciers of higher Himalaya and dense forest cover of mid-Himalaya (INCCA, 2010).

The Himalayas influence the climate of the Indian subcontinent by sheltering it from the cold air mass of Central Asia. The range also exerts a major influence on monsoon and rainfall patterns. They prevent frigid and dry arctic winds from blowing south into the subcontinent keeping South Asia much warmer when compared to regions located between corresponding latitudes throughout the globe. They are a barrier for the moisture-laden monsoon winds, preventing them from travelling further northwards and thus facilitating timely and heavy precipitation in the entire Northern India. Within the Himalayas, climate varies depending on elevation, location, aspect, vegetation cover and rain shadow zone (INCCA, 2010).

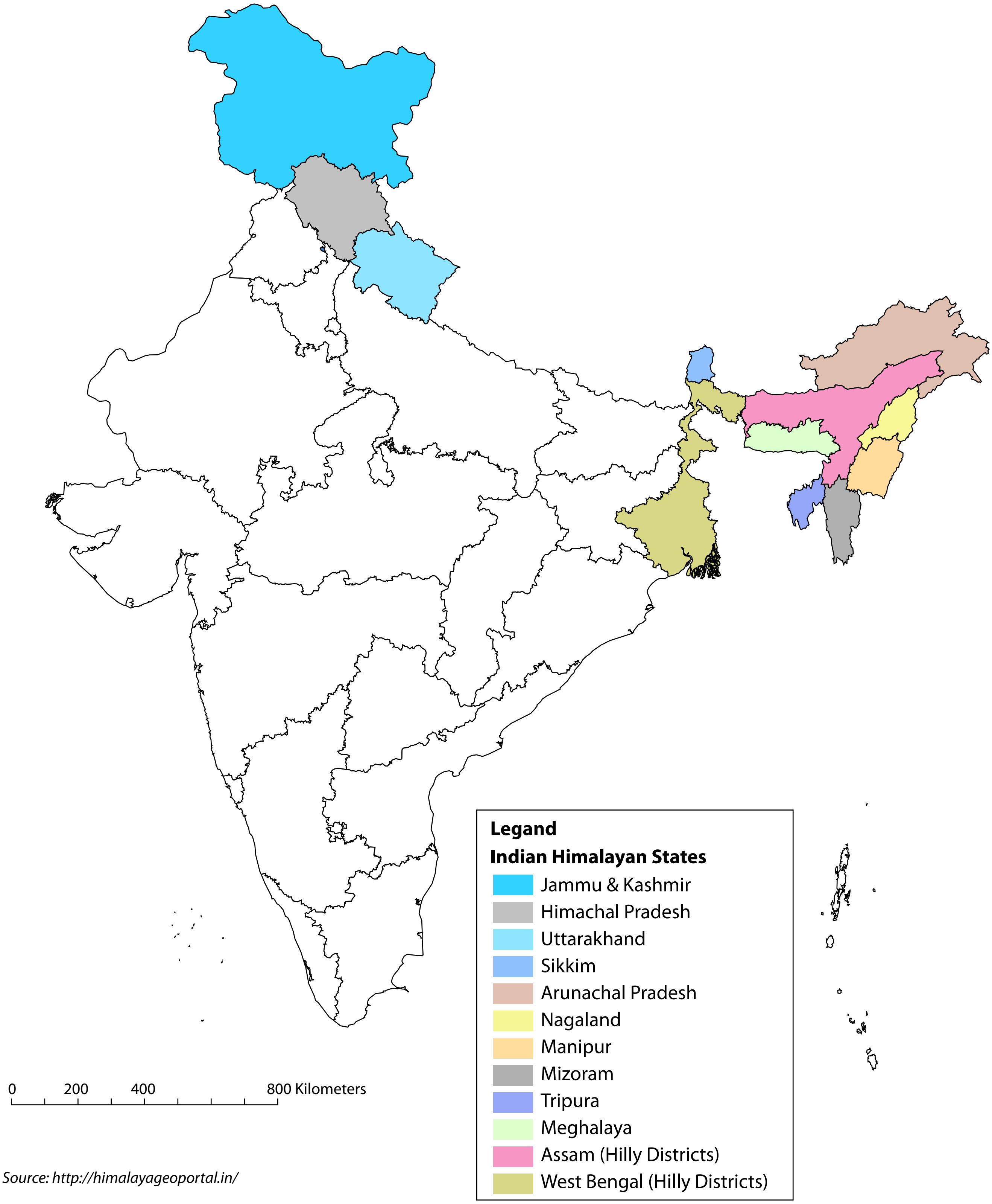
The Himalayan region is one of the most important mountain systems in the world and is referred to as the "third pole" and the "water tower of Asia". It forms the highest concentration of snow and ice cover in the world outside the Polar Regions. The higher altitudes are covered with permanent snow, which contributes to the valley glaciers, but the larger part of the Himalayas lies below the snow-line. The major river systems of the Indo-Gangetic plains including the Ganges, the Indus and the Brahmaputra originate from the Himalayas. Over 9,000 Himalayan glaciers and high altitude lakes form a unique reservoir storing about 12,000 km3 of fresh water (INCCA, 2010).

More than 65% of the geographical area of IHR is under forests, representing one-third of the total forest cover and nearly half (46%) of the very good forest cover of the country. The forests of the region provide life supporting, provisioning, regulating, and cultural 'eco-system' services to millions of local as well as downstream people (INCCA, 2010).

Nearly 40 million people inhabit the Himalayas (3.8% of the total population of the country). The economy of the Himalayas as a whole is poor with low per-capita income. Much of the Himalayan area is characterized by a very low economic growth rate combined with a high rate of population growth, which contributes to stagnation in the already low level of per-capita gross national product. Most of the population is dependent on agriculture, primarily subsistence agriculture; modern industries are lacking. The skilled labour needed to organize and manage development of natural resources is also limited due to low literacy rates. Most of the Himalayan communities face malnutrition, shortage of safe drinking water, poor health services and education systems (INCCA, 2010).

Figure 1.1: Twelve States in the Indian Himalayan Region

The Indian Himalayan Region



Source: http://himalayageoportal.in/

1.2 Climate change trends and impact in IHR

The Himalayan region is the youngest and the loftiest mountain chain in the world. It has more than 30 peaks exceeding 7,600 m in elevation and still rising, which makes it unstable and fragile. The Indian Network for Climate Change Assessment (INCCA) 4x4 report (2010) concluded that the Himalayas have undergone major changes in the last century based on the observed and projected climate change scenarios. Trends indicate that warming is occurring at much higher rates in the high altitude regions than in the low altitude areas in the Himalayas (Shrestha & Eriksson, 2009). Increasing variation in precipitation (both rainfall and snow), and temperature has altered the soil moisture availability, plant phenology and viable altitudinal range, and pest susceptibility. These effects are likely to be exacerbated due to the result of projected climate change, such as increased temperature, altered precipitation patterns and changes in the trends of extreme weather events. According to the IPCC (2014), impacts are expected to range from reduced genetic diversity of species to glacial melt in the Himalayas leading to increased flooding that will affect water resources within the next few decades. The INCCA report (2010) has identified that communities inhabiting mountain ecosystems are particularly vulnerable to extreme weather conditions such as high temperatures, altering rainfall patterns, receding glaciers and permafrost thawing.

What are the trends of temperature changes in IHR?

Observed Trend: As indicated in INCCA Report (2010), the minimum temperature is observed to be increasing in most parts of the Western Himalayan region (J&K, Himachal Pradesh and Uttarakhand) and in certain parts of the North-Eastern region from 1901 to 2007. The warming is mainly contributed by winter and post-monsoon temperatures. For maximum temperature, an increasing trend is observed for IHR in the long term (1901-2007) while in the last three decades (1971-2007), a warming trend is observed in the Western Himalayas and a mix trend of cooling and warming is indicated in the North-eastern region.

Projection: The annual temperature in the Western Himalayan region is projected to increase from 0.9±0.6 °C to 2.6±0.7°C in 2030's. The net increase in temperature is ranging from 1.7°C to 2.2°C with respect to the 1970's. Seasonal air temperatures also show rise in all seasons. However, winter temperatures during October, November and December in the Q1 simulations[2] show a decrease by 2.6°C in 2030's with respect to 1970's. For the North-Eastern region, the surface air temperature is projected to rise from 25.8 to 26.8 °C in 2030's with a standard deviation ranging from 0.8 to 0.9. The rise in temperature with respect to 1970's is ranging from 1.8 to 2.1 °C (INCCA, 2010). According to the Hindu Kush Himalaya Assessment (HIMAP), even if global warming is limited to 1.5°C, warming will likely be atleast 0.7°C higher in the Northwest Himalaya region. The report also highlights a rising trend of extreme warm events in the Hindu Kush Himalaya over the past five to six decades and a falling trend of extreme cold events (ICIMOD, 2019).

What are the trends of precipitation changes in IHR?

Observed trend: Over the past decades (1981-2007), increased monsoon precipitation (intensity) has been observed over the high mountain belt of the Himalayas, particularly in the east. The greatest decrease in monsoon rainfall has been observed in the south in the Ganges basin. While the number of extreme rainfall events is indicated to be decreasing, the intensity of each event (amount of rainfall) appears to be increasing (Shrestha *et al.*, 2015).

Projection: The Providing Regional Climates for Impact Studies (PRECIS)[3] run for 2030's indicates that the annual rainfall in the Western Himalayan region may vary between 1268±225.2 mm to 1604±175.2 mm respectively. The projected precipitation shows a net increase in 2030's with respect to the simulated rainfall of 1970's in the Himalayan region by 60 to 206 mm. The increase in annual rainfall in 2030's with respect to 1970's ranges from 5 to 13%. All seasons in the Western Himalayan region indicate an increase in rainfall, with the monsoon months of June, July, August and

[2] GCM PRECIS model 50X50 Resolution

[3] Providing Regional Climates for Impact Studies (PRECIS) is a regional climate modelling system developed at the Met Office Hadley Centre with the intention of allowing users in developing countries to easily produce detailed climate projections for any chosen region of the world. (https://www.metoffice.gov.uk/research/applied/international-development/precis)

September showing the maximum increase in rainfall by 12 mm. The winter rain in the months of January and February are also projected to increase by 5mm in 2030's with respect to 1970's, with minimum increase in October, November and December. The projected mean annual rainfall for the North-Eastern region is varying from a minimum of 940±149mm to 1330 ±174.5 mm. The HIMAP report has indicated significant increase in the number of wet days and extreme rain events over the Western Himalaya. In case of Eastern Himalaya, the total amount of precipitation did not change much and the number of rainy days decreased, which meant a higher amount of rainfall in a shorter period of time (ICIMOD, 2019).

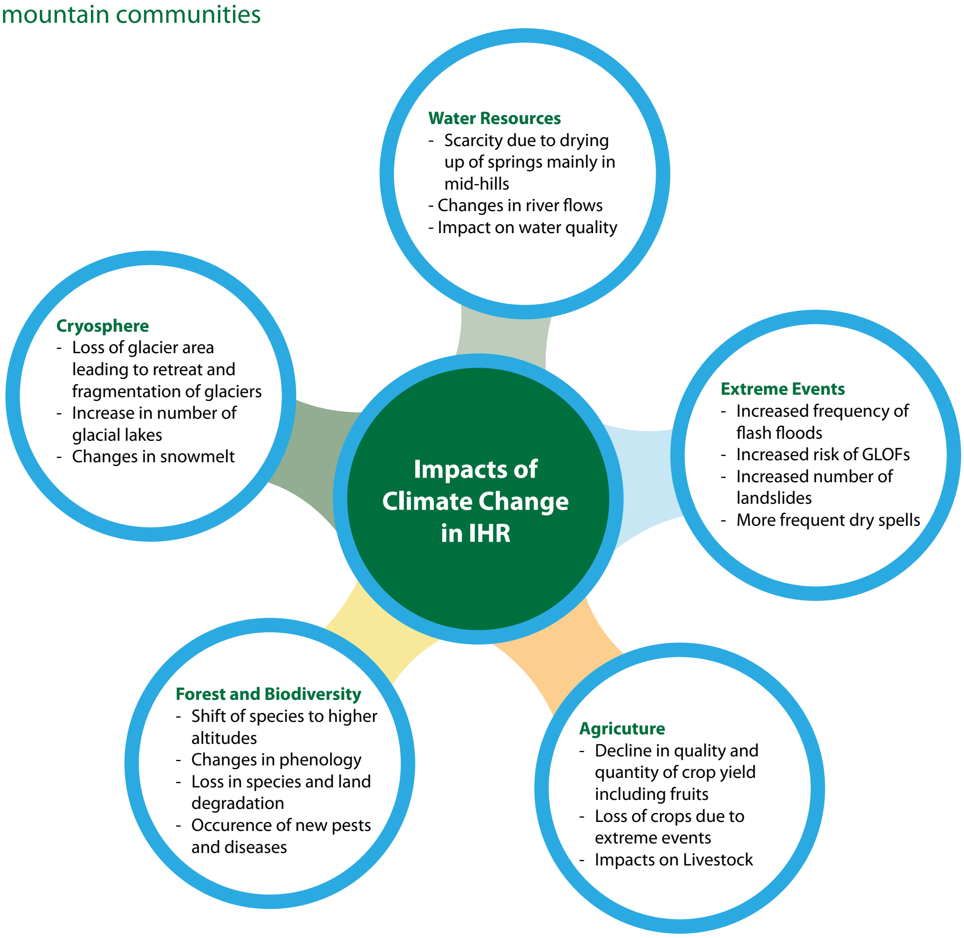
The increase with respect to 1970's is by 0.3% to 3%. The northeast also shows a substantial decrease in rainfall in the winter months of January and February in 2030's with respect to 1970's with no additional rain projected to be available during the period March to May and October to December. However, the monsoon rainfall during June, July and August is likely to increase by 5 mm in 2030's with reference to 1970's which is a rise of 0.6% (INCCA, 2010). The monsoon precipitation in the IHR is likely to become longer and more erratic (Shrestha *et al.,* 2015)

What have been the impacts of Climate Change in IHR?

The observed trends in the climate of IHR are resulting in adverse impacts on the natural resources of the region. Climate change in IHR has caused significant impacts on glaciers, snow melt, and permafrost, and has led to changes in the hydrology and water resources of major river system of the Himalayan region, and also some biodiversity hotspots. Fragmentation and retreat of glaciers has been observed leading to formation of more glacial lakes.

The changes in the glaciers along with erratic rainfall and increased rainfall intensity are leading to changes in the flow of water in the rivers originating and flowing in the region. The frequency of extreme events is also

Figure 1.2: Some of the impacts of climate change on natural resources leading to effects on the well-being and livelihoods of mountain communities



increasing in the form of more flash floods. Conversely, some areas are facing the issues of water scarcity due to decrease in rainfall coupled with drying up of springs. Mountain springs, which are the primary source of water for rural households in the Himalayan region, are also getting affected by climate change. The problem of dying springs is becoming prominent across IHR as a result of rising temperatures, rise in rainfall intensity and reduction in its temporal spread and a decline in winter rain (GoI, 2018).

Changes in temperature are having impacts on the biodiversity of the region. Many flora and fauna species are experiencing a shift to higher altitudes in response to rising temperatures. Shifts in phenology[4] are seen as the timing of the flowering of many species has been altered. Many agriculture and horticulture crops are experiencing changes in the yield due to climate variability. Owing to high dependence on natural resources for livelihoods, the mountain communities are getting adversely affected due to these observed changes in natural resources in IHR leading to many socio-economic impacts.

Unprecedented development, surge in population and higher demand for natural resources has led to serious environmental degradation in IHR. These factors have made the region more fragile to the impacts of climate change. The projected changes in climate variables are likely to further aggravate the impact on ecosystem and communities. However, in-depth understanding on the extent of observed and projected impacts in IHR are still limited due to the absence of reliable long term data. The need is to generate more knowledge on the risks and impacts of climate change in IHR and accordingly design solutions to address these risks.

The observed and projected climate change in the Himalayas and its likely impact calls for immediate response towards climate change risks in IHR in terms of plans, policies and programmes. The next module provides information/description on the response mechanisms in place at international, national, IHR and sub-national level.

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[4] The science dealing with the influence of climate on the recurrence of such annual phenomena of animal and plant life as budding and bird migrations

Module 2

RESPONSE TO CLIMATE CHANGE RISKS AT GLOBAL AND NATIONAL LEVEL

Climate change is being observed in IHR as discussed in Module 1. This Module provides information on how international and national policy initiatives are responding to climate change issues in IHR.

There is a limited understanding of the specific impacts and vulnerabilities to climate change in IHR. The lack of understanding on quantifying and measuring the vulnerabilities that people are exposed to further adds to the existing knowledge gaps. This acts as a major deterrent in taking informed policy decisions, effective planning and its implementation.

Though considerable progress has been made on improving the understanding of the significance of mountains and their specificities – fragility, marginality, inaccessibility and richness of niche ecosystem products and services, it is far from adequate to make a tangible impact on mainstreaming mountain agendas in the global policy fronts.

2.1 International cooperation and agreements relevant for the Himalayas

The United Nations General Assembly (UNGA) declared 2002 as the International Year of Mountains (IYM) through a resolution, which was supported by 130 countries. Subsequently, the Bishkek Global Mountain Summit 2002 made a milestone progress towards drawing global attention to the mountain issues.

Following the Mountain Year and Mountain Summit, several new initiatives were undertaken which include:

- Adelboden Group out of which the Sustainable Agriculture and Rural Development in Mountains (SARD-M) project emerged
- Global Change in Mountain Regions (GLOCHAMORE) and
- The Mountain Research Initiative (MRI)

In the year 2002, the Mountain Partnership was launched at the World Summit on Sustainable Development in Johannesburg (ICIMOD, 2010).

IPCC AR 4 (2007) brought attention to the fact that little is known about the HKH region from a scientific perspective. In 2008, the International Centre for Integrated Mountain Development (ICIMOD) organised the International Mountain Biodiversity Conference out of which the new concepts of trans-Himalayan transects and transboundary landscape approaches evolved (Shrestha & Eriksson, 2009). The Lucerne World Mountain Conference held in October 2011 noted the impacts of global changes on the mountains, and issued a call for action to include the mountain agendas at the Rio+20 Conference. International and regional cooperation with regard to technology transfer, technical assistance and multilateral funding is the key to address this issue.

What is Paris Agreement? How is it relevant for the Himalayas?

In 2015, countries across the globe committed to create a new international climate agreement by the conclusion of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP 21) held in Paris. Known as the Paris Agreement, it is a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris Agreement requires all countries (Parties to the Convention) to outline and communicate their post-2020 climate actions, known as their "Nationally Determined Contributions" (NDCs) and to strengthen these efforts in the years ahead (UNFCCC, 2018).

As part of the Paris Agreement, around 190 countries have committed to reducing their GHG emissions and taking various measures to ensure that the global temperature does not go beyond 1.5 °C (as compared to the pre-industrial time). But, even when the world manages to maintain the global average temperature rise at 1.5°C, there will be a greater increase in temperature in IHR. By 2050, temperatures across the IHR are projected to increase by about 1-2°C (Gupta et al., 2018), urging for more robust actions.

India submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015. It subsequently became the NDC in 2016. India's NDC identifies mountains as a priority region for actions related to climate change adaptation.

2.2 National Level Initiatives in IHR

National Action Plan on Climate Change

Recognizing the challenges of climate change, the Government of India launched the National Action Plan on Climate Change (NAPCC) in 2008, with eight specific missions. Of the eight missions outlined in India's NAPCC, efforts are focused on adaptation in the missions related to sustainable agriculture, increasing water use efficiency, sustaining the Himalayan ecosystem and creating sustainable habitats.

National Mission for Sustaining the Himalayan Ecosystem

The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) is the only mission under the NAPCC to have a regional focus. It is a multi-pronged, cross-cutting mission across various sectors. It contributes to the sustainable development of the country by enhancing the understanding of climate change, its likely impacts and adaptation actions required for the Himalayas- a region on which a significant proportion of India's population depends for sustenance. The mission seeks to facilitate formulation of appropriate policy measures and time-bound action programmes to sustain ecological resilience and ensure the continued provisions of key ecosystem services in the Himalayas. The Department of Science and Technology (DST) under the Ministry of Science & Technology, Government of India is the nodal agency for coordinating the implementation of NMSHE.

The most crucial and primary objective of the mission is to:

- Develop a sustainable national capacity to continuously assess the health status of the Himalayan ecosystem,
- Enable policy bodies in their policy-formulation functions; and

- Assist states in the IHR with their implementation of actions selected for sustainable development.

Secondary objectives of the NMSHE identified within the overall primary objective are:

- Networking of knowledge institutions engaged in studies on Himalayan ecosystem and development of a coherent data base on the geological, hydrological, biological and socio- cultural dimensions. It also includes traditional knowledge systems on preservation and conservation of the ecosystem.
- Detection and decoupling of natural and anthropogenic induced signals of global environmental changes in mountain ecosystems and prediction of future trends on potential impacts of climate change on the Himalayan ecosystem.
- Assessment of the socio-economic and ecological consequences of global environmental change and design of appropriate strategies for growth in the economy of the mountain regions and the lowland systems dependent on mountain resources in the region.
- Studying of traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms inclusive of farming and traditional health care systems.
- Evaluation of policy alternatives for regional development plans towards sustainable tourism development, water and other natural resource management for mountain ecosystems in the region.
- Creation of awareness amongst stakeholders in the region for including them in the design and implementation of the programme.
- Assisting the states in the IHR with informed actions required for sustaining the Himalayan ecosystem.

To read more about NMSHE, visit the knowledge portal: http://www.knowledgeportal-nmshe.in/Home.aspx

National Mission on Himalayan Studies

The National Mission on Himalayan Studies (NMHS), a central sector grant-in-aid scheme was launched by the Government of India in 2015. The NMHS is being implemented by the Ministry of Environment, Forest & Climate Change (MoEF&CC) and the nodal and serving hub is with G.B. Pant National Institute of Himalayan Environment & Sustainable Development. The mission aims to provide much needed impetus through holistic understanding of system's components and their linkages, in addressing the key issues relating to conservation and sustainable management of natural resources in IHR. The ultimate goal is to improve quality of life and maintain ecosystem health of the region to ensure long- term ecological security to the country (GoI, 2018).

The NMHS envisages to work towards a set of linked and complementary goals to:

- Foster conservation and sustainable management of natural resources;
- Enhance supplementary and/or alternative livelihoods and overall economic well-being of the region;
- Control and prevent pollution in the region;
- Foster increased/augmented human and institutional capacities and the knowledge and policy environment in the region; and
- Strengthen, greening, and fostering development of climate-resilient core infrastructure and basic services assets

The NMHS also aims to complement and supplement the outcomes of NMSHE anchored by DST. The mission supports innovative studies and related knowledge interventions towards the sustenance and enhancement of the ecological, natural, cultural, and socio-economic capital assets and values of the IHR (GoI, 2018).

Himalayan State Regional Council

National Institution for Transforming India (NITI) Aayog has constituted the 'Himalayan State Regional Council' in November 2018 to ensure sustainable development of the IHR. Five thematic working groups contributing to sustainable development in the IHR were set up by NITI Aayog in 2017 to foster well-being of the people in the region. The Himalayan State Regional Council has been constituted to review and implement identified action points based on the reports of these five Working Groups. The council is chaired by Dr. V.K. Saraswat, Member, NITI Aayog and will consist of the Chief Secretaries of the Himalayan states, the secretaries of key central ministries, and senior officers of NITI Aayog as well as special invitees (PIB, 2018).

2.3 State Level Initiatives in IHR

State Action Plan on Climate Change

The State Action Plan on Climate Change (SAPCC) of each state of India has been developed in order to strengthen the existing policies and programmes of the state government. These policies have been undertaken in the past two decades with an objective to protect ecology and environment for sustainable and inclusive development of the states. The SAPCCs have been developed by all the mountain State governments with the technical support from various international agencies.

The main content of the SAPCC commonly covers the following:

- Climate profile of the state: regional development issues vis-à-vis national priorities in NAPCC, baseline assessments, expected future assessments, and knowledge gaps.
- Assessment of vulnerability to climate change: assessment of current and future vulnerability temporally and spatially.
- GHG emissions and energy needs: Sectoral emissions and future energy needs of different sectors.
- Climate change strategy: Identification of entry points in existing programmes or schemes and cost–benefit analysis of proposed actions.
- Climate change action plans: Identification of existing sources of funding for the plans, additional finances required, and monitoring and evaluation.

Figure 2.1 shows the linkages of the SAPCCs of Himalayan States with the primary and secondary objectives of NMSHE.

Figure 2.1: Comparison of NMSHE linkages in IHR SAPCCs

NMSHE	J&K	UK	HP	Skm	Asm	Meg	Man	Nag	Miz	ArP	WB	Tri
Primany Objectives												
Building human and knowledge capacities at the national level	●	●	●	●	●	●	●	●	●	●	●	●
Building institutional capacities	●	●	●	●	●	●	●	●	●	●	●	●
Building evidence-based policy implementation capacities	●	●	◐	◐	◐	◐	◐	●	◐	◐	◐	●
Building capacities for continuous learning & pro-active designing of development strategies	●	●	●	◐	●	●	NA	●	●	●	●	●
Scientific assessment of the vulnerability of the Himalayan ecosystem	●	●	●	●	●	●	●	●	●	●	●	●
Research for framing evidence-based policy measures to protect fragile ecosystems	●	●	●	●	●	◐	●	●	●	●	●	●
Time-bound action programmes at the states level	●	●	●	●	●	●	●	●	●	●	●	●

NMSHE	J&K	UK	HP	Skm	Asm	Meg	Man	Nag	Miz	ArP	WB	Tri
Secondary Objectives												
Network knowledge institutions in Himalayan Ecosystems	●	●	●	◔	●	●	●	●	NA	NA	●	●
Develop bio-geo database for Himalayan eco-systems	●	●	●	●	●	●	●	●	●	●	●	●
Detect & decouple natural & anthropogenic induced signals	◔	◔	◔	◔	◔	◔	◔	◔	◔	◔	◔	●
Assessment of the socio-economic and ecological consequences of global environmental change	●	●	●	◔	●	◔	◔	●	●	●	●	●
Studying of traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms	●	●	●	●	●	NA	●	●	●	●	●	●
Evaluation of policy alternatives for regional development plans for key sectors	◔	◔	◔	◔	◔	◔	◔	◔	◔	◔	◔	◔
Creation of awareness amongst stakeholders	●	●	●	●	●	●	◔	●	●	●	●	●
Development of regional cooperation with neighbouring countries	●	●	●	NA	NA	●	◔	●	NA	NA	●	●

Source: IHCAP, 2016

Key: Explicit articulation = ● Implicit articulation = ◔

Climate adaptation is one of the major goals of India's NDC, which will be implemented post 2020. Many states including Himalayan states are now in the process of revising their SAPCCs for strengthening their climate adaptation strategies. This is in lieu of the evolving climate realities and recent advancement in understanding of climate science, impacts and vulnerabilities.

This module provided an overview of some polices and plans in place to respond to climate change in the Himalayas. In order to utilize the available resources in the most effective and efficient manner, it is useful to begin with an assessment of the vulnerability and risk of the region. This is an important exercise to ensure that adaptation strategies are tailor made.

The next module outlines a methodology for risk and vulnerability assessment.

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- India's Nationally Determined Contribution (https://nmhs.org.in/pdf/INDIA%20INDC%20TO%20UNFCCC.pdf)
- National Mission for Sustaining the Himalayan Ecosystem (http://www.knowledgeportal-nmshe.in/)
- The mountain partnership (http://www.fao.org/mountain-partnership)
- United Nations Framework Convention on Climate Change (https://unfccc.int/)

Module 3

VULNERABILITY AND RISK ASSESSMENT

3.1 Introduction

While changes are being observed in the key climate parameters in IHR (Module 1), there are complex and diverse characteristics of the natural ecosystems and human systems in the region which makes it more vulnerable to climate change. This module explains some of the concepts related to vulnerability and provides a methodology for conducting a vulnerability and risk assessment in IHR.

What is Vulnerability?

Vulnerability refers to the propensity or predisposition to be adversely affected (IPCC, 2014). Predisposition indicates certain lack of capacity of the system to deal with the adverse impact of a hazard. Vulnerability is conceptualized as an internal property of a system that is a function of its current endogenous lack of capacity to overcome the adverse impact of a stressor. Hence, vulnerability of a natural system or socio-economic system is assessed as a function of its sensitivity (first order impact of a stressor/hazard) to a hazard/stressor and its lack of (adaptive) capacity to overcome such sensitivity (IHCAP, 2017).

Moving towards the concept of Risk

Earlier studies on climate change focussed on assessing vulnerability (IPCC, 2007). Over recent years, there has been a shift in the conceptualization of vulnerability with emergence of 'climate-risk' as a central concept (IPCC, 2012). Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure and hazard (IPCC, 2014). For example, risk of flood-related impacts may result from a flood event (hazard) affecting infrastructure and people in flood plains (exposure) where the community is marginalized or response strategies are lacking (vulnerability). These three components are governed by changes in climate system as well as socio-economic processes.

Within the conceptualization of climate change-related risk, vulnerability is clearly linked to the intrinsic conditions of a society or system, while the changes in the climate system contribute to hazards and trends. Vulnerable systems may or may not face climate change risk depending on their exposure to hazards. For example, weak infrastructure in areas exposed to floods face higher risk of getting affected by floods. The differentiation between the basic concepts of risk, hazard, vulnerability and exposure provides a sound basis for the development of adaptation strategies that need to consider both the changes in frequency or magnitude of hazards due to climate change as well as societal dynamics that shape the exposure and vulnerability of people and social-ecological systems (IHCAP, 2017).

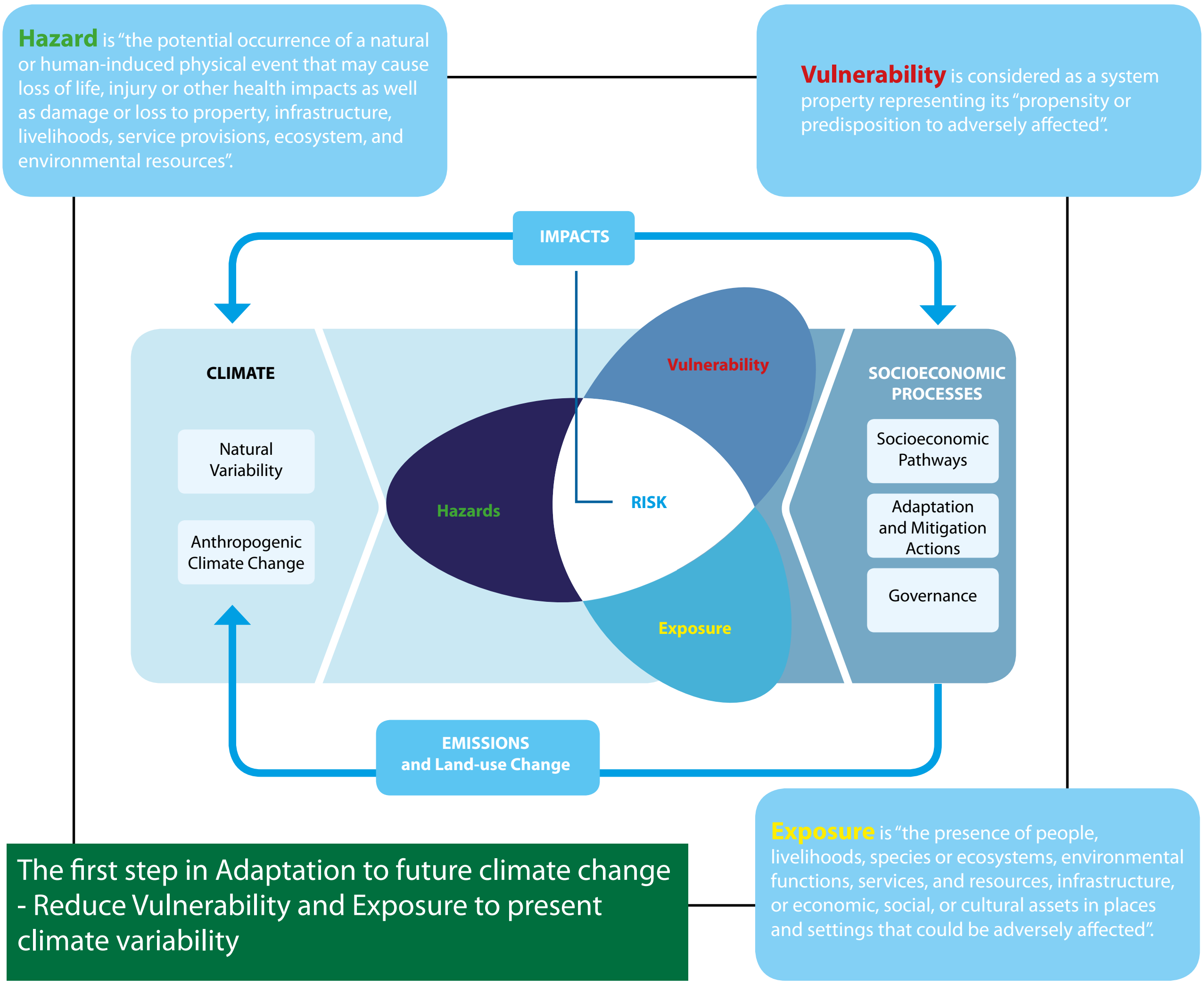
3.2 Framework for Vulnerability and Risk Assessment

The risk management framework adopted by IPCC in the Fifth Assessment Report (IPCC 2014) depicts that hazard, exposure and vulnerability interact; and result in risk within the overall climatic and non-climatic physical and socio-political environment (Figure 3.1).

The main goal of the risk management and assessment framework is to assess the impacts of climatic hazards to enable development of adaptation strategies. According to this framework, the risk or impact is a function of

Figure 3.1: Risk management and assessment framework

Risk arises from interaction of vulnerability, exposure and hazard



Source: IPCC, 2014

hazard, exposure and vulnerability. Vulnerability is only one of the components. Risk, according to this framework, is assessed as a probable harm that can be caused to a natural system or humans by an expected hazard. Risk assessment enables minimizing the impact of a future hazard event by undertaking preparatory activities. Under impending climate change, which is expected to only aggravate in the near future, understanding of the current climatic hazards and future climate change trends and hazards is imperative. It will enhance the coping mechanism of the communities to deal with an uncertain future.

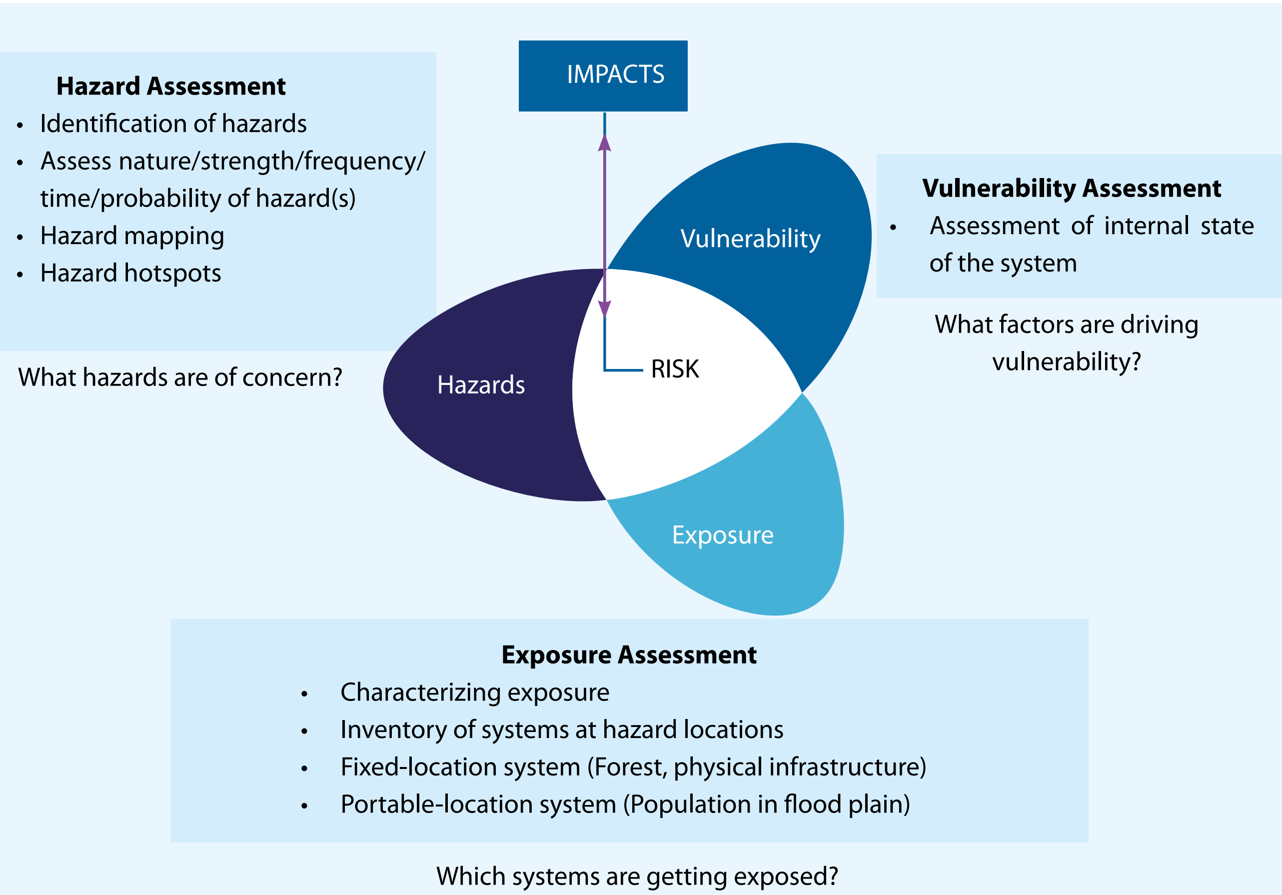
Risk Assessment

Risk arises as a result of the interaction of Vulnerability (V), Hazard (H) and Exposure (E) (IPCC 2014). Risk is assessed for a vulnerable system of interest, for a hazard/s, when such system is located at a place where such climatic hazard is likely to occur.

Hazard is defined as the potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2014). Hazard includes both the slow onset events (e.g. increase in mean temperature or decrease in rainfall leading to impacts such as species extinction, vegetation change or groundwater shortages) and the fast onset events (e.g. floods, including GLOF, heat waves or landslides). These events may cause loss of life, injury, or other health impacts, as well as damage and loss to infrastructure, livelihoods and ecosystems.

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2014). Vulnerability considers only sensitivity

Figure 3.2: Steps for assessment of hazard, vulnerability and exposure for evaluating risk



Source: Sharma et al., 2018

and adaptive capacity as the two cofactors. Risk assessment thus involves assessment of V, H and E that give rise to risk. The conceptual framework to assess risk outlining the steps to assess each of the components – Hazard, Vulnerability and Exposure is shown in Figure 3.2.

Read more about the VRA framework and related concepts: Assessing Vulnerability and Risk to Climate Change (IHCAP, 2017) http://ihcap.in/reports

3.3 Why assess Vulnerability and Risk in IHR?

Climate risk assessments help in identifying areas that have been, or can be, most affected by the adverse impacts of climate change. Identification of such climate hotspots is the first step towards adaptation planning at local, national or regional scales. While the scope of managing the hazard and exposure component of risk is limited, the maximum manageability is of vulnerability. Awareness about the likely adverse impacts and the perception of threat due to climate change creates the demand for vulnerability assessment as it will provide information about the nature and extent of vulnerability and identify its sources.

Identification of vulnerabilities helps in enhancing the preparedness level. Further, vulnerability assessment helps in identifying vulnerable communities, vulnerable regions or sectors; raising awareness; prioritizing the allocation of adaptation funds; identifying mitigation target; monitoring of adaptation policy; and, scientific research (Hinkel 2011).

If the results of the vulnerability and risk assessment are acceptable to all the key stakeholders, it can facilitate quick decision making at the policy level. This underlines the importance of stakeholder participation in the assessment exercise to ensure quality and utility of the assessment outcomes.

Himalayan region is one of the most sensitive regions to climate change. Vulnerability assessment is imperative for the region. Approximately 17 million inhabitants of the Himalayan region are exposed to climatic risks and complexities. Difficult terrain, climatic variability, lack of enabling physical infrastructure, high level of environment degradation and high incidence of poverty are some of the contributing factors to high vulnerability of the region. Lack of communication and access to resources acts as deterrents that lead to reduced capability of the Himalayan communities to deal with climate change.

The Himalayan region has many glaciers which give rise to numerous rivers. With increasing temperature, the area covered by permafrost and glaciers are decreasing in the region. IHR is experiencing increased climate variability, and in particular monsoon rainfall variability, leading to higher frequency of extreme events. This has implications towards the vulnerability of natural ecosystems, such as mountain streams, due to changes in flow and flood regimes, and the agriculture system, which is the primary source of livelihood for the hill communities. With limited livelihood options and lack of development infrastructure vis-à-vis road, transport, power supply and communication, the Himalayan communities experience higher marginalization. There is high dependency on natural resources to sustain their livelihood.

Difficult terrain, inaccessible areas and climate variability make the Himalayan region highly sensitive to any climatic and anthropogenic changes. The biophysical and socio-economic constraints exacerbate the vulnerability status of region. The need is to build the adaptive capacity of the Himalayan communities to deal with risks due to climate change. Vulnerability assessment can be carried out to identify the drivers of vulnerability to these communities. This will assist in designing adaptation interventions specific to that area and identification of the differential vulnerability of different social groups such as the marginalised communities.

A vulnerability assessment provides an understanding of the underlying factors of sensitivity and adaptive capacity. This information is crucial while integrating climate change concerns in development planning and finding solutions to reduce vulnerability. *For detailed understanding on conducting a vulnerability assessment refer to Annexure 3.*

3.4 Step wise Guide for Conducting Risk Assessment in IHR

Steps for assessing and dealing with risk are presented in Figure 3.3. It starts with defining the objectives of risk assessment and culminates in taking vulnerability reduction measures to reduce and manage risk. As the elements constituting risk (V, E and H) are dynamic in nature, risk has to be periodically assessed and managed. These steps are universal and are applicable to natural and socioeconomic systems.

Step 1 - Defining the need and key objectives of risk assessment: Identifying the need for risk assessment is fundamental to taking up of such an exercise. Working in collaboration with the key stakeholders provides a holistic understanding of the risks and ensure an informed view of the situation. This is imperative to ensure that the key findings of the risk assessment form the basis of an informed policy decision and planning appropriate strategies. The identified needs for assessment make it easy to define the assessment objectives in a lucid and precise manner.

Step 2 - Type and scenario of risk assessment: The purpose of risk assessment is to deal with the current as well as future risks. Accordingly, risk to a system of interest is assessed for current climate hazards and extremes, and future climate change trend and hazards. This step requires assessment of climatic hazards.

Step 3 - Identification of sector, community, region and scale of assessment: Risk is assessed for a sector (say agriculture, health and water resources) or community or social or socio-economic risk for a region. Assessment could be carried out at local or larger scales such as at household, village, district, state or at country level.

Step 4 - Assess vulnerability, exposure and hazard as outcome vulnerability: Once a system of interest and the scale of assessment are decided, the outcome vulnerability of the system from exposure to an identified hazard is assessed. Assessment of exposure

Figure 3.3: Steps for doing a risk assessment

1. Define the objective of risk assessment (involvement of stakeholders in decision making enhances the utility of assessment)
2. Identify the hazard(s) of concern causing risk and the system(s) under risk; and decide the resolution, scale and time frame for the assessment
3. Characterize and assess hazard(s) (for nature, frequency, intensity and location) and assess outcome vulnerability of system(s) for anticipated hazard(s)
4. Mark hazard hotspots from hazard assessment and prioritize vulnerable systems/s from vulnerability assessment
5. Combine the spatial distribution maps of hazard hotspots and priority system(s) locations to identify the priority districts/blocks/GP under risk
6. Take-up assessment at local scale to identify the site-specific factors driving the vulnerability to the identified hazard(s)
7. Identify vulnerability reduction/adaptation measures in consultation with stakeholders to manage risk (this helps in dealing with the current risk and prepares against future risks)

and hazard through appropriate indicators is part of the assessment of outcome vulnerability.

Step 5 - Assess the probability of occurrence of hazard at system location: Probability of the occurrence of hazard/s at the place where system is located can be estimated using baseline date. For future hazards, such information could be generated using appropriate climate change projection models.

Step 6 - Quantify risk: Having quantified the outcome vulnerability in step 4 and probability in step 5, risk can be quantified as a product of the two.

Step 7 - Representation of risk: The risk quantified in step 6 can be represented in various formats such as spatial maps, charts, tables and index for effective communication with stakeholders, including decision makers.

Read more on Risk and Vulnerability Assessment: Vulnerability and Risk Assessment in the Indian Himalayan Region: Framework, Method and Guidelines (Sharma et al., 2018).

Also read its application for the IHR through a capacity building initiative involving all 12 Himalayan State Government Officials: Climate Vulnerability Assessment for the Indian Himalayan Region Using a Common Framework (2019).

For detailed understanding on conducting Vulnerability Assessment (mentioned as Step 4 of risk assessment), please refer to Annexure 3.

As explained above, a vulnerability and risk assessment exercise gives a fair idea of the sectors and/or regions which require priority action. Once this is done, the next step involves devising adaptations in response to the vulnerability and risk. The next module focusses on the key concepts related to adaptation planning.

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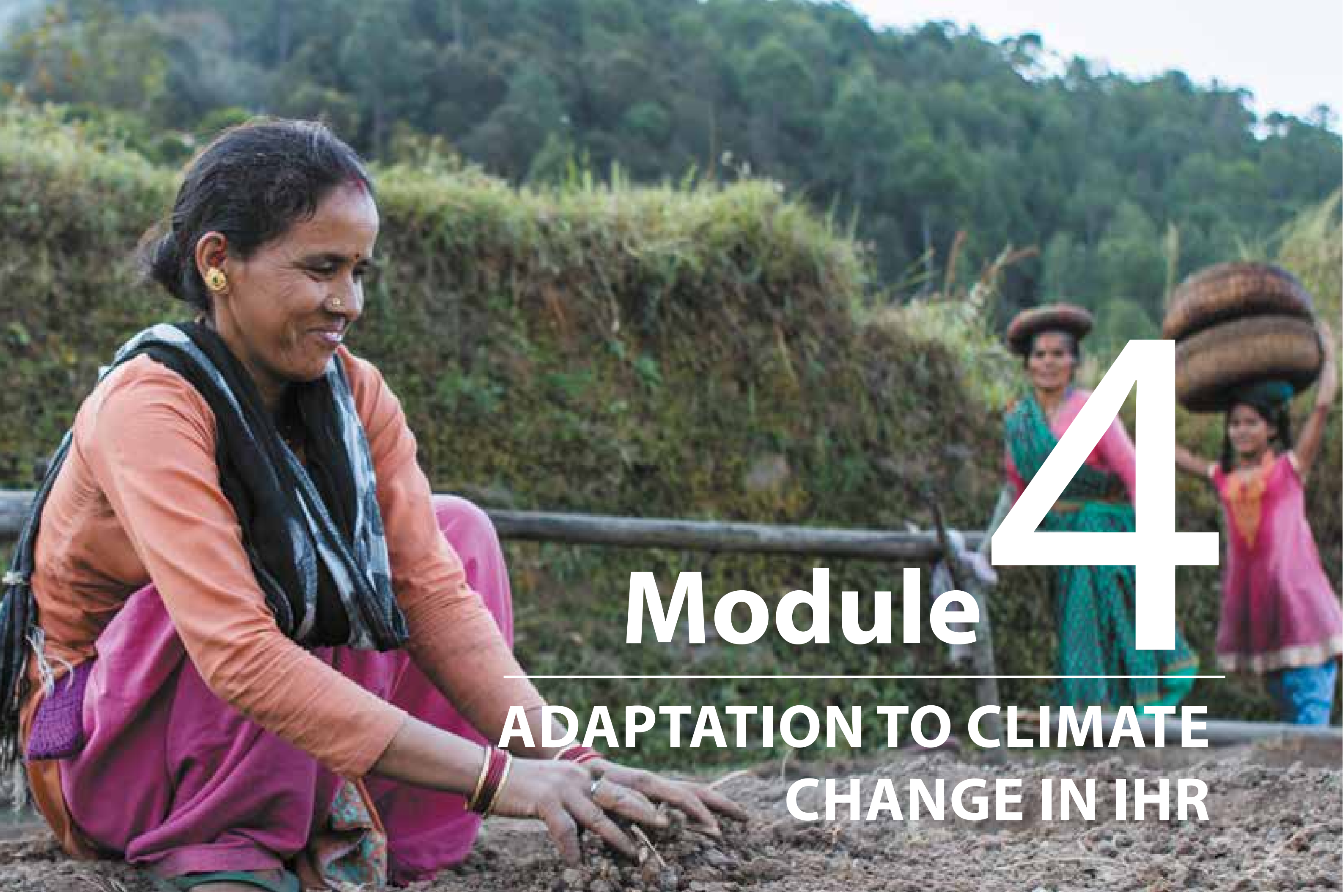


Module 4

ADAPTATION TO CLIMATE CHANGE IN IHR

4.1 Introduction

Owing to the high vulnerability of IHR to climate change, there is an urgent need to enhance the preparedness of the communities and natural systems. This module explains the key concepts related to climate change adaptation and mitigation. It provides guidance on planning and implementation of adaptation strategies in IHR.

The inevitability of climate change is an unquestionable reality established on the basis of evidences recognized by the national and scientific committees. Extreme weather conditions due to climate change will impact the environment, biodiversity, and water resources significantly. This will disrupt the productive processes vis-à-vis social and economic growth. The coping mechanism of at-risk communities will also be affected due to significant changes in the Himalayan ecosystems. Thus, it becomes imperative to enhance the resilience of the mountain communities to cope up with the effects of climate change. Climate projections and models can help in anticipating the consequences of climate change, which in turn can guide informed decision making at the policy level to enhance the preparedness of the institutions and at-risk communities. This underlines the need to have an appropriate adaptation strategy planned and implemented.

What is adaptation?

IPCC AR5 (2014) defines adaptation as 'process of adjustment IPCC AR5 (2014) defines adaptation as 'process of adjustment to actual or expected climate and its effects'. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects. According to the UNFCCC, adaptation is defined as "practical steps to protect countries and communities from the likely disruption and damage that will result from effects of climate change." For example, flood walls should be built and in numerous cases it is probably advisable to move human settlements out of flood plains and other low-lying areas." (UNFCCC, 2013).

Current scientific evidence suggests instability in the Himalayan ecosystem as a result of climate change impacts. Vulnerability is also increased as a result of cascading effects of changes in composition and distribution of natural resources – water, forest and agro-biodiversity. Thus, adaptation is imperative for responding to climate change risks in the IHR and enhancing the preparedness level of communities and institutions.

The adaptation strategies must be tailor-made according to the geophysical dimensions such as altitude and slope of a particular area, which is even more pertinent for the Himalayan region.

Adaptation and Development- Differences and linkages

The key factor that differentiates adaptation from usual developmental activities is the fact that adaptation takes into account the climate change risks and vulnerabilities in the short- and long-term. Adaptation is a response mechanism not just to deal with climate change but also with multiple stresses.

Climate change and development have close linkages; discussions on the relationship between the two have increased over the past few decades. The impact of climate change hinders the achievement of development goals at all levels. Thus, in many cases, the most suitable adaptation actions also provide development benefits in the near term, as well as reductions of vulnerabilities in the longer term. In most developing countries, adaptation is being integrated in the development context in the national adaptation strategies (IPCC, 2014).

Adaptation to climate change and risks takes place in a dynamic social, economic, technological, biophysical, and political context that varies over time, location, and sector. This complex mix of conditions determines the capacity of systems to adapt. Societies and economies have been making adaptations to climate change for centuries. However, losses from climate-related extreme events are substantial and, in some sectors, increasing—indicating patterns of development that remain vulnerable to temporal variations in climatic conditions and to climate change (IPCC, 2014) .

Different types of Adaptation

Autonomous (Spontaneous) adaptation: Adaptation in response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change (IPCC, 2014). For example: shifts in crop calendars in response to rising temperatures in mountain regions are an example of spontaneous adaptation. Another example is changes in crop varieties in response to changing climate. In Kullu valley, people have started growing low chilling varieties of apples, as a response to increasing temperature in the Himalayan region.

Planned Adaptation: It is the result of a deliberate policy decision based on an evidence that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state (IPCC, 2014). In response to increasing risks of Glacial Lake Outburst Floods (GLOFs) in mountains, establishing a flood risk and an early warning system is an example of planned adaptation.

Adaptation can also be explained as being incremental or transformational.

Incremental adaptation: Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale. Example: adjustments to cropping systems via new varieties, changing planting times, or using more efficient irrigation.

Transformational adaptation: 'Paradigm-shift' adaptation that changes the fundamental attributes of a system in response to climate and its effects. For example: change in the means of livelihood from cropping to livestock or migrating to a new place in search of a livelihood.

The need for adaptation in IHR

According to IPCC (2014), adaptation needs arise when the anticipated risks or experienced impacts of climate change require action to ensure the safety of populations, and the security of assets, including ecosystems and their services. Adaptation needs are the gap between what might happen as the climate changes and what we would desire to happen. Adaptation to climate change is necessary to build the resilience of communities and enable them to cope up and adapt to the changes in the external environment.

As discussed in Module 1, it is evident that climate change is inevitable. The observed and projected data of climate variability in the IHR further establishes this reality. The impacts of these changes on the natural resources in IHR are being observed.

Although response mechanisms are in place at national and state levels (Module 2), these must be adapted to the specific needs arising due to the diverse impacts of climatic complexities in the mountain system in IHR. The need is to have robust strategies and measures in place to enhance the preparedness level of the communities towards current and future impacts. Hazard vulnerability and risk assessment can help in identifying key risks and vulnerabilities (Module 3) as well as in the identification, planning and implementation of appropriate adaptation measures and strategies.

Different approaches to Adaptation

There is no single approach to adaptation planning because of the complex, diverse, and context-dependent nature of adaptation to climate change. Approaches can vary according to the context and the level of governance. There are two general approaches observed in adaptation planning and implementation to date: top-down and bottom-up.

Top-down approaches are scenario-driven and consist of localizing climate projections, impact and vulnerability assessments, and formulation of strategies and options. National governments often follow this approach. National adaptation strategies are increasingly integrated with other policies, such as disaster risk management. These tendencies lead to adaptation mainstreaming, although there are various institutional barriers to this process (IPCC, 2014).

As the consideration of the social dimensions of climate change adaptation has attracted more attention, there is an increased emphasis on addressing the needs of the groups most vulnerable to climate change, such as children, the elderly, disabled, and poor. **Bottom-up approaches** are needs driven and include approaches such as Community-Based Adaptation (CBA)[5]. CBA is often prominent in developing countries, but communities in developed countries also use this approach (IPCC, 2014).

The combination of top-down and bottom-up activities strengthen the links between adaptation planning and implementation. In either approach, participation by a broad spectrum of stakeholders and close collaboration between research and management has been emphasized as important mechanisms to undertake and inform adaptation planning and implementation. Local governments and actors may face difficulties in identifying the most suitable and efficient approaches because of the diversity of possible approaches, from infrastructure development to "softer" approaches such as integrated watershed management. National and subnational governments play coordinating roles in providing support and developing standards and implementation guidance. Therefore, multilevel institutional coordination between different political and administrative levels is a crucial mechanism for promoting adaptation planning and implementation (IPCC, 2014).

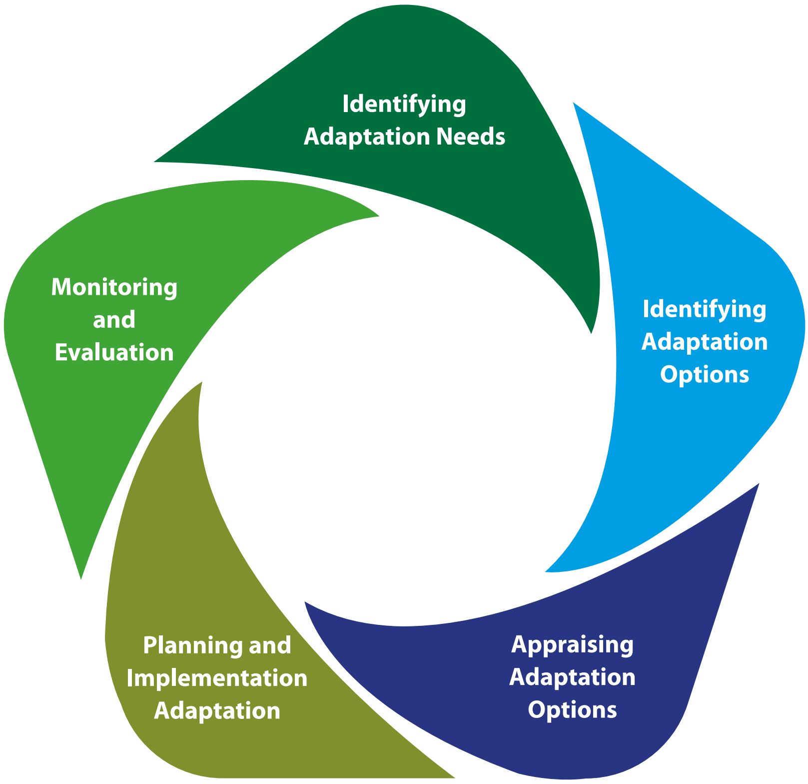
4.2 Stages of the adaptation process

The basic steps towards adaptation are depicted in fig 4.1, and they generally remain same when adaptation is planned at national, state, district, block, city or panchayat level (PROVIA, 2013).

Step 1 - Identifying adaptation needs: The first step towards adaptation is to gain more knowledge about the risks, impacts and vulnerabilities as well as opportunities faced in the context of climate change in IHR. Some guiding questions may be: What impacts may be expected under climate change? What are the vulnerabilities and capacities of the target group for which adaptation is being planned? Are vulnerable communities (target groups) aware of potential threats? What major decisions need to be taken?

[5] Community-based adaptation (CBA) is a form of adaptation that aims to reduce the risks of climate change to the world's poorest people by involving them in the practices and planning of adaptation. It adds to current approaches to adaptation by emphasizing the social, political, and economic drivers of vulnerability, and by highlighting the needs of vulnerable group (IIED, 2015)).

Figure 4.1: Steps in Adaptation



Source: PROVIA, 2013

Step 2 - Identifying adaptation options: The next step is to identify adaptation options which can meet the adaptation needs of the target groups. The identification process should answer the question: How can we address the specific risks and opportunities?

The adaptation measures can be:

- Changes required in policies, practices and procedures
- Inclusion of diversified portfolio of measures, e.g. an early warning system for predicting floods from GLOFs
- Including measures that can be at the supply or demand end
- Building new structures or retrofitting existing structures
- Building partnerships for an integrated approach
- Increasing awareness amongst all stakeholders

Identification of appropriate adaptation measures requires a prudent approach. Recognizing the fact that there are several viable options that result in effective adaptation and minimize the risks associated with implementation, and most importantly are cost-effective even in the face of associated uncertainties. These options are normally referred to as no-regrets, low regrets, win-win and flexible or adaptive management.

No-Regrets Adaptation Options – Adaptive measures that deliver net socio-economic benefits are No-Regrets Adaptation Options. These measures include those justified as cost-effective under current climate conditions (including those addressing its variability and extremes) and are further justified when their introduction is consistent with addressing risks associated with projected climate changes.

The feasibility of implementing these adaptation measures must take into account the existing barriers and potential conflicts. Moreover, these measures are particularly appropriate for the near term objectives and can provide experience to undertake further assessments of climate risks and adaptation measures.

Examples include:

- Actions or activities directed at building adaptive capacity as part of an overall adaptive strategy;
- Avoiding building in high-risk areas (e.g.. flood plains) when relocating; and
- Reducing leakage from water utility infrastructure;

Implementation of such strategies requires initial investments but overall these are cost effective, considering the targeted risks and realized benefits.

Such strategies will require investments but overall are at least cost neutral when the immediacy of the targeted risks and realized benefits are considered.

Low-regrets (or limited regrets) options – These are low-cost adaptive measures with relatively large benefits realised under projected future climate change.

Examples include:

- Building extra climate headroom in new developments to allow for further modifications (e.g., increased ventilation, drainage) consistent with projected changes in temperature and precipitation;
- Restricting the type and extent of development in flood-prone areas; and
- Developing and operating additional water storage facilities (e.g., water groups building and operating a joint water reservoir).

Win-Win options –These are the adaptation measures that have the desired result in terms of minimising the climate risks or exploiting potential opportunities as also have other social, environmental or economic benefits. Within the climate change context, win-win options are often associated with those measures or activities that address climate impacts and also contribute to mitigation or other social and environmental objectives. These types of measures not only address climate risks, but also deliver the desired adaptation benefits.

Examples include:

- Flood management that includes creating or re-establishing flood plains which increase flood management capacity and support biodiversity and habitat conservation objectives;
- Improving preparedness and contingency planning to deal with risks, including climate; and
- Green roofs and green walls which have multiple benefits in terms of reducing building temperature and rainfall runoff from buildings, and increased green spaces within urban areas, that reduces energy use for both heating and cooling.

Flexible or adaptive management options – These encompass putting in place incremental adaptation options, rather than undertaking large-scale adaptation at once. The measures are introduced based on current assessment, however designed to allow for incremental change. This means change in strategies as knowledge, experience and technology evolve. Hence, adopting flexible management options reduces risks by way of following a prudent approach in dealing with climate risks.

"Delaying" - a specific adaptation measure or a series of measures are a part of the flexible or adaptation management strategy. It requires commitment to continue building the necessary adaptive capacity while monitoring and evaluating the evolving risks for necessary corrections. A decision to delay introducing a specific action is often taken when the climate risks are below defined thresholds or when the required adaptive capacity (e.g., regulatory or institutional circumstances) is insufficient to allow effective action.

Examples include:

- Delay in the implementation of specific adaptation measures while exploring options and working with various levels of government to build the necessary standards and regulatory environment;

Step 3- Prioritising adaptation options: Once the adaptation options have been identified, the next step is to select and prioritise a few options for implementation. This is because the resources for implementation are usually limited and one needs to take decisions accordingly. This process involves weighing the pros and cons of different options and identifying those that best fit the adaptation objectives. Some of the chosen measures will be implemented in the planning process; while some actions could be implemented now or in the near future as they require additional information, resources, or support from authorities before implementing.

It is necessary to rank measures in terms of their preferences in the present scenario, which may change from time to time and take precedence over one another during the next review of the preparedness plan.
Some of the criteria that can be considered for prioritising adaptation measures for implementation are:

- **Effectiveness:** describes the extent to which the adaptation option reduces vulnerability and provides other benefits. This requires consideration of effectiveness of the adaptation option under different scenarios.
- **Costs:** describes relative costs of an adaptation option. This requires consideration of investment costs, long-term operational and maintenance costs, reconstruction costs, etc. It must also take into account the economic and non-economic costs, and costs of damage.
- **Feasibility:** answers whether the necessary legal, administrative, financial, and technical resources exist. Adaptation measures that can be implemented under the current operational framework will usually be favoured

Additional criteria may include, depending on the context, such as political and social acceptance, urgency, biodiversity friendliness, relative speed of implementation or benefits, 'no regrets' potential, avoiding detrimental effects on other development goals, alignment with funding requirements or other eligibility criteria, and alignment with policy priorities, etc.

Step 4 - Planning and implementing adaptation actions: Once an option has been chosen, implementation can begin. Implementation is a complex and challenging process, and many times the analytical work is not translated into concrete plans and actions. The process of planning and implementation requires focus on practical issues, such as budgeting, assigning responsibilities, setting up institutional frameworks, and taking action.

Major obstacles at this stage include:

- lack of motivation and common purpose;
- concerns that the desired adaptation measures are not actually feasible; and
- lack of clarity around objectives or agreement on priorities.

At this stage, it is important to understand that adaptation measures are a part of larger initiative and not standalone measures. At times, it'll be difficult to differentiate adaptation actions from measures that are focused on development goals such as improving livelihoods at the local level. For example, restoration of forest land on which mountain communities are dependent for livelihoods could provide both adaptation and development benefits.

One of the most crucial factors in the entire process of adaptation planning and implementation is stakeholder engagement. It helps in attaining consensus on objectives, responsibilities and accountability for implementation of the adaptation plan. Involvement of stakeholders at an early stage, for example, while identifying and prioritizing adaptation options can increase the probability of acceptance of the plan (PROVIA, 2013).

Step 5 - Monitoring and evaluation of adaptation: As measures are implemented, the process is monitored and evaluated to ensure it goes as planned, identify any problems, document the outcomes achieved, change course as needed, and draw lessons from the experience.

Read more about M&E in Module no. 15

Evidence based adaptation planning: An example from Kullu District, Himachal Pradesh

Kullu is one of the most vulnerable districts of Himachal Pradesh to climate change risks. Understanding the need for adaptation, an Indo-Swiss collaborative research in Kullu district was undertaken under IHCAP. It involved researchers from Switzerland and India. Specific joint studies were conducted covering thematic areas such as climate, cryosphere, floods, agriculture, perception, forestry and biodiversity using an integrated vulnerability, risks and hazard framework. As part of the studies, more than 40 scientific papers on climate change impacts, glaciology, risks and vulnerability assessment were generated. The research helped in establishing a baseline and developing a sound scientific understanding about the key risks and vulnerabilities in the district. It contributed towards identification of various adaptation options. Stakeholder consultations were undertaken to prioritize the adaptation options and detailed project proposals were developed for three prioritized options.

4.3 Factors to be considered while planning for adaptation

Stakeholder participation

Communities do not govern in isolation, and climate change impacts do not follow jurisdictional boundaries. Preparing for climate change will require building new collaborations or strengthening existing partnerships (e.g., with other local governments, tribes, federal and non-profit organizations, and the private sector) to address the impacts that occur both within and outside of the community's jurisdiction.

The stakeholder skills, experience and perspectives are useful. Hence, stakeholder participation in selecting adaptation options is necessary to not only select the adaptation options but also help to prioritise them and make them socially, economically and culturally appropriate. The understanding of the process of impact and the underlying factors causing the impacts, the nature and scope of climate risks, and scientific knowledge and factual knowledge of measures to be applied on ground are intrinsic towards choosing the adaptation tools.

Local Level Context

Though climate change is a global phenomenon, it manifests locally. The local topography, vegetation cover, water bodies, built environment etc. shape the micro climate. For example, within India most of the districts are showing warming trends, but some districts are also showing cooling trends. Also, the rainfall projections uniformly show an increase in amount of rainfall in the future, the current observed trends also indicate decrease in rainfall in some areas. This is concerning for areas that are only dependent on rainfall and rainfed rivers.

Increase in extreme precipitation events are uniformly projected across all districts in India by 2050s, but number of days and intensities are not uniform spatially. The local circumstances determine the impact due to climate change, which can range from low to severe. The adaptive capacity of the system and the population that it covers with its services makes the communities either more or less vulnerable. Thorough understanding of the local impacts and vulnerabilities is imperative for adaptation planning.

Existing adaptive capacity

Understanding of the current gaps of the communities and ecosystem to adapt to climate variability, assessment of gaps and suitable measures is a must to develop appropriate mitigation measures. This will enable increasing the adaptive capacity of the communities and ecosystem.

Ongoing Adaptation measures

Climate change is manifesting new risks and impacts. Many traditional practices followed in the past may still be applicable in the scenario of climate change. Traditional knowledge can contribute towards developing an understanding on good practices for adaptation, especially in mountain regions, characterised by huge variabilities.

Avoidance of Maladaptation

Maladaptation refers to actions, or inaction that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future (IPCC, 2014). The concept of maladaptation becomes even more critical in mountain context as there are upland-lowland linkages. For example, increased water harvesting structures upstream to cope with erratic rainfall may harm and reduce the opportunities for communities downstream to manage their own risks (IPCC, 2014).

Maladaptation arises in many forms but several broad causes can be identified. Actions that may benefit a particular group, or sector, at a particular time may prove to be maladaptive to those same groups or sectors in future climates or to other groups or sectors in existing climates. For example, some development policies and measures deliver short-term benefits or economic gains but lead to greater vulnerability in the medium- to long-term. Agricultural policies that promote the growth of high-yielding crop varieties through subsidies with the objective of boosting production and increasing revenues may achieve these objectives in the short term. However, it will also reduce agro-biodiversity; and increase exposure and vulnerability of mono-crops to climate change and finally undermine the adaptive capacity of farmers in the long term (IPCC, 2014).

It is thus important to understand the issues of the target area where adaptation interventions are being implemented and also develop a holistic understanding that ensures no scope for maladaptation.

4.4 Mainstreaming of adaptation into development plans

What is mainstreaming of adaptation in development and why it is important?

Climate change impacts multiple sectors and groups. Designing of specific adaptation projects and their implementation are not always possible due to several constraints. Studies in the field of climate change suggest that any climate change adaptation activity cannot be undertaken without addressing other development concerns vis-à-vis poverty reduction and sustainable development. These are inter-linked, and climate change adaptation measures must take into account the other existing vulnerabilities.

Climate change adaptation approach must be integrated into existing policies, programmes or decision making processes related to resource management, community development, livelihoods enhancement, sustainable development and risk management.

Mainstreaming climate change adaptation is defined as a process of considering climate risks and integrating adaptation approaches into development projects to address the risks. This involves identification of the existing development programmes in the domain of natural resource, built environment, and human systems. These can be state implemented programmes or part of national initiatives.

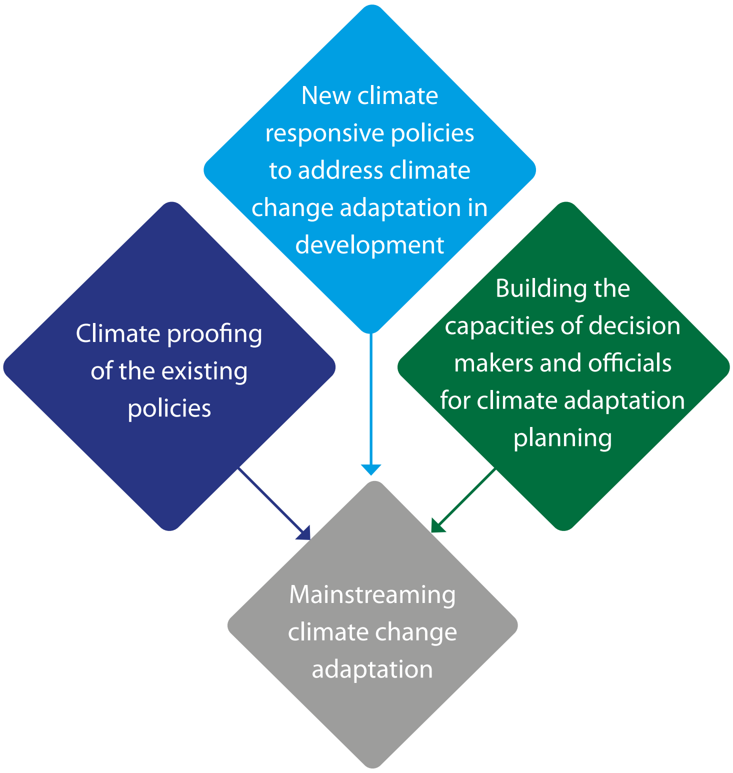
The next step is to identify additional steps required to integrate climate change concerns in the ongoing programmes. These interventions can be technological or policy measures, financial mechanisms to reduce the impacts and associated vulnerabilities or innovative institutional mechanisms. The assumption is that the development project has a goal related to poverty reduction, livelihood security, or improved well-being for target populations, and that the sustainability and impact of the initiative can be increased by integrating climate change into development planning. This is different from a "targeted" adaptation project, where the explicit goal is to build resilience to climate change. Mainstreaming climate change adaptation can, therefore, ensure that development programs and policies are not at odds with climate risks at present or in the future (CARE, 2009).

Mainstreaming climate change adaptation can achieve two main objectives:

- 'Climate-proofing' of project which implies reducing the risks posed by climate change to project activities, stakeholders, and results; and
- Ensuring that project or program activities maximize their contribution to adaptive capacity of target populations and do not inadvertently increase vulnerability to climate change - through interventions designed to build resilience while achieving development goals.

Mainstreaming of climate change adaptation may involve the following elements:

Figure 4.2: Mainstreaming Climate Change adaptation in planning process



(Source: SDC and DA, 2015)

Mainstreaming of climate change adaptation into development- Examples

Dhara Vikas: Changes in rainfall pattern including increased intensity of rainfall, reduction in temporal spread and decrease in winter rainfall resulted in the problem of drying-up of springs and water scarcity in many parts of Sikkim, particularly South and West Sikkim. About 80% of the rural households in the state depend on springs for meeting their water demand. Responding to the urgent need for ensuring water security, the Rural Management and Development Department (RMDD), Government of Sikkim, started the Dhara Vikas initiative in 2008 to revive the state's dying lakes, springs and streams. The initiative was launched under the centrally sponsored Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) scheme, with technical support from other government agencies and organisations like World Wildlife Fund (WWF), India; People's Science Institute, Dehradun; ACWADAM, Pune; and Arghyam, Bengaluru. The initiative had an innovative approach as it was linked with the MGNREGA national scheme for sustainable funding support. Activities such as lying of trenches and pipes were taken up under the MGNREGA programme. The initiative helped in the revival of about 50 springs and brought about 900 million litres of annual groundwater recharge in four years. It presents an excellent example of integrating solutions for climate change adaptation in the existing government schemes (GoS, 2011).

Based on the learnings from the Dhara Vikas Initiative, the Government of West Bengal has also started spring shed management activities in hill districts of the state. Panchayats & Rural Development Department of the Government of West Bengal and Rajarhat PRASARI have been working on these spring shed management activities under MGNREGA through a State Government initiative known as the Jharnadhara Programme. Under the initiative, 600 springs have been identified for rejuvenation through active representation from the community.

Mainstreaming climate change adaptation in development:

An example of a project contributing towards mainstreaming climate change adaptation is the Climate Change Adaptation Project implemented in 25 villages across Sangamner and Akole blocks of Ahmednagar district in Maharashtra. The project was implemented from 2010-15 by NABARD, Swiss Agency for Development and Cooperation (SDC) and Watershed Organisation Trust (WOTR) with the support of the Government of India and the Government of Maharashtra. With more than 20,000 beneficiaries, the project fostered climate resilient development in the region through a multi-sectoral and integrated approach. Through the project, communities and local institutions sustainably managed regenerated local ecosystems. The productivity of natural resources was enhanced which contributed towards improved quality of life of the poor. There was also an increased understanding of climate issues. Various knowledge products were developed to create a favourable policy and institutional context that promoted adaptive action. The experiences, learnings and impacts of this successful pilot contributed in strengthening of the competencies of NABARD in working towards climate change adaptation (NABARD, 2015).

How can climate change adaptation be integrated into development plans?

For integration of climate change adaptation into development planning, the first step is the identification of a state or local level development programme. The next step involves ascertaining additional steps required to address climate change risks. An example of such integration is as follows:

The Horticulture industry of Himachal Pradesh has emerged as an important sector of the state's economy with an annual turnover of more than Rs. 2000 crores accounting for about 6.2% of the Gross State Domestic Product (GSDP). Varied agro-climatic zones- subtropical to high altitude cold deserts of Himachal Pradesh enable the farmers of the state to undertake successful cultivation of a wide range of horticultural crops such as fruits, vegetables, flowers, medicinal and aromatic plants, roots and tuber crops. Currently, all the districts except for Lahaul and Spiti are the centers of production of horticulture produce.

About 20% of gross cropped area of Himachal Pradesh is covered with horticulture. The main emphasis of the State government is to enhance the production and productivity along with quality improvement of horticulture produce through the introduction of regular bearing, high-yielding and good quality hybrid varieties.

The focus is on adoption of improved production technologies such as

- High density planting,
- Integrated orchard management practices,
- Precision farming,
- Hi-tech greenhouse cultivation,
- Mechanization of horticulture,
- Rain water harvesting
- Integrated pest and disease management
- Modern post-harvest technologies (such as creation of cold chain from producing areas to the terminal markets, including primary and secondary processing techniques for value addition of the produce).

Programme	Horticulture Mission
Key aim	To maximize economic, ecological and social benefits from horticulture development
Sensitivity to climate change	• Sensitive to rising temperatures • Erratic rainfall projections • Soil erosion
Current steps taken	• Strengthen farm inputs – seeds, water resources, water use efficiency, organic amendments • Adoption of Integrated Pest Management • Developing disease forecasting units • Post-harvest management • Supporting food processing • Assistance provided by the state for horticulture for area expansion, water resource creation, planting material, on-farm management of produce, post-harvest processing etc. • Market linkages available • Supporting research
Goal for adaptation	• To make horticulture production climate resilient in various production centres of the state across all altitudes
Adaptation actions	• Ensure horticulture expansion in the state is aligned to agro climatic zones for which regulation is necessary • Farmers are aware about climate change and adopt measures to deal with the change for which research lessons need to be communicated to the farmers, • Ensure water use efficiency, spread use of organic amendment, managing emerging pests and diseases etc. • Rapidly expand irrigation potential by constructing surface water resources • Measures for avoiding soil erosion need to be in place
Stakeholders	Farmers, Horticulture department, Soil and Water Irrigation Department, Forest Department, Department of Science, Technology and Environment.

The horticulture produce in the state is booming with involvement of large scale, small scale and medium-scale farmers. Only 20% of the area under horticulture is irrigated as it requires less water than crops like rice and wheat. The suggestion for integration of climate change towards this initiative is thus as follows:

This module provides a generic view of how to devise adaptation strategies and actions in response to the identified vulnerability and risk. The next few modules (5-12) provide information on adaptation for various key sectors such as water, agriculture, horticulture, forest, biodiversity, health, disaster risk reduction, urban risk resilience, energy and tourism.

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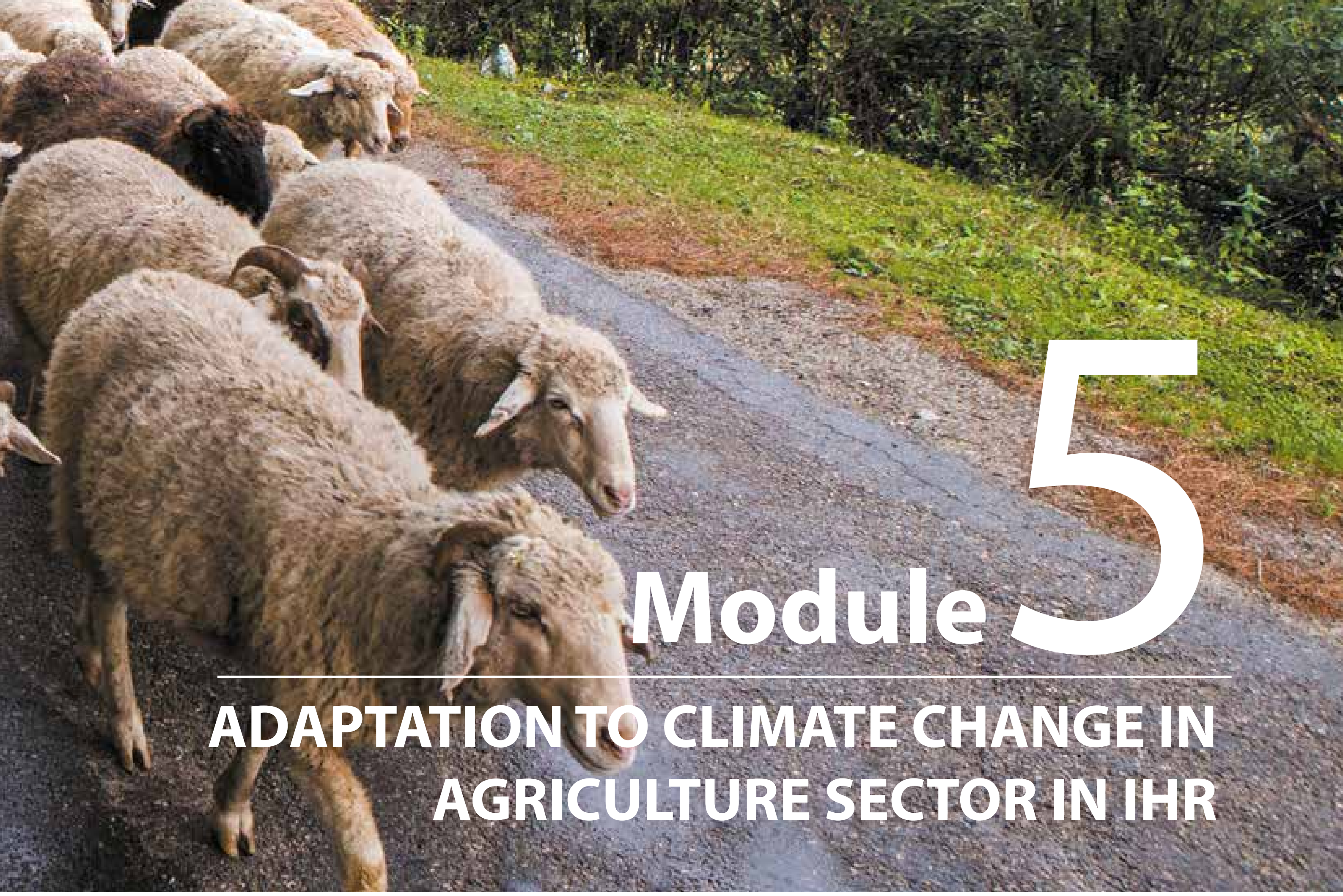

Module 5

ADAPTATION TO CLIMATE CHANGE IN AGRICULTURE SECTOR IN IHR

5.1 Introduction

While module 4 provides a conceptual understanding of adaptation and guidance on planning for adaptation, there is a need to have an in-depth understanding of issues, impacts and vulnerabilities to climate with respect to key sectors. This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change in agriculture sector.

The Himalayan agriculture is characterised by distinctly cold winter season, terraced farm plots on steep hill slopes and complex farming systems consisting of agriculture, horticulture, animal husbandry , poultry and fishery. Despite the presence of springs and streams, lack of irrigation water is a common constraint. Similarly, trees and shrubs are found ubiquitously, but fodder availability for livestock production is limited. The key socio-economic descriptors of these farms are their small size, often managed by women and contribute only a miniscule portion towards the total family income. The complex nature of the Himalayan agriculture makes prioritization of sustainability issues imperative for maintaining farm productivity, and ensuring food and economic security.

Current farming practices in the Himalayan region have been diversified with multiple cropping systems. Agriculture in the Himalayan region is mostly rain-fed, and therefore it is vulnerable to change in rainfall pattern and frequency. It is mostly confined to terraces carved out of hill slopes.

Agriculture in the Himalayas is more prominent in the southern aspects as compared to the northern aspects. The dependence of livelihoods of people in the Himalayas on agriculture is very huge. Many people are dependent on allied activities like post-harvest management, horticulture, and food processing. IHR is a major source of some of the food crops, fruits and medicinal crops. Major horticulture crops grown in Himalayas include apple, orange, pineapple and cardamom. About 20% of the total area under fruit cultivation of India is in the IHR that contributes about 12% of the total fruit production of the country (GoI, 2014). Rice is the staple food and occupies highest fraction of the total area under cereals, followed by maize in the North-Eastern Region. Wheat is cultivated in small areas in Arunachal Pradesh, Meghalaya, Sikkim and Tripura. Pineapple and citrus are important fruits in Eastern Himalayan Region (ICAR, 2016).

5.2 Impact and Vulnerabilities of Agriculture to Climate Change in IHR

What are the impacts of climate change on agriculture and horticulture?

Changing climatic conditions have stressed Himalayan agricultural and livelihood systems. The major contributing factors are extreme temperature (minimum and maximum), melting of glaciers and snow, altered precipitation patterns and hydrological disruptions, and more frequent and severe extreme weather events. Scientific observations and studies on climate change impacts on agriculture in the Himalayan region are limited and focus mainly on climate sensitivities.

According to the Agricultural Handbook of ICAR (2016), the number of rainfall events and number of rainy days has declined by 52% and 34%, respectively during the last ten years in Himalayan region. The incidence of high intensity rainfall and droughts has increased. These changes have disrupted the hydrological systems and reduced the availability of water resulting in frequent crop failures, decline in irrigation potential (25%), decreased agricultural productivity (26%), and loss of rural livelihoods (34%) in traditional rural sectors in the region.

Changes in rainfall patterns during monsoons and winter impact various stages of crop growth vis-à-vis flowering and fruiting. Due to the observed and projected climate change, there is high uncertainty in crop production in the near future, and adequate attention has to be given to sustain the Himalayan agriculture. An impact assessment study by BAIF (2012) of climatic components with rice-wheat cropping system showed that the higher mean, maximum and minimum temperatures during winter season have resulted in poor wheat grain yield, while lower mean, maximum and minimum temperatures resulted in poor rice grain yield in the Western Himalayan region.

Changes in climatic conditions are causing expansion of the normal range of pests leading to occurrence of more diseases in crops. Increase in temperature is causing shift in cultivation area at higher elevations. For instance, rise in minimum temperature has resulted in significant impact on temperate fruits of Arunachal Pradesh and is leading to shift in apple and kiwi cultivation to higher elevation due to non-fulfilment of chilling temperature requirement (Bhagawati et al., 2017).

According to INCCA report (2010), with increasing temperature, upward shifts in agriculture may result in loss of permanent pastures and grassland (Bugyals) to arable cultivation, which is already very low in IHR. This may cause lower availability of fodder and can adversely affect livestock sector and agriculture. With the reduction in rainfall, the rain-fed agriculture will suffer the most. Horticultural crops like apple are also showing decline in production and areal coverage, particularly due to decline in snowfall.

Many of the crop species in the Himalaya vary in their response to CO2. Crops such as wheat, rice, and soybeans respond readily to increased CO2 levels wherein corn, sorghum, sugar-cane, and millet plants follow different climatic conditions. Short-term studies indicated that photosynthesis is stimulated more in wheat species as compared to maize and corn species in response to CO2 enrichment (Rosenzweig et al. 2001).

Decline in Apple production in IHR

Apple farming is an important activity and profession of farmer communities in the some of the Himalayan states of India, particularly, Arunachal Pradesh, Himachal Pradesh, J&K, and Uttarakhand. Studies based on perceptions of farmers on the effects of climate change on apple farming along the latitudinal gradient indicate that at all elevation ranges there has been a decline in fruit size and quality. This is mainly attributed to increase in atmospheric temperature. Temperature surge and decrease in winter rainfall and snowfall has led to a decline in apple production in Kullu (Himachal Pradesh). An assessment of productivity of apple in Kullu from 2003 to 2015 indicates a decreasing trend except for the high production during the years from 2004-05 and 2012-13.

A shift of apple belt to higher elevations has also been observed. Farmers' perceptions obtained from a study in Kullu indicate a shift in the timings of flowering and fruiting of horticulture crops, reflecting reduction in crop periods (IHCAP, 2016).

Impacts on Livestock

Livestock farming in mountain areas has primarily been of a migratory nature. Depending on the availability of pasture, people move with their animal holdings in summer to highland pastures, coming down to the lower hills and valleys during the winter. To a large extent this practice continues, particularly for sheep and goats. It is a well-known fact that environmental factors affect livestock production. These occur through change in altitude, the mean annual temperature, seasonal and diurnal variations, rainfall, humidity and atmospheric pressure.

The climatic factors, coupled with poor grazing, a scarcity of green fodder, particularly in winter, traditional systems of stock management, genotypes that have not been improved, and fairly high morbidity and mortality rates appear to be the major constraints in livestock development. Temperature increase at higher altitudes has made the livestock sector more vulnerable in the region. The resulting impact of these phenomena on the livestock in the IHR is heat stress and diseases like foot and mouth in cattle. These impacts are projected to get aggravated as a result of rise in temperature (INCCA, 2010).

5.3 Challenges leading to vulnerabilities in agriculture sector in IHR

Agro-based socio-economic issues in IHR

Land holding in the Himalayas is largely small with holdings (< 1 ha in majority of cases) distributed over small parcels of land and the agricultural productivity is very low (6 - 13 q per ha). The small farms of the hill region with an average farm size of less than 2.0 ha do not produce enough to feed the family even if a satisfactory crop is harvested. Farming is often reduced to a supplementary source of income for the household; managed primarily by women as men migrate to seek employment elsewhere. Agricultural practices used are not modern; technological intervention is minimal and the output achieved is much less, in spite of the favourable soil and environmental conditions.

Market & Value Chain

Post-harvest handling of farm produce is another challenging issue in hill areas. The marketable surplus available from each farm is usually small. Aggregation and subsequent transportation of the produce from remote hilly locations to city markets is an ordeal in itself. Moreover, monetary returns are not promising either (BAIF, 2012). Many temperate fruits are suitable for processing, but facilities for value addition and market linkages are unavailable.

Various impediments vis-à-vis coordination with farmers, lack of infrastructure, transportation, lack of awareness about low cost value addition methods and inaccessibility to progressive markets make it difficult to establish linkages and create a sustainable value chain. Also, there is no existing mechanism for loss prevention and market intelligence - the key factors in value chain management. Rising temperatures make it even more difficult to store raw products and fruits for longer duration, thus affecting production.

5.4 Adaptation in agriculture sector

While there are ongoing schemes to improve the agricultural productivity in each of the states, they may not be sufficient to meet the requirements and ensure resilience of agriculture sector in a changing climate. Thus, planned adaptation based on scientific understanding is required to be adopted at state and local level.

The actual potential of farmland and other resources cannot be realised so long as farmers look at agriculture as a secondary or subsistence occupation. The primary focus of agricultural development in hilly areas has to be on introducing high-yielding crops and cropping practices that would result in increased farm output, irrespective of climate change scenario.

At the same time, opportunities for crop diversification must be leveraged. The adaptation plan should be flexible to allow changes in proposed interventions pertaining to specific local conditions. Research institutions in the region have developed promising technologies and their dissemination can help increase farm output substantially. Some adaptations for climate resilient livelihoods include diversified farming practices such as vegetables, medicinal plants, organic farming, horticulture and drought-resistant traditional crops (IRMA).

Adaptation measures implemented in the Himalayan region include greenhouses, sprinklers, micro irrigation, and high value crops. The main challenge of rural livelihoods is the lack of local human capital. This requires implementation of strategies such as:

- Developing an institutional mechanism to promote and popularise entrepreneurship initiatives among the youth;
- Developing policies and framework to enhance capacities of farmers to add value to various types of farm produce by processing, marketing, branding, and transportation;
- Supporting areas like rural finance, entrepreneurship development, crop diversification, and participative community farming that create livelihood opportunities.

The approach should be to identify suitable crops, combine them spatially or temporally to design production systems and introduce management practices that ensure ecological and economic sustainability. A key determining factor in crop selection is the altitude. Indicative lists are available for different altitudes which may be appropriately modified to suit expected climate change impacts. On the technology development front, there are continuing efforts to develop genotypes for environments beyond their native ranges. Advances in growing crops within shelters such as poly houses are also making it possible to grow crops in new locations or during off-seasons (BAIF, 2011).

Conservation and management of soil and water resources should be addressed with priority in the mid-hill areas which hold high potential for agricultural production. Whereas retaining runoff water in ponds is a potential adaptation option for terraces higher up the slope, those in lower slopes can be provided drip or gravity based irrigation. Emphasis should be on maximising efficiency of resource use in terms of farm productivity per unit of land or water consumed. In this regard, the immense scope for growing high value crops and aquaculture has to be explored.

The approach for **water management** on terraced land should be to harvest rainwater, check surface flow and minimise runoff losses. This can be achieved through the construction and maintenance of physical structures. Farm planning for such environments should incorporate resource efficient production technologies, water and nutrient budgeting, inclusion of perennial vegetation and soil-water conservation measures at whole watershed level.

Post-harvest activities in fruit production play an important role in enhancing shelf-life with assured quality, especially in a case of increased temperature due to climate change. In case of malta (Citrus spp.) in Uttarakhand, shrink wrapping technique is adopted to keep fruits fresh for about 5 months. Zero-energy cool chambers are other alternatives to store fruits for longer durations. Losses during transportation delays can also be minimised by using such post-harvest processing and value addition techniques (BAIF, 2012).

Agroforestry is another practice that has high potential in hill areas. It is an extension of cropping systems, but with the introduction of perennials together with annual crops. This can especially be beneficial in the context of climate change adaptation as agroforestry can play a crucial role in sustenance of many ecosystem services. Agricultural wasteland has to be brought under tree-based systems. Among the options for agroforestry are high density plantations of fruit trees.

Climate Smart Agriculture

Climate-Smart Agriculture (CSA) is an integrative approach to address the interlinked challenges of food security and climate change. Its three objectives are (FAO, 2010):

- Sustainably increase agricultural productivity, to support equitable increases in farm incomes, food security and development;

Case Study

Integrated Organic Farming System: An Approach to Improve Livelihood Security of Farmers in Sikkim

Shri Nim Tshering Lepcha, resident of east Sikkim had been practicing traditional agriculture in his 2 ha land, his only means of livelihood. Due to unavailability of assured irrigation, farmers in this region have been practicing rainfed farming system with an integrated approach that brings together agriculture, horticulture and animal husbandry. Sikkim is rich in biodiversity with abundant plant species because of which the soil is rich in organic matter content and makes the conversion easier. However, the fragile ecosystem in Sikkim hills demand sustainable farming practices without depletion of its natural resources.

During the years 2013-2016, Krishi Vigyan Kendra, Indian Council of Agricultural Research (ICAR), Sikkim Centre in collaboration with the organic farming technological backup of ICAR Research Complex for North-Eastern Himalayas (NEH) region, Sikkim Centre initiated some developmental interventions for the capacity building of farmers, on-field demonstrations, and one-on-one support.

Organic manures, bio-fertilizers and organic fungicides were introduced under National Innovations on Climate Resilient Agriculture (NICRA) with the purpose of introducing Sh. Lepcha to the Integrated Organic Farming System (IOFS) as a means to increase the farm income.

A slew of other measures were introduced as listed below:

- Agri-polythene sheets (250 GSM) for the purpose of making Jalkund, a micro-rain water harvesting structure,
- Low-cost plastic tunnels (transparent UV stabilized sheet of 45 GSM) for sequential vegetable cultivation,
- Garden pea (TSX-10) under zero-till in rice-fallow rotation,
- Cultivation of improved maize line RCM 1-1 and improved rice line RCM-10,
- Backyard poultry production with Vanaraja,
- Hybrid Napier cultivation as fodder grass on terrace risers.
- Scientific management practices of fisheries with Grass carp and Common carp,
- Milk cow crossbred Jersey and
- Large cardamom cultivars Sawney and Varlangey.

Other than these, farming of a variety of vegetables such as cabbage (variety - Rare Ball), cauliflower (variety – Suhasini), broccoli (variety – Everest) tomato (variety - Arka Samrat), coriander (variety - Super Midori), spinach (variety - All Green), radish (variety -Chinese White) were sequentially cultivated under low cost plastic tunnels.

Jalkund, a life-saving water reservoir designed with dimensions of 5 m x 4 m x 1.5 m (capacity of 30,000 l.), proved to be an indispensable tool in fulfilling the water requirement of crops through gravitational sprinkler irrigation system. This encouraged Sh. Lepcha to opt for diversification of the integrated organic farming system, with institutional intervention and his competence. The result was an astounding three-fold increase in his income with considerably low investment on labour cost.

His success has inspired other farmers in the village to emulate his footsteps and make a shift from traditional farming to an integrated approach that's economically viable and profitable. Interventions such as these have the potential to create a positive impact on the optimum utilization of scarce natural resources in the fragile mountain ecosystem. At the same time, it has paved way for better lives and providing sustainable livelihood options to the farmers in the state.

Source: NICRA, ICAR, 2016

- Adapt and build resilience of agricultural and food security systems to climate change at multiple levels; and
- Reduce GHG emissions from agriculture, including crops, livestock and fisheries.

CSA can be useful in mountain context to increase the resilience of farming sector to climate change. The approach can help people managing agricultural systems respond to climate change in an effective manner.

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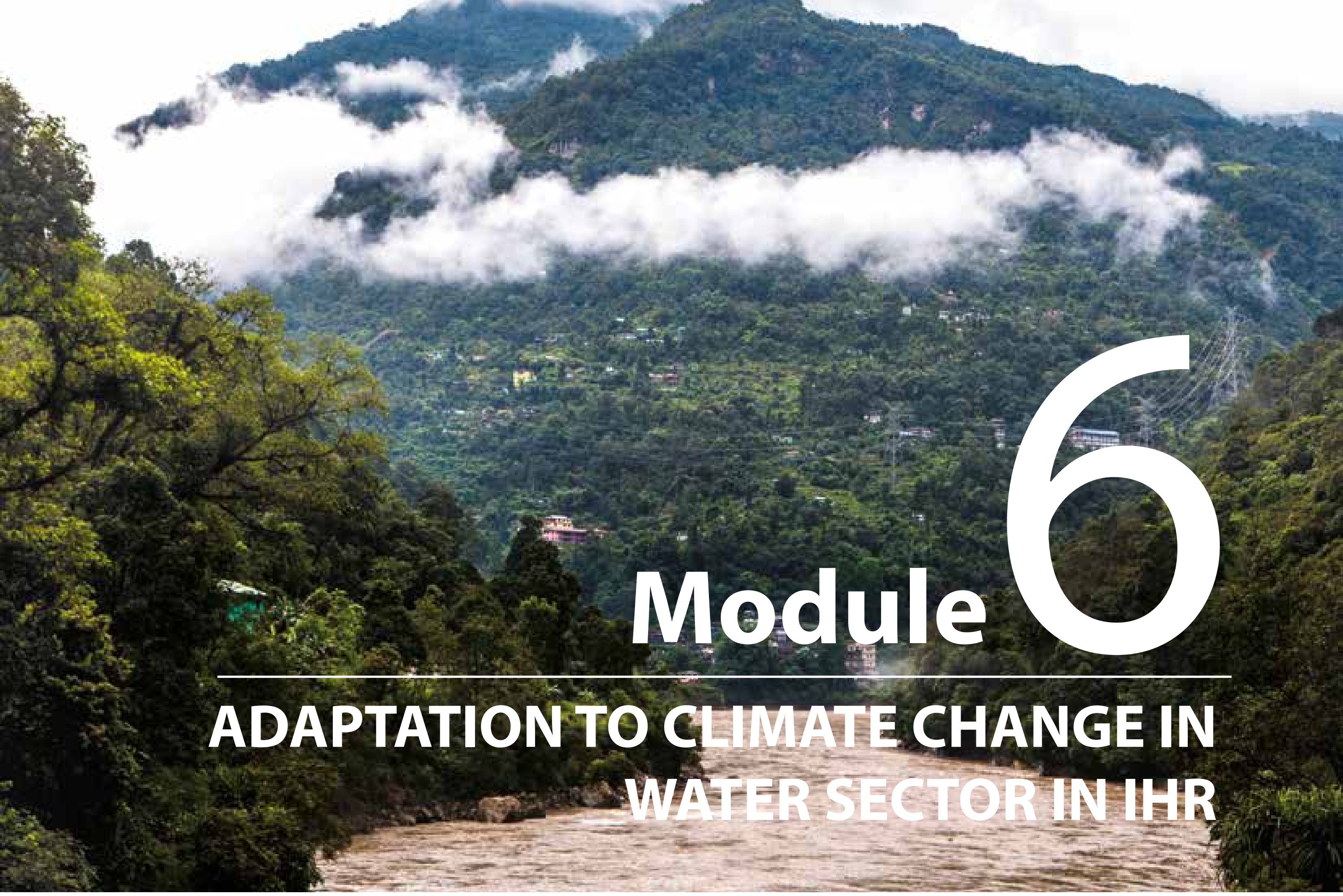

Module 6

ADAPTATION TO CLIMATE CHANGE IN WATER SECTOR IN IHR

6.1 Introduction

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change in water sector.

The Himalayas are known as the water towers of Asia. The water in the region is stored in the glaciated mountains in the form of snow and ice. The region contains over 50% of permanent snow and ice fields outside the polar regions covering an area of 43,000 km2. The melting of this snow and ice contributes to the flow of water in the rivers downstream. Himalayan glaciers are estimated to provide around 8.6 x 106 m3 of water annually, feeding Asia's seven major rivers including Indus, Ganga and Brahmaputra (GoI, 2010). The vast quantity of water stored within and emerging out of upstream mountain catchments in the Himalayas is an important source for drinking, sanitation, irrigation, and hydropower generation to roughly 1.5 billion people downstream.

Apart from the water stored as snow and ice, the water resources in the Himalayas also include freshwater lakes and springs. Himalayan lakes are situated at an altitudes varying from 600 m to 5600 m and are exposed to climatic conditions that vary from cold deserts of Ladakh to wet humid of Manipur. A total of 4699 lakes have been mapped in IHR which lie at an elevation of above 3000m. This includes 1996 small lakes (<2.25 ha area) (ISRO, 2012). Springs are one of the most crucial sources of water, especially in the mid-hills of Himalayan region. As rivers or streams flow much below the settlements, it becomes difficult for the communities to fetch water from these sources to meet their daily water demand.

Originating from underground aquifers, springs are the groundwater discharge points, which serve as natural and accessible source of fresh water for ecosystem and human communities in the mountains. About 60-80% of the population in Indian Himalayan states depends on springs for their daily water requirement. Water from the springs is vital for supporting domestic and irrigation water demand in the mountains, particularly in dry season. These springs are recharged by water accumulated in underground aquifers during monsoon. Traditionally, conservation and protection of springs has been an integral part of the culture of indigenous communities in the Himalayas.

6.2 Impact and Vulnerabilities of Water Resources to Climate Change

The Himalayan region is heavily burdened with increased dependency on its water resources for irrigation, food, hydropower, and industries. The Himalayas have more snow and ice than anywhere else outside the poles, which makes this region with all its associated large river systems especially vulnerable to climate change and related impacts.

Glacier retreat is being observed in IHR although there is a great degree of uncertainty about the extent to which the overall glacier melting is occurring. A study was conducted by MoEF and Indian Space Research Organisation (ISRO) to monitor more than 2000 glaciers distributed throughout the Himalayas, for their advance/retreat over a period of 15 years based on satellite data analysis and field expeditions. This study indicates that 76% of glaciers have shown a retreat in area, 7% have advanced, while 17% are static. This study does not conclusively indicate any uniform response of the Himalayan glaciers to climate change (MoEF, 2012). More robust and in-depth detailed studies are required to study the impacts of climate change on glaciers.

Glacial melt associated with climate change, has led to the formation of glacial lakes behind terminal moraines (parallel ridges of debris deposited along the sides of a glacier). Many of these high-altitude lakes are potentially dangerous. The moraine dams are comparatively weak and can breach suddenly, leading to the sudden discharge of huge volumes of water and debris. The resulting GLOFs can cause catastrophic flooding downstream, with serious damage to life, property, forests, farms, and infrastructure. Identification of potential lake sites and predicting the expansion of existing lakes are crucial for timely monitoring and mitigation of these hazards. Many inventories on glacial lakes have been carried out in the IHR; one of these inventories suggests the presence of 251 glacial lakes (>0.01 sq. km) of which 105 present GLOF risk, 12 are critical (Maanya et al., 2016).

Upstream changes in glaciers, snow and ice cover are changing the run-off into the rivers. Due to the reduction in contribution from glaciers or due to reduction in monsoonal precipitation reduction in river discharge is very likely under the future warming scenarios (MoEF, 2012). Such a situation would result in substantial decline in the rates of groundwater recharge in some areas. Combined with variations in summer monsoon precipitation and surface water flows, depleted groundwater would lead to water stress in many parts of the Himalayas and downstream.

Water scarcity is also one of the major issues being faced in many parts of the Himalayas. Although the major rivers such as the Ganges originating from the snow and glacier-covered high mountains have abundant seasonal and annual water supply, the mountain communities still face water scarcity. This is on account of undulating terrain conditions that pose accessibility challenges.

A combination of natural and anthropogenic factors is adversely affecting the recharge of aquifers in mountain regions resulting in drying up of springs. These are:

- Changing rainfall pattern, including reduction in rainfall periods, increased intensity of rainfall or prolonged dry season;
- Rapid land use changes due to development activities such as road construction and tunnelling, hindering rainwater percolation into aquifers; and
- Deforestation, forest fires and landslides

Drying up of springs is posing threat to the water availability and increasing the vulnerability of communities to climate change in the mid-hills of the Himalayan region. About half of more than three million perennial springs in IHR States have either already dried up or become seasonal, resulting in acute water shortages across thousands of Himalayan villages (GoI, 2018). Reduced water availability is increasing drudgery as water needs to be fetched from far off places and is giving rise to water-related conflicts. Drying up of springs not only impacts the natural resources in the ecosystem but also results in socio-economic implications for the communities living in the region.

Additionally, mountain communities in IHR face loss of property and lives due to water-induced natural hazards which are getting aggravated due to climate change. Due to its physical setting, the Himalayan region is prone to various water-induced hazards (landslides, floods, glacial lake outburst floods, and droughts) due to the negative impacts of climate change in the Himalayas. Annually, during the monsoon season, floods wreak havoc on the mountains and the plains downstream. These floods are often trans-boundary. The social and economic setting of the region makes its people more vulnerable to natural hazards. Lack of supportive policy and governance mechanisms at the local, national and regional levels, and the lack of structural and non-structural measures of flood mitigation lead to increased vulnerability.

Fragmented and uncoordinated water management in IHR has increased its vulnerability to climate change. Rising water consumption and rapidly growing population is causing increasing pressure on the available water resources in the fragile Himalayan region. Climate change has exacerbated the situation by creating uncertainty about the future water availability and water security. This calls for immediate action for ensuring water availability in the scenario of changing climate.

6.3 Adaptation to climate change in Water sector

Adaptation in water sector in IHR requires options that increase the resilience of people and ecosystems by improving water management. Some of the broad adaptation options for water sector include:

- Adaptation by increasing water supply and ecosystem services:
  - Expansion of rainwater harvesting to improve rain-fed cultivation and aquifer recharge;
  - Increased storage capacity by building reservoirs;
- Adaptation by decreasing water demand and increasing water-use efficiency:
  - Improvement of water-use efficiency by water recycling;
  - Improved management of irrigated agriculture (e.g. changing the cropping calendar, crop mix, irrigation method and repair and maintenance of irrigation infrastructure);
  - Expanded use of economic incentives to encourage water conservation; and
  - Improvement of urban water and sanitation infrastructure;
- Adaptation by improving flood protection:
  - Construction of flood protection infrastructure;
  - Restoration and maintenance of wetlands and lakes; and
  - Improved flood forecasting and establishing early warning system

Approaches for adaptation in water sector

Integrated water resource management (IWRM): IWRM is identified as an effective approach to assess vulnerabilities and explore adaptation options in the context of a changing climate and an evolving regulatory environment. IWRM is a planning and management framework that considers a range of supply-side and demand-side water resources processes and actions and incorporates stakeholder participation in decision-making. The IWRM framework encompasses analysis of the costs and benefits of demand-side and supply-side management options. It also promotes-

- an open and participatory decision-making process;
- development of water resource alternatives that incorporate consideration of community values and environmental issues which may be impacted by the ultimate decision; and
- recognition of the multiple institutions concerned with water resources and the competing policy goals among them (UNFCCC).

Adaptive Water Management (AWM): Adaptive management is a systematic process for improving management policies and practices by learning from the outcomes of implemented management strategies. Water management regimes are still shaped by the tradition of a command and control approach focusing on technical solutions. The implementation of innovative water management approaches requires major structural changes in existing water management regimes. Such structural changes are slow since lock-in effects and barriers impede change. This implies the need for an integrated management approach which adopts a systemic perspective rather than dealing with individual problems in isolation. Therefore, adaptive policies are designed and guided by hypotheses regarding the range of possible responses of the system including both environmental processes and human behaviour to management interventions.

It is important to note that while identifying adaptation options for water sector, it is crucial to consider the socio-economic factors that drive the supply and demand of water in a region.

Examples of adaptation interventions in IHR

Jalkunds: *Jalkund* is a suitable technology for providing climate resilience and improving livelihood of small and marginal farmers in Himalayan ecosystem.

The average annual rainfall of the North-eastern region of India is about 2000 mm. Almost 70% rainfall is received during rainy season. Hill farmers suffer from extreme water scarcity during November to March. Rain water harvesting and efficient utilization holds promise for sustainable livelihood in hills. Jalkund, a micro rain water harvesting structure is found suitable for the farmers residing in the hill top for small scale agricultural activities. The stored water in Jalkund can be utilized for multiple purpose e.g. irrigating crops, rearing livestock (pigs, poultry etc.) and for domestic use.

Spring-shed Management: There is increasing evidence that springs are drying up or their discharge is reducing throughout the Himalayan region. In order to bring the issue of spring shed management to the centre stage in the context of sustainable development in IHR, NITI Aayog constituted a working group on "Inventory and Revival of Springs of Himalaya for Water Security" in 2017. The objective is to mainstream spring shed management in the sustainable development agenda in IHR. The DST was designated as the lead institution to finalise a report on the theme. The report on 'Inventory and Revival of Springs in the Himalayas for Water Security Contributing to Sustainable Development in Indian Himalayan Region' was developed by the working group of NITI Aayog. The report highlights the importance of spring-shed management as key for water security and adaptation to climate change in the Himalayan region. The report mentioned that research studies and initiatives to address spring management in India have gained momentum in recent years due to the seriousness of the emerging crises around springs. The initiatives are largely community-centric focussing at distribution rather than regeneration. It also helped mitigating the rural water crises to some extent. The report came out with several general and specific recommendations, the most prominent one being the launch of a National Programme on Regeneration of Springs in the Himalayan Region, charting out several short, medium and long-term actions.

The concept of spring shed management is well-ingrained in the form of pilots of varying scales across the Himalayan states. The first systematic initiative was undertaken through the *Dhara Vikas* Programme by the Rural Management and Development Department (RM&DD), Government of Sikkim. In other states such as Himachal Pradesh, Nagaland and Uttarakhand, low-scale and focused pilots were implemented as part of Forest Panchayats constituted under the Forest Act.

The concept of spring shed management is best summarised through a step-wise methodology. First developed as a planning tool under *Dhara Vikas*, an eight-step methodology is increasingly being used and customised through a variety of processes.

Read the NITI Aayog report: Report of Working Group I: Inventory and Revival of Springs in the Himalayas for Water Security

(Available at https://niti.gov.in/writereaddata/files/document_publication/doc1.pdf)

Case Study

Dhara Vikas: Creating water security through spring-shed development in Sikkim

Background:

Dhara Vikas (spring shed development) is a government-sponsored program, implemented in partnership with NGOs and other institutions. The objective is to increase the discharge of springs in rural Sikkim. It is modelled with the idea of protecting spring's catchment area and provides recharge of its aquifer. An example of a decentralized management, its implementation requires community participation. The project was conceptualized in 2008, although 2009 was spent in capacity building and the first project was implemented in 2010.

A village level water management, wherein communities work to improve the water supply through spring shed development.

The technology behind the *Dhara Vikas* program is based on slowing the movement of water down slope. With the change in rainfall patterns, water absorption capacity of the soil is reduced during the monsoon season and the groundwater is not adequately recharged. To address this issue and increase the discharge of springs in winter, water needs to be slowed down enough to percolate down and recharge the spring aquifers.

The installation of trenches in barren lands and drains in cultivated land, gives rainwater a place to rest and percolate down into the ground water. The drains in the cultivated land provide additional water to the crops, as well as catching the soil and nutrients that have run off from other terraced fields.

Implementation of the *Dhara Vikas* initiative has primarily focused on executing a scientifically robust strategy and generating awareness. The initiative's strategic focus has been on controlling runoff water and increasing its permeation to enhance groundwater recharge.

The key activities include:
- Developing springs-sheds,
- Enhancing hydrological contribution of hill-top forests,
- Reviving lakes to function as recharge structures,
- Expanding minor irrigation networks for paddy cultivation,
- Terracing sloping lands,
- Enhancing water storage infrastructure,
- Developing para-professionals in geohydrology, and
- Carrying out research and documentation.

Dhara Vikas has not required any separate grievance redressal mechanisms. To facilitate the implementation required committed involvement of villagers.

Decisions related to digging of trenches and recharge points were based on principles of geohydrology, which mitigated the potential problems associated with arbitrary decisions. All work-related resolutions have been taken up in the Panchayats and sorted through village-level discussions.

Awareness Generation:

Awareness generation has been an important part of *Dhara Vikas*. As the project was initiated in response to the problem of water scarcity, the villages with the most acute shortage were selected for implementation during the initial phase in 2009. Public awareness was high in the areas where the pilot was conducted. Micro level planning invariably involved discussion with the local population. As the initiative was being implemented through MGNREGA, the locals were also kept updated on aspects of implementation.

Dhara Vikas has created a significant impact by recharging lakes and reviving several springs in Sikkim. As many as 50 springs have been revived in Kaluk, Rhenock, Ravangla, Sumbuk, Jorethang and Namthang. Further, five lakes, namely Dolling, Deythang, Nagi, Karthok and Datum, were revived by the initiative.

It has also led to reforestation of seven hill-top forests at Simkharka, Sadam, Tendong, Maenam, Gerethang, Chakung and Sudunglakha.

Overall, with an investment of Rs. 2.5 crore over the last four years, Dhara Vikas has brought about 900 million litres of annual groundwater recharge.

Bamboo irrigation, Meghalaya (Source: CSE)

In Meghalaya (one of the seven north-eastern states in India), tribal farmers of Khasi and Jaintia hills use the 200-year-old, ingenious system of tapping of stream and spring water by using bamboo pipes to irrigate plantations. About 18-20 litres of water entering the bamboo pipe system per minute gets transported over several hundred metres and finally gets reduced to 20-80 drops per minute at the site of the plant.

It is an innovative irrigation method that makes use of streams and spring water sources on hilltops and directs them to fields of betel leaf and dark pepper crops planted in Arecanut plantations. Bamboo channels are utilized to tap perennial water from up slopes, which is cleverly diverted to the lower parts using gravity; a system that wastes very little water and works to this day. Bamboo Drip irrigation framework is widely prevalent in Jaintia hills and extends to the Muktapur area which have steep slopes with a rough landscape, rendering ground channels unfavourable.

Usually, water sources are distant from plantation sites and so the main bamboo channel runs several meters, sometimes even couple of kilometres. Water is thus obtained and managed through a brilliant bamboo system of secondary and tertiary channels to reach every corner of the plantation, up to the base of the hill. Channel sections are made of bamboos of different diameters, to control the water flow in such a way that the water reaches the site in the lower reaches, without any spillage. The channels are supported by forked branches. Bamboo has a natural hollow inside, which is why it becomes possible to use it as a conduit for water.

Depending on the slope and the direction in which the water needs to travel to reach the field, different sizes of bamboo are used. One must see it to understand the intricacy and the efficiency of the system. It is estimated that even up to 20 litres of water flows into the channel every minute, from the main water source, covering a few hundred meters, becomes a trickle for better absorption- a great example of drip irrigation system. The last channel segment allows water to be dropped close to the base of the plant.

At a time when global warming, depletion of resources and deforestation threatens the balance of nature and its diverse ecosystems, bamboo is a viable solution and resource that is both remarkably useful and eco-friendly. A sustainable renewable resource, bamboo is one plant that stands above the rest in terms of usefulness and speed of growth. Bamboo forests grow naturally and stretch across large expanses throughout Meghalaya.

It is a miracle plant used by locals as a sturdy building material for drip irrigation and has the strength of steel, lighter in weight and very cost effective. It grows rapidly; even after the harvesting season, self-propagates and a new bamboo forest can quickly spring up preventing deforestation and soil erosion. It is, thus, easily available for farmers.

Unlike other plants, bamboo is naturally antibacterial and does not need harmful pesticides and fertilizers to grow. It also produces about 35% oxygen which keeps the air clean. Bamboos are easily repairable and are bio-degradable substance. It can naturally turn into humus which can keep the soil fertile. Traditional farmers are aware of the green and sustainable use of bamboo. It is a renewable resource that regrows almost as quickly as it can be consumed and is thus a reliable resource for farmers for centuries to come.

Source: NITI Aayog, 2015

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Module 7

ADAPTATION TO CLIMATE CHANGE IN FORESTRY SECTOR

7.1 Introduction

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change in forestry sector.

Forests are not only the source of goods and services but also provide a sink for atmospheric CO2, which is on the rise due to various anthropogenic activities. In the IHR, forest is the major land use/land cover category (as recorded forest area). According to the State of Forest Report (FSI, 2011), about 41% of geographical area in the IHR (against the national forest cover of 21.0%) is covered by forests, out of which 16.9% area is under very dense forest cover, 45.4% under moderate forest cover and the remaining 37.7% under open forest category. The Himalayan vegetation is patchy in distribution because of diverse topography, frequent landslides, variation in rocks and frequent fires. The ecology of the Himalayan region transforms as elevation increases.

Tropical and subtropical broadleaf forests are found at the base of mountains. Because of variation in topography, weather, soils, and rainfall, these forests range from dry tropical evergreen to northern wet tropical forests. Most of the forest area is managed by State Forest Departments in Western Himalayan states and Sikkim while in the North Eastern Himalayan States large areas are community owned. Uttarakhand is the only state where all types of ownerships exist, while Nagaland has mainly private forests. Although the rest of the country seems to be witnessing a reduction in the dense forest cover, situation in the IHR appeared to have improved as per the Forest Survey of India (FSI) assessments of 2001 and 2011, and is generally believed to be due to many local governance institutions (e.g., Van Panchayats) (Negi and Dhyani, 2012).

Himalayan forests help maintain soil fertility and essential atmospheric moisture in the adjacent plains through rivers originating from the region. The Himalayan region is one of the most recognized biodiversity hotspots in the world, with diverse forests providing ecosystem services to both upland and lowland communities. Forests of the IHR provide a myriad of Ecosystem Services (ES) to people not only to the inhabitants of the region but also to the people residing in the lowlands connected with the river systems in terms of regulated flow of water, soil and nutrients, which support many land based and developmental activities.

In most of the Himalayan States, the percentage of area under forest of the total geographical area is much higher than the national average. Area under forests in the 12 Himalayan states as per the assessment by FSI, 2017 is given below:

The people of IHR, like elsewhere in other mountain ecosystems, are heavily dependent for their livelihood on their surrounding natural resources and production from primary sectors such as agriculture, forestry and animal husbandry, etc. The dependency of the continually growing population on finite resources, lack of viable technologies to mitigate the mountain specificities and enhance production to meet the ever increasing demands are depleting the natural resources with subsequent increase in marginality of farmers, poverty and out migration.

7.2 Impact of Climate change on forests in IHR

Forests of the IHR are facing a number of anthropogenic and natural threats. Illicit felling of trees, extraction of medicinal plants and other minor forest product, poaching of wildlife, age-old practice of Jhum cultivation in the north-east region, destruction of forests due to mega-projects and natural events such as floods and landslides are some of the major challenges being faced by the forests of IHR. Additionally, traditional practice of shifting cultivation is one of the major factors affecting the forest cover in Himalayan states. Recent figures show that there has been reduction in forest cover in some of the NEH states such as Arunachal Pradesh, Mizoram, Meghalaya, Nagaland and Tripura due to shifting cultivation as the duration of the cycles have been shortened (FSI, 2017). Fire is another factor that causes irreparable damage to the forest ecosystem and habitat loss for many of the indigenous varieties of plants and animals.

Table 7.1: Area under Forests in Himalayan States

S. No.	State	Area Under Forests (Km^2)				
		Very Dense	Moderately Dense	Open Forest	Total Forest	%age of forest cover of the total geographical area
1.	Arunachal Pradesh	20721	30955	15288	66964	79.96
2.	Assam	2797	10192	15116	28105	35.83
3.	Himachal Pradesh	3110	6705	5285	15100	27.12
4.	Jammu & Kashmir[6]	4075	8579	10587	23241	10.46
5.	Manipur	908	6510	9928	17346	77.69
6.	Meghalaya	453	9386	7307	17146	76.45
7.	Mizoram	131	5861	12194	18186	86.27
8.	Nagaland	1279	4587	6623	12489	75.33
9.	Sikkim	1081	1575	688	3344	47.13
10.	Tripura	656	5246	1824	7726	73.68
11.	Uttarakhand	4969	12884	6442	24295	45.43
12.	West Bengal	2994	4147	9706	16847	18.98

Source: FSI, 2017

[6] CFSI, 2017

How is climate change affecting forest resources in IHR?

Climate change is causing an additional stress to the Himalayan ecosystems that are already struggling due to other anthropogenic pressures such as over-exploitation, land degradation and habitat destruction. The impacts of climate change on forests in IHR and the ecosystem services they provide are also affecting communities in both upland and lowland areas. Climate change is causing noticeable effects on the life cycles and distributions of many plant species such as medicinal plants. For example, evidence has shown that an altitudinal shift is occurring in their habitation range. Shift in the timing of flowering/fruiting native species such as Rhododendrons has been observed (Negi and Dhyani, 2012). Changing rainfall pattern is also contributing to the increasing incidents of forest fires in Himalayan States such as Uttarakhand.

Most of the mountainous forests (sub-alpine and alpine forest, the Himalayan dry temperate forest, and the Himalayan moist temperate forests) are susceptible to the adverse effects of climate change. Climate change is likely to impact the sub-alpine and alpine plant species that inhabit mountain ranges with restricted habitat availability, above the tree line, in the form of severe fragmentation, habitat loss, or even local extinction if they fail in moving to higher elevations (Singh et al., 2011). The assessment of climate impacts shows that in Himalayan region, about 56% (55 out of 98) of the forested grids are likely to undergo change (INCCA, 2010). Vulnerability assessment showed that over half of the forests are likely to be adversely impacted in the Himalayan region by 2030s.

The assessment shows that the adverse impacts are more severe in the upper Himalayan stretches. In contrast, north-eastern forests are estimated to be least vulnerable. Although the impacts of climate change are being observed on many species, knowledge gaps related to uncertainties of climate change impacts likely in future and adaptive capacity of forests in the Himalayas towards these impacts still exists. Climate change is likely to affect the composition of the forests as each of the species will respond to the impacts in a different manner. There is a need to generate better understanding on climate change impacts on individual species and on the ecosystem for accordingly identifying adaptation strategies in IHR. There is an imminent need at the regional level, to have reliable information to predict the most vulnerable forest types as well as regions. For critically endangered or vulnerable flora and fauna species, and the societies or communities that depend on them, it is of paramount importance to better understand how these sensitive ecosystems will respond to further climate change.

7.3 Adaptation in Forest Sector

Forests are a rich repository of genetic diversity. There is a need, with community participation, to make special plans, and provisions for initiating activities that will facilitate the maintenance, protection, conservation and wise use of biodiversity in the entire IHR in the scenario of current and projected climate change. Studies to adequately understand risks of climate change on forest species and to develop better understanding on forest habitat loss, cost of restoration and reintroduction, vis-a-vis benefits of conservation need to be given higher attention. Studies on response of forest biodiversity, especially the unique and high value taxes, towards changing climate would help in appropriately designing appropriate adaptation measures. In view of the significance of the region, Government of India has established over 173 Protected Areas (PAs) in the Indian Himalayan states, which cover approximately 47, 500 sq. km area. The coverage under PA network in IHR has steadily expanded over the years (MoEF&CC, 2009). While there has been success in establishing PAs and more experimental, multiple land use conservation areas in the region, much remains to be done to safeguard the biological wealth of the IHR currently present in areas outside formally protected reserves.

How can community forest management contribute towards adaptation to climate change in IHR?

Community forestry is a branch of forestry which deals with the management of forests in such a way that it not only helps conserve forests but also contributes in enhancing part of household income from timber and Non-Timber Forest Products (NTFPs). In addition, community forestry helps augmenting ecosystem services for local as well as larger communities. The word community forestry has different connotations in different parts of the world including IHR depending upon a variety of factors. In IHR three broad types of community forestry regimes are present including state sponsored Joint Forest Management (JFM) programme being implemented in all the IHR states, Van Panchayat in Uttarakhand, and a traditional system mainly in north-eastern Himalaya.

Joint Forest Management involves management of forest with the involvement of forest department, local level institution and to some extent NGOs. By involving in the management of forest, JFM helps in making the local communities aware of the fragility of the forest resources, who in turn contribute towards the regeneration and protection of the degraded forestlands. Forests are a means of livelihood for the communities dependent on it directly. It empowers locals in the decision making in forest management.

The **Van Panchayats (VPs)** of Uttarakhand are one of the oldest examples of participatory forestry institutions in India. Presently 12,089 are managing about 16% of the total forest area of the state. Despite of success in management of VPs, the institution has been facing several challenges such as lack of adequate financial resources and appropriate incentives, signalling the need of policy, institutional and financial interventions (Negi and Dhyani, 2012).

There are diverse **traditional community forestry systems** and institutions existing in the north-eastern Himalayan states. Local communities conserve and manage majority of forests through traditional institutions in the region. Large areas of forests are protected for practicing shifting agriculture (Jhum). Smaller areas of forests are also protected as scared groves such as those of Khasis and Jaintias of Meghalaya to meet socio-cultural needs and safety forests of the Mizos in Mizoram for village safety and water supply. In Arunachal Pradesh, there are Anchal reserved forests protected for earning economic benefits for community through the sale of forest products (Negi and Dhyani, 2012).

These community forest management practices have direct relevance towards adaptation to climate change. These practices facilitate in conservation and increase of the forest cover and the natural resources in the region as well as strengthen the socio-economic status of the communities. This eventually contributes towards increased adaptive capacity of local communities to the threats of climate change.

What is REDD +? How can it help in climate change adaptation?

Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries and role of conservation (collectively known as REDD+) under UNFCCC is a process to pass financial incentives to the communities for halting deforestation and encourage forest conservation thereby enhancing forest carbon stocks. Forest dwelling communities in India have been successful in transforming the deteriorating state of their natural forests to sustainable management, thereby avoiding deforestation and the subsequent release of CO2 emissions into the atmosphere (UNFCCC, 2018).

The implementation of REDD+ activities can maintain and enhance ecosystem services important for adaptation of communities. REDD+ actions can also influence important aspects of adaptive capacity. For example, training on sustainable management of forests can build human capital for adapting forest use to climate change. Also, the earnings from REDD+ carbon certificates would contribute to the enhanced adaptive capacity of the communities.

What is Ecosystem based adaptation?

Ecosystem-based Adaptation (EbA) is defined as "the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change" (CBD, 2009). EbA is based on the rationale that healthy ecosystems can help to improve the resilience of people to both climatic and non-climatic threats by assuring essential ecosystem services.

EbA involves a wide range of ecosystem management, conservation, and restoration activities. It considers the needs and the multiple social, economic and cultural co-benefits for local communities. This approach helps to improve ecosystem functioning and to secure the provisioning of ecosystem services. EbA is considered an efficient, sustainable, and low-cost approach to improve resilience of societies and reduce their vulnerability against the negative effects of climate change. For example, constructing check dams to control floods in mountain regions is highly cost-intensive. Alternatively, if degraded forests and waste lands are restored, it would not only provide benefits in terms of flood control, but would also involve lesser financial resources. Additionally, it would provide co-benefits to the ecosystem and the communities such as increased biodiversity. This is an example of a no-regret and a win-win option providing benefits even in the case of uncertainties related to climate change.

Appropriately designed ecosystem management initiatives can also contribute to climate change mitigation by reducing emissions from ecosystem loss and degradation, and enhancing carbon storage. The characteristic feature of EbA is the inclusion of communities and the use of participatory approaches which results in a win-win situation for both communities and ecosystems. EbA integrates available scientific knowledge, promotes the gathering of new knowledge, and combines it with local and traditional knowledge (IHCAP, 2017).

Case Study

Van Panchayat of Kashiyalekh in Kumaun Himalaya

Village communities in Uttarakhand hills in India have been involved in community forestry management known as Van Panchayat (VPs). It is a unique example of community based forest management and environmental governance at local level. People in Uttarakhand depend highly on these VPs for fodder, fuelwood, timber, NTFPs etc.

A case study was undertaken in Kashiyalekh VP (Mukteshwar, Kumaun Himalaya), covering local areas of Sunkiya, Buribanna, Chakhuta and Gazaar villages. Some of these VPs are quite old and spread over a large area. Van Panchayat comprises of a total of 9 members (4 female and 5 males including 1 Sarpanch). Wood cutting, grazing of cattle, mining are strictly restricted in van panchayat. It permits to collect only dry fallen wood and otherwise fine is levied amounting to Rs. 50/- and Rs. 500/- in case of cutting green leaves and wood, respectively. To safeguard and protect forests, a security guard is appointed whose salary is contributed by each household periodically. For collection of dry leaves and woods in the van panchayat area, there are standard criteria: (i) it will be open during the months of May-June; (ii) only one member of each family is allowed to enter and pay Rs. 10 per household for collecting one sac (approx. 35 kg) and one head load (approx. 40 kg) of fodder and fuelwood, respectively. The money collected from this standard practice is deposited into the Van Panchayat account as "royalty" and utilized by the village people through consensus of VP.

Earlier the condition of forests was deteriorating by day in these villages, but with the intervention of Van Panchayat's and strict adherence to the rules, the forests were revived and protected from depletion and degradation of land and natural resources could be saved through community participation. Observing the significance and critical role played by the forest for ensuring a sustainable ecosystem, the local community people agreed that the forest management practices should be strictly as adhered to and strict rules must be implemented such as imposing fine and punishment to the defaulter.

Use of rake to collect fallen dry leaves should be prohibited as it affects natural regeneration of the VP. Van Panchayat members organize meeting monthly along with Van Suraksha Samiti (VSS), Self Help Group (SHG) etc. and give their suggestion for the betterment of forests. This shows their commitment towards forest protection and management. Every year, Van Mahotsav is celebrated and plantation drives are organized for the enrichment of forest resources.

Women actively participate for the betterment of forest and also prepared thematic songs on protection and management of van panchayat for creating awareness amongst the communities. With the slew of initiatives undertaken by Van Panchayats, the local communities are hopeful that the forests resources can be protected and sustained effectively for next generation through strict adherence to Van Panchayat rules.

Source: Barola et al., 2016

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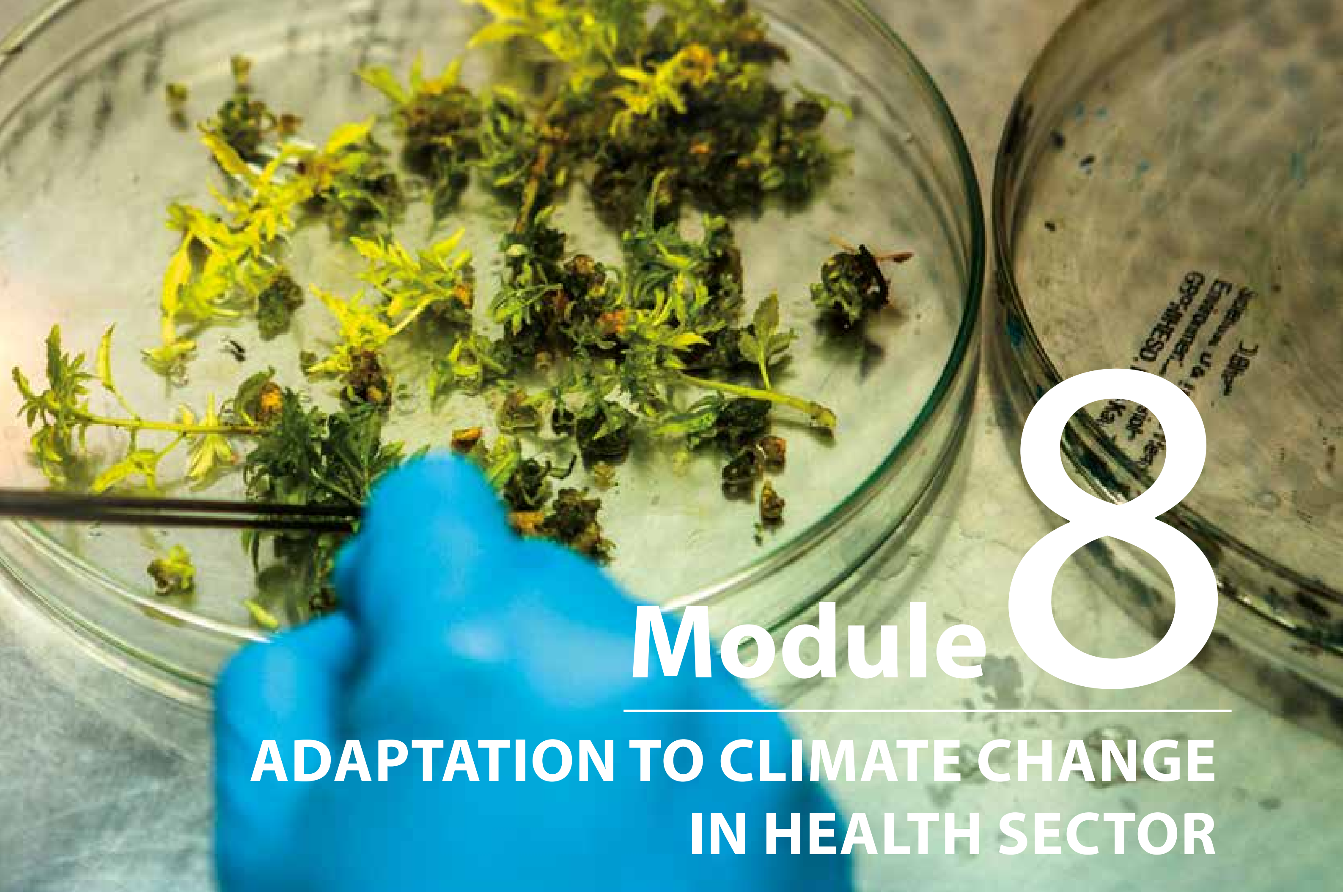


Module 8

ADAPTATION TO CLIMATE CHANGE IN HEALTH SECTOR

8.1 Introduction

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change in health sector.

The ongoing and projected changes in the climate of the Himalayas and its impact on the natural resources, particularly water, can lead to subsequent effects on the well-being of local communities. Water scarcity as a result of reduced snow or increased drought, is likely to increase water-related public health issues in the mountainous arid basins downstream.

As discussed in module 1, climate models have projected increase in temperatures and rainfall intensity in the Himalayan region. Based on these projections, malaria is likely to spread into new areas of states like Jammu & Kashmir and Uttarakhand, and affect people for a longer period every year in the North-eastern states and other parts of the country. Due to glacier retreat and other climatic changes, the flow in the rivers of IHR is likely to change which may increase the vulnerability to water-borne diseases like diarrhoea.

Climate change is one of the biggest global heath challenges of the 21st century and a growing public health threat. Human beings are exposed to climate change directly through changing weather patterns (more intense and frequent extreme events) and indirectly through changes in quality of water, air, food quality and quantity, ecosystems, agriculture, livelihoods and infrastructure. The impacts of climate change varies on the basis of health vulnerabilities, dependent on different variables such as population sensitivity to diseases, and their ability to respond to and recover from the impacts. The vulnerability of health sector to climate change is even higher in mountainous regions due to lack of accessibility to healthcare services.

8.2 Impacts of Climate Change on Humans Health in IHR

Understanding the impacts of climate variability and change at the local and regional level requires information from multiple sectors. However, health surveillance data is not usually available at the local level in the IHR. Obtaining detailed estimates of the burden of climate-sensitive diseases specific to mountain regions is difficult. Climate change related impacts on mountain ecosystems could affect population health by creating favourable conditions for disease vectors; forest fires' avalanches, heavy snowfalls, major storms, floods, and droughts; depth and duration of snow cover and length of snow-free season; and changes in cloud cover and sunlight available. The impacts can be categorised as:

- **Higher morbidity and mortality from extreme weather and climate events:** During the monsoons, floods including flash floods are a common phenomenon in the IHR. The region also experience extreme weather conditions. These extreme weather events are likely to get aggravated by climate change. It will result in increased loss of life and injuries due to damage to infrastructure. These extreme events impact mountain communities and visitors from other geographical locations too.
- **Expansion of insect- and rodent-borne disease:** Many vector-borne diseases are sensitive to ambient temperature and precipitation. Even small fluctuation in temperature and precipitation, vegetation, water availability may increase or decrease the distribution and abundance of vectors, making the communities vulnerable to diseases. According to the INCCA report (2010), an increase in incidence of malaria due to opening up of transmission windows at higher latitudes can be a potential impact of climate change in the Himalayas.
- **Incidents of water related diseases:** In many mountain regions, the quantity, variability, and timing of runoff from snowmelt and glaciers can directly and indirectly affect the incidence and prevalence of water-related diseases. Water related infectious diseases have four means of transmission: infections spread through water supplies (water-borne); infections spread through lack of water (whether clean or contaminated) for personal hygiene (water-washed); infections spread through an aquatic invertebrate host (water-based); and infections spread by insects that depend on water (Bradley, 1977). These categories are not mutually exclusive; many diarrhoeal diseases have more than one means of transmission. All means of transmission are likely in mountain regions. The importance of diarrhoeal diseases in mountain regions has been shown in a number of studies (i.e. Pokhrel and Vivaraghavan, 2004).
- **Malnutrition:** Loss of agricultural land due to flash floods, soil erosion and subsequent shortage in food production and distribution leads to malnutrition. This underlines the need to undertake more research studies to understand how climate change could affect animal health particularly the range and incidence of various diseases that could affect humans, either directly through disease or indirectly through food security.

As highlighted in INCCA (2010), climate change is projected to have mostly negative and large health impacts on many population groups, especially the poorest, in large areas of North Western and NEH. These could include direct health impacts such as heatstroke, and indirect impacts such as increased diarrhoea risk from water contamination via flooding, or higher risk of mortality from the impact of large-scale loss of livelihoods.

Projected Scenarios of Climate Change Impacts on Health

According to INCCA Report (2010), the climate projections for 2030s are derived from the PRECIS. It is a regional model developed by the Hadley centre and implemented by the GHG emission scenarios, arising out of the IPCC defined A1B socio-economic scenario for the future. In the IHR region, the transmission windows are open for 7-9 months in the baseline scenario and continue to do so in the 2030's with increase in temperature. Also, in the 2030's in the North-eastern region and upper reaches of the Himalayan region, the windows tend to open for 7-9 to 10-12 months with respect to baseline scenario.

The transmission windows in some parts of the Himalayan region i.e. J&K, Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh continue to have only 0-2 months open for transmission even in the 2030's. The transmission windows in some parts of the Himalayas in the projected scenario show slight reductions in the extent of category V (10-12 months are open continuously for malaria transmission) while the same increasing in north-eastern parts of India.

8.3 Adaptation strategies to reduce health Impacts of climate change in IHR

Operational framework for health

An operational framework for health resilience has been developed by the World Health Organisation (WHO)

Table 8.1: Potential impacts of climate change on health in IHR

Regions	Climate parameters	Probable impacts on ecosystems	Emerging Impacts on health
Himalayan Region	• Increase in temperature by 0.9oC to 2.6oC by 2030s with respect to 1970s • Increase in intensity by 2-12% in 2030s with respect to 1970s	• Increase in Forest fires • Increased glacier melt	• Loss in forest litter & wood used for heating purposes in the cold season – morbidity due to extreme cold • Flash floods leading to large scale landslides and hence loss of agriculture area affecting food security • Increase in incidence of malaria due to opening up of transmission windows at higher latitudes • Increase in morbidity due to unprecedented rise in temperature
North-East Region	• Surface air temperature is projected to increase between 0.8 to 2.1oC • Decrease in winter precipitation • Increase in intensity of summer precipitation • Increase in night-time temperatures	• Cereal production likely to be benefited, but yield of paddy will be negatively affected due to projected increase of night-time temperature. • Tea plantations to be affected due to soil erosion • Increase runoff and landslides during summer precipitation • Decrease in yields in winters	• Loss of employment and adverse effect on health • Expected to face an increase in incidence of malaria due to temperature and humidity increase.

Source: INCCA, 2010

in 2015. The goal of the framework is to enhance the capacity of health systems to protect and improve population health in an unstable and changing climate. The framework aims to achieve its goal through activities that build capacity to effectively monitor, anticipate, manage and adapt to the health risks associated with climate variability and change.

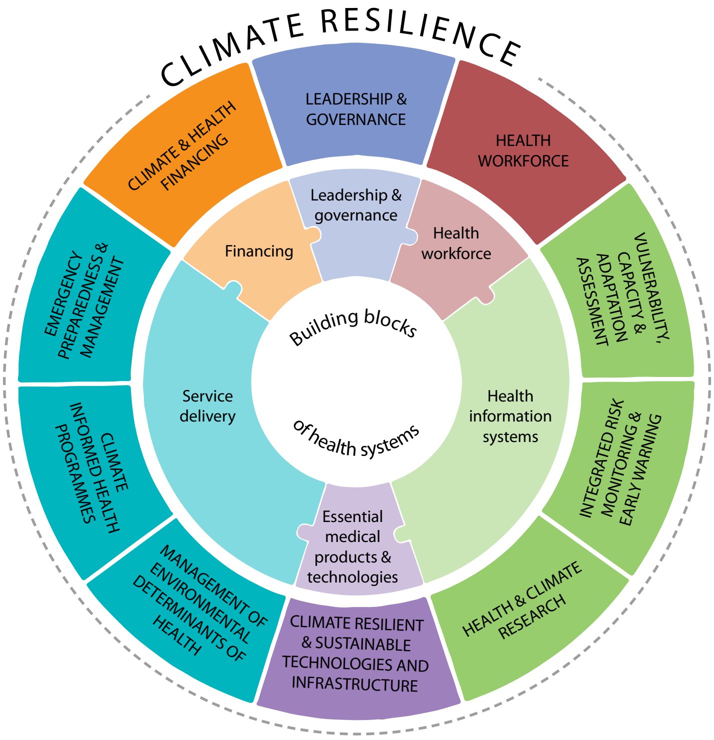
In order to provide a comprehensive health response to climate change, the following range of functions need to be strengthened to increase climate resilience. Starting from health sector building blocks, and taking into account existing global and regional mandates, the operational framework elaborates on 10 components that provide a comprehensive approach to integrating climate resilience into existing health systems (Fig 8.1). These can provide the structure for a health adaptation plan, including the allocation of roles and responsibilities, as well as human and financial resources. This framework can be applied in the Himalayan context by integrating into development plans related to health sector.

Challenges of adaptation strategy to reduce the health Impacts of climate change in IHR

One of the key steps towards adaptation to health impacts in the Himalayas include undertaking intensive research to generate better understanding on the likely impacts of climate change. This will enable formulation of appropriate adaptation strategies. The current research challenges that will help in better understanding of the relationship between climate change and health in IHR include:

- a particular weather pattern is associated with more than one health endpoint (e.g. high ambient temperature can cause heat stress, reduced crop yields that adversely affect crop security, etc.);

Figure 8.1: Operational Framework for Health Resilience



Source: WHO, 2015

- lack of unexposed group;
- lack of a baseline before anthropogenic climate change began;
- spatial and temporal variations in disease determinants and outcomes; and
- analytical challenges.

There are additional challenges pertaining to climate and socio-economic scenarios. Effective analysis of vulnerability and adaptation to climate change requires working across disciplines and agencies. Difficult terrain makes the mountainous regions difficult to access, further adding to the complexities. Poor health infrastructure, low income, and ecosystems under stress from multiple external factors pose further problems. However, given the current challenges, high quality research using best available information on climate scenarios for different regions in IHR can help in getting to a good starting point towards building resilience.

Interventions for climate sensitive disease in IHR

Interventions that are required for reducing the health impacts of climate variability are:

- Effective health education programmes,
- Improvement of health care infrastructure,
- Inter-sectoral disaster preparedness plans,
- Integrated vector monitoring and control, and appropriate sewage, and
- Solid-waste management practices.

Most of the states in IHR have State disaster management plans and disaster management committees that are comprised of all relevant line departments, including the department of health. The dissemination of information to individuals, hospitals, district medical offices, and others is through electronic and print media. However, connectivity issues in the mountain regions limit the usefulness of communication technology, thus impacting emergency communication and coordination mechanism.

Dealing with the health impacts in the IHR

As concluded by INCCA (2010), India's overall population health has improved greatly since Independence. The life expectancy has doubled from 32 years in 1947 to 66 years in 2004 - nevertheless, many threats to health and life expectancy still remain. Climate change can further increase the burden of disease, especially for the vulnerable communities of the IHR with poor access to medical facilities. Research on health impacts of climate change in India is at a nascent stage. Studies that are available are limited only to malaria transmission projections. To address the issue of knowledge gaps, it is imperative to undertake large-scale collaborative work. It would require concerted actions stakeholders representing multi sectors such as public health institutes, meteorologists, earth scientists and economists at the national level to develop climate-health impact models.

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Module 9
MAKING URBAN AREAS OF IHR RESILIENT TO CLIMATE CHANGE

9.1 Introduction

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change in urban sector.

Trend of Urbanization in the Indian Himalayan Cities

With a population of 1.2 billion, India is set to become the world's most populous country by 2025. Data of 2011 Census indicates that majority of the population in India still lives largely in its villages, with only 31% of the population living in urban areas. The United Nations (UN) estimates suggest that by 2050 India will have a population of around 56% living in urban areas. The change in percentage of urban population in the 12 Himalayan States from 2001 to 2011 is shown in Fig 9.1. The figure indicates high percentage of urban population growth in some of the north-eastern states like Sikkim, Nagaland and Tripura. This indicates that a large number of new towns have emerged during the decade, contributing significantly to urbanization. On the flip side, trends from Himachal Pradesh indicate slow growth in urban population.

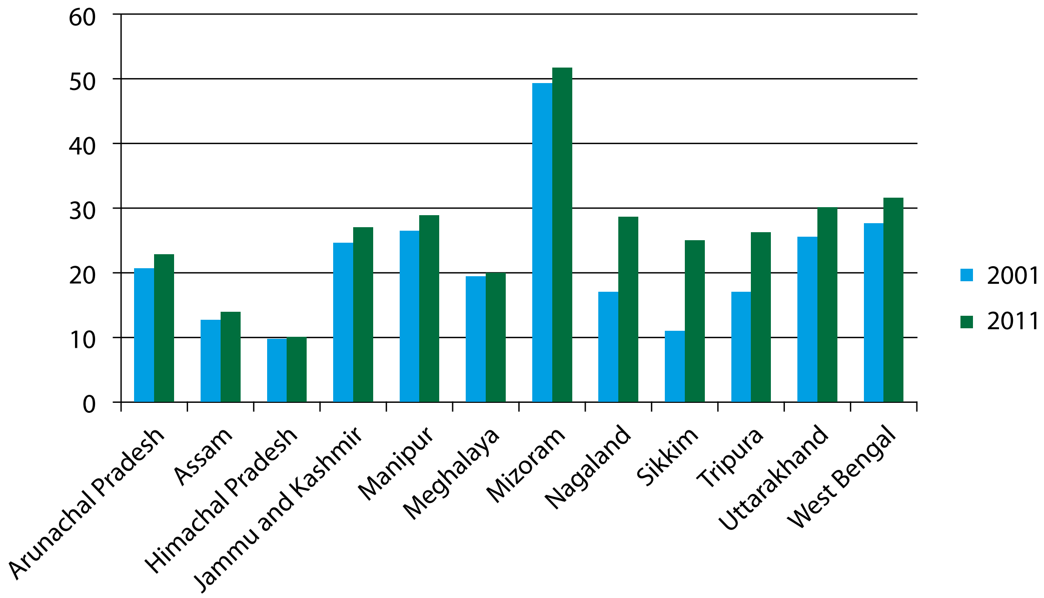
Within these states, a comparison of the top three urban centres reveals that the population is mostly concentrating in and around the state capitals. Most of these are also the major tourist places. Rapidly urbanizing towns will exert enormous amount of pressure on the already scarce resources and create new challenges for the city administration to manage. Planning for urban resilience will require multi-stakeholder consultations and creation of sustainable infrastructure. Population growth, increased infrastructure development, and urban expansion in cities is increasing the fragility of the ecosystem. This results in loss of forests, surface water bodies, depleting groundwater levels and deterioration of water quality in urban areas.

9.2 Urban Risks and Vulnerabilities in the IHR

What is Urban Risk?

As discussed in the previous section, major cities in the IHR are experiencing rapid and unplanned expansion. This trend of urbanization is exposing people and assets to the risks of increasing hazards, which are mainly

Figure 9.1: Urbanization trends in Himalayan States from 2001 to 2011



Source: Census of India, 2001, 2011

exacerbated by climate change. With urbanization there is a concentration of population in cities, as observed in the case of state capitals and major tourist places. This is dependent on various factors, the most important being economic structure, ecological setting, functional characteristics, relationship with hinterland and initial population size (Tufail, 2014).

Urban Risks faced in IHR

As indicated by the data in section 9.1, urban population is expanding rapidly in the IHR. This trend is particularly noticeable in some of the eastern Himalayan states. Cities and urban centres in the region are facing increased risk from disasters. The potential of economic and human losses from the natural hazards is being exacerbated by the rate of unplanned urban expansion and influenced by the quality of urban management.

Climate change further contributes towards multifarious challenges in cities. There is a shortage of already scarce natural resources such as water. Further, there are challenges pertaining to the livelihoods of the people living in these urban centres. Large populations concentrated in urban areas result in urban heat island effect, which is an increase in temperature formed over urban areas. This effect can be more intense in the mountain areas due to heat trapping effect in the valley. Informal settlements and population of urban poor living in peri-urban areas is increasing steadily. Climate change is also giving rise to urban growth. These settlements, mainly the urban poor, are particularly vulnerable to the impacts of climate change due to their tendency of residing in high risk areas and unsafe structures, limited access to basic and emergency services, and a general lack of economic resilience. Due to the impacts of climate change on key livelihood generating sectors, such as agriculture and forestry, many people are forced to migrate to the urban centres for employment.

According to a study conducted by Integrated Research and Action for Development (IRADe), hill cities of Shillong, Dehradun and Srinagar have lower population densities as compared to other mainland cities. However, they are exposed to increasing natural hazards like landslides and flash floods. Shimla, on the other hand, is designed for a maximum population of 25,000 on a pedestrian scale, but it accommodates around 1.7 lakh people. The results are barren concrete jungles; inadequate drainage and sewage; and increase in vehicular traffic. Design and construction of roads and bridges is extremely challenging in the mountain regions. With mushrooming population, cities grapple with unprecedented challenges as a result of increased demand for resources.

Another important aspect contributing to urban risk is the unregulated tourism and increased influx of tourists. There are environmental concerns arising out of increased vehicular emissions, energy requirements and buildings. For instance - in Ladakh, traditionally, dry toilets were used. However, with the influx of tourists, there is an increased demand for hotels and lodges with flush toilets. Many urban centres of the Himalayan states are facing similar conditions, wherein traditional practices have to be amended to accommodate the needs of the migrated population or tourists (Fig 9.2).

Additionally, the Himalayan region has been subjected to unplanned and unsafe construction. This causes enormous environmental degradation and conversion of forest areas to barren lands. Most of the towns lie in the ecologically sensitive zones and have fragile ecology. Maintaining environmental quality, topography, and accessibility are the major challenges for present development in the hill towns.

The challenges being faced by the urban areas in the IHR have increased the vulnerabilities towards climate change. Expansion in fragile areas has increased the sensitivities towards flash floods and landslides which may become more frequent due to climate change. The increased pressure on limited resources has affected the adaptive capacity of the communities in urban areas. (Fig 9.3).

9.3 Urban Resilience in IHR

What is Resilience?

United Nations Human Settlement Programme (UN-HABITAT) defines resilience as **"the ability of human settlements to withstand and to recover quickly from any plausible hazards. Resilience against crises not only refers to reducing risks and damage from disasters (i.e. loss of lives and assets), but also the ability to quickly bounce back to a stable state."**

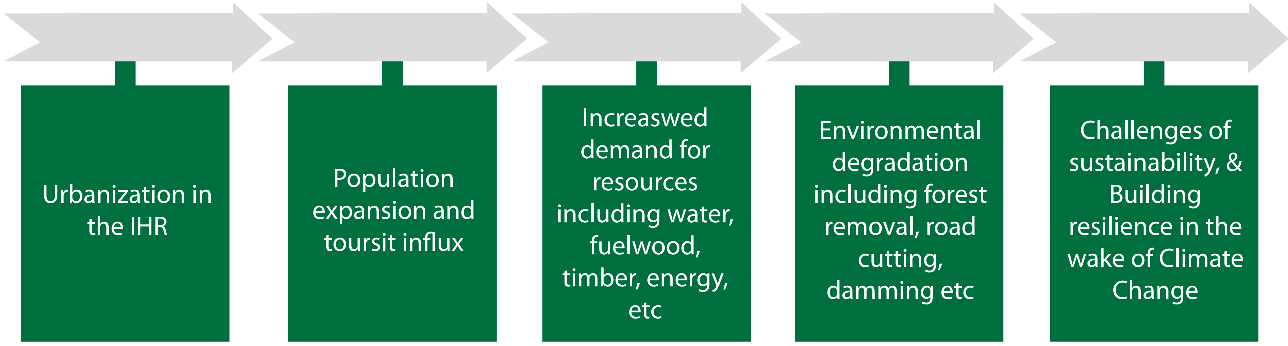
What is Urban Resilience?

IPCC defines urban resilience as the **"capacity of cities to function, so that the people living and working in cities- particularly the poor and vulnerable- survive and thrive in the face of shocks and stresses related to climate change".**

Figure 9.2 Risks and challenges of urbanization seen in major urban centres

(Source: IMI)

Figure 9.2: Urban Risk and its relation with climate change in IHR



Urban resilience is a concept that encompasses climate change adaptation, mitigation actions and disaster risk reduction, in the face of complex and rapidly growing urban areas and the uncertainties associated with climate change. The concept emphasises on considering the cities as dynamic systems, capable of evolving and adapting to survive and even thrive in the face of volatile shocks or stresses.

Cities, across the world are experiencing rapid population growth and large scale development, making them increasingly susceptible to climate change impacts. One of the major concerns for cities facing urbanization is to maintain environmental sustainability. However, since the services within an urban environment are interlinked and the risks interconnected, it is essential for the urban resilience policies to address multiple sectors and dimensions. This includes sectors like land use planning, energy management, ecosystem services, housing and transport, water supply and sanitation, health services, and waste management. This is possible through a robust infrastructure, good governance and participatory approach with multi-stakeholder interactions. To simplify the above complexity, Fig 9.4 will help understand the concept of urban resilience.

Various aspects of urban resilience have been discussed in the above sections. However, it is important to understand the dimensions that make cities resilient. Fig 9.5 below summarises the concept of urban resilience in the context of the Indian Himalayan Region.

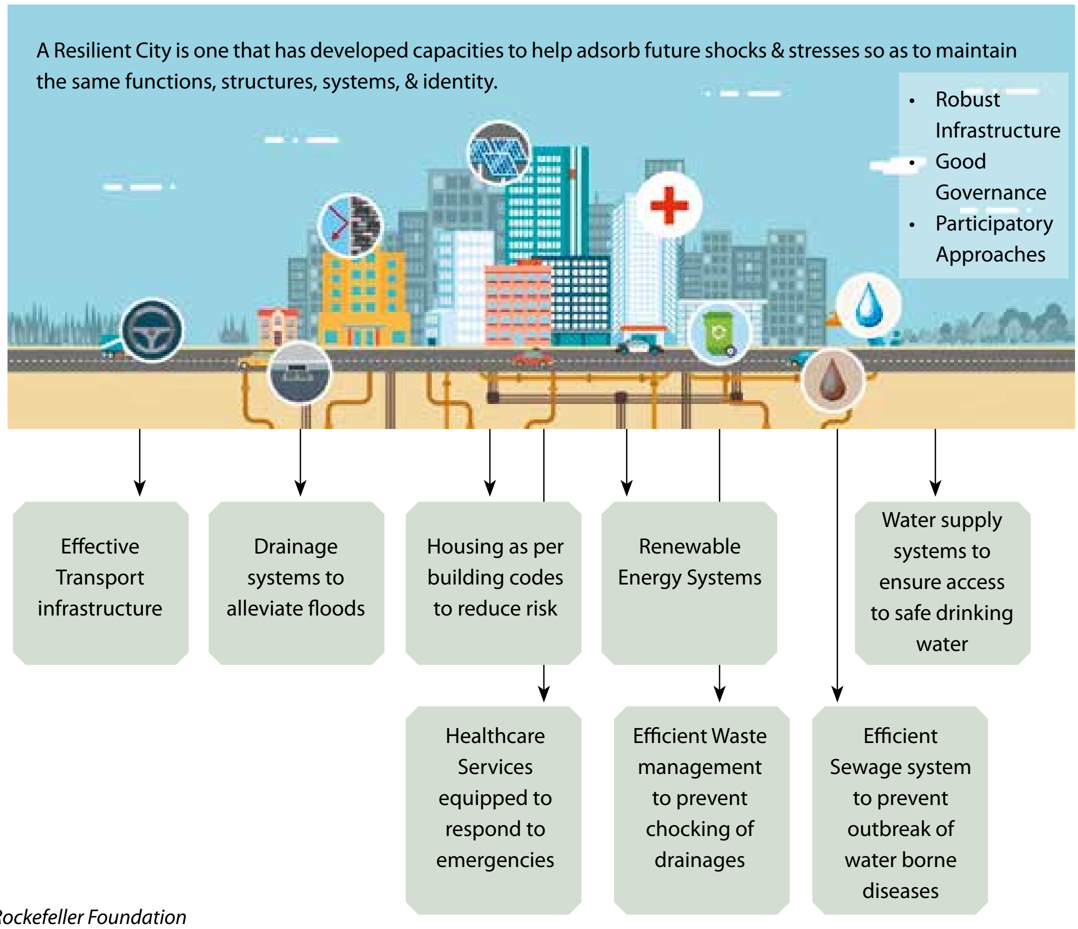
Lack of planning and implementation of adaptation measures to reduce the risks of climate change in the IHR is likely to have large scale implications on the quality of life and economic development of the cities. Cumulative actions considering the dimensions of urban resilience are required to address the current and projected risks in the urban areas of IHR. Moreover, given the uncertainties related to climate change, there is an urgent need to have implementation in order to have a strong evidence base on what contributes to building resilience of urban areas to climate change in IHR.

Better urban management and governance are the key factors in reducing disaster and climate change risks and making cities safer. There is a need to mainstream risk assessment and management processes for urban development. Multiple interventions and integration of lessons into state level development planning can help in achieving the goal of urban risk resilience in the IHR.

What is Climate resilient urban planning?

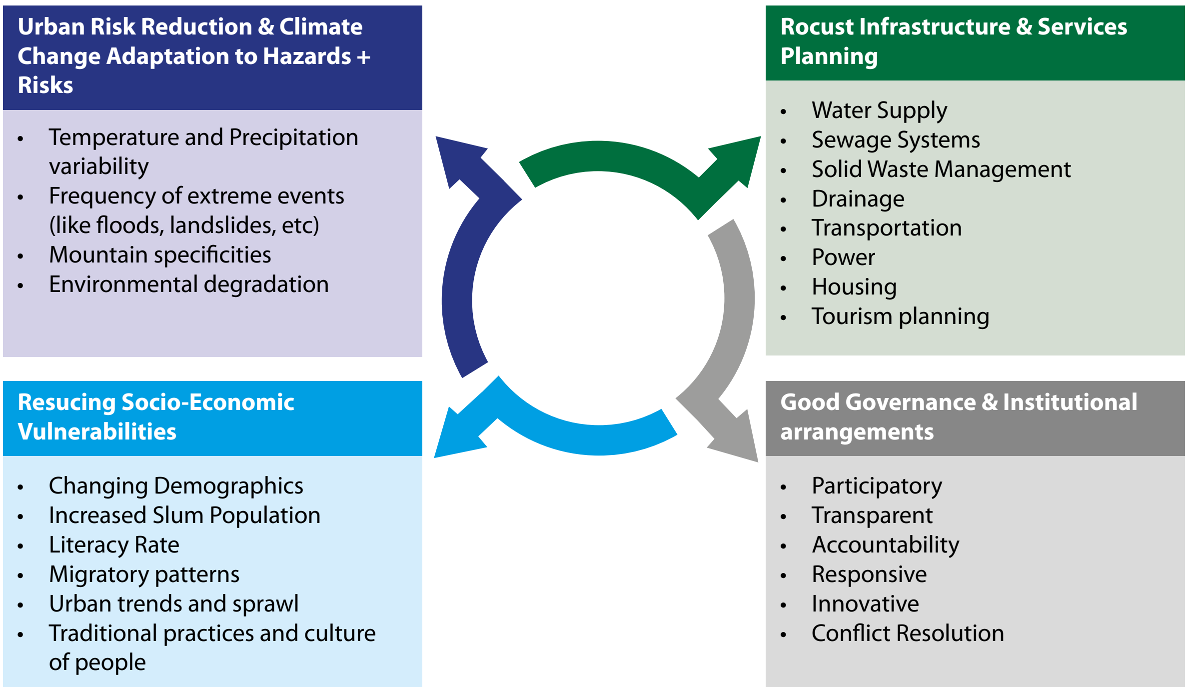
One of the primary steps for addressing the urban risks in the Himalayan region is to conduct vulnerability and risk assessment. The framework described in Module 3 of this manual can be referred for this purpose. This assessment can facilitate the identification of the key risks and vulnerabilities of a particular city and contribute towards building long-term sustainable risk reduction plans. The assessment can also help to improve the knowledge base and increase the capacity to deal with short- and long-term hazards. Climate resilient urban planning involves using the results of the risk assessment for planning and implementing risk reduction plan. This process involves identifying specific solutions to address the risk and mainstreaming them in municipal planning. To make the climate resilient urban planning process more robust and evidence based, stakeholder consultations is imperative.

Figure 9.3: Resilient Cities and the Interlinkages



Source: Rockefeller Foundation

Figure 9.4: Dimensions of Urban Resilience in IHR



Source: IRADe

Case Study

Shimla moving towards smart city (ICLEI)

Shimla's economy is predominantly services focused, particularly in the government and tourism sectors. Being the state and district capital, the city houses many representative government agencies. Due to large influx of tourists, there is a significant pressure on services and infrastructure.

The city experiences regular landslides that appear to be getting worse with changing rainfall patterns. In 2013, several hundred houses were destroyed in landslides. Furthermore, freezing of pipes in winters poses challenges for water availability. Increasing population, mainly because of tourists during summers places stress on the water supply and sanitation systems. Water has to be pumped to Shimla in order to meet the ever increasing demand. Sewage system that handles waste is over 117 years old and suffers challenges due to increased pressure.

Shimla Municipal Corporation piloted the ICLEI-ACCCRN Process (IAP) of climate resilient planning during 2012. The IAP pilot was an innovative approach to building climate resilience that draws on the Asian Cities Climate Change Resilience Network (ACCCRN) experiences of the previous years. The IAP brought together key stakeholders in a series of workshops to assess current vulnerabilities of the city, as well as the city's adaptive capacity –examining critical urban systems such as water, electricity and communications systems.

Future climate projections were presented with particular attention towards how these projections may impact already vulnerable people and urban systems. Participatory approach and interactive workshops helped to identify and prioritize actions that could reduce the risk of future climate impacts.

Through the initiatives, the Shimla Municipal Corporation (SMC) devised a structured process for identifying future climate vulnerability 'hotspots' to target for priority action. However, maintaining the continuum of the process is a challenge amidst staff transfers and changing roles.

IAP is designed to facilitate learning and ongoing actions with key objectives being able to help the SMC to understand its future climate risks and determine priority actions in collaboration with the key stakeholders.

Some of the key results of the IAP are:

- Future climate scenarios were identified for Shimla. These can be useful in integrating climate change considerations into plans and policies.
- Vulnerability Hotspots' were formally identified and documented. The process enabled the key vulnerable sectors to be identified, that is, water supply, tourism and transport. This enabled the plotting of vulnerability hotspots where these vulnerable sectors intersected in particular geographic areas.
- Participating staff members have acquired an understanding on climate change impacts.
- Actions identified in the Climate Resilience Strategy (CRS) are being implemented.

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Module 10 DISASTER MANAGEMENT IN IHR

10.1 Introduction

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change related to disaster management.

What is a Disaster?

United Nations International Strategy for Disaster Reduction (UNISDR) defines disaster as " A serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts".

IPCC (2012) has defined disaster risk as 'the likelihood over a specified time period of severe alterations in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery'.

It mentions that exposure and vulnerability to weather and climate events determine impacts and the likelihood of disasters (disaster risk). For example, the impacts of flash floods will vary depending on the location where flooding has occurred and the extent to which communities are exposed to the flood. There can be primary and secondary disasters. For example, an earthquake may be a primary hazard resulting in disaster and giving rise to a number of landslides (secondary).

What is the difference between a hazard and a disaster?

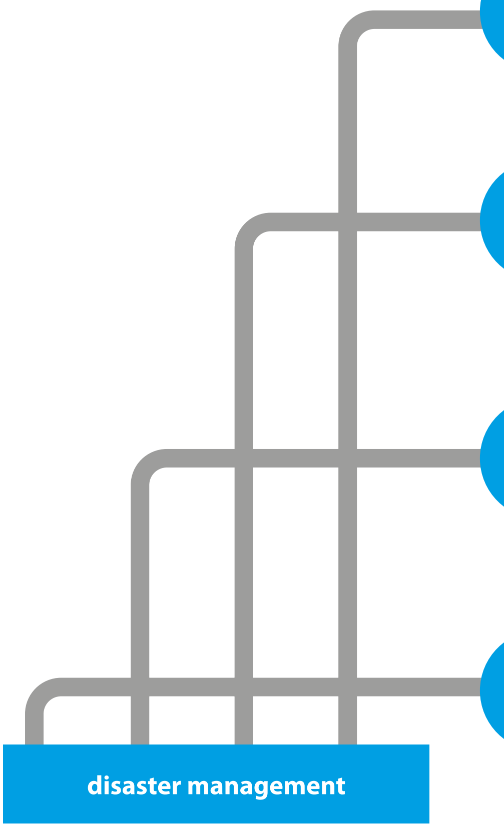
Hazard is phenomenon or situation, which has the potential to cause disruption or damage to people, their property, their services and their environment. Disaster is a sudden accident or a natural catastrophe that causes great damage or loss of life.

What is Disaster Management?

UNISDR defines disaster management as the organization, planning and application of measures preparing for, responding to and recovering from disasters. It is the systematic process of using administrative decisions, organisation, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises of all forms

Phases of Disaster Management

The four phases of disaster management can be defined in detail below:



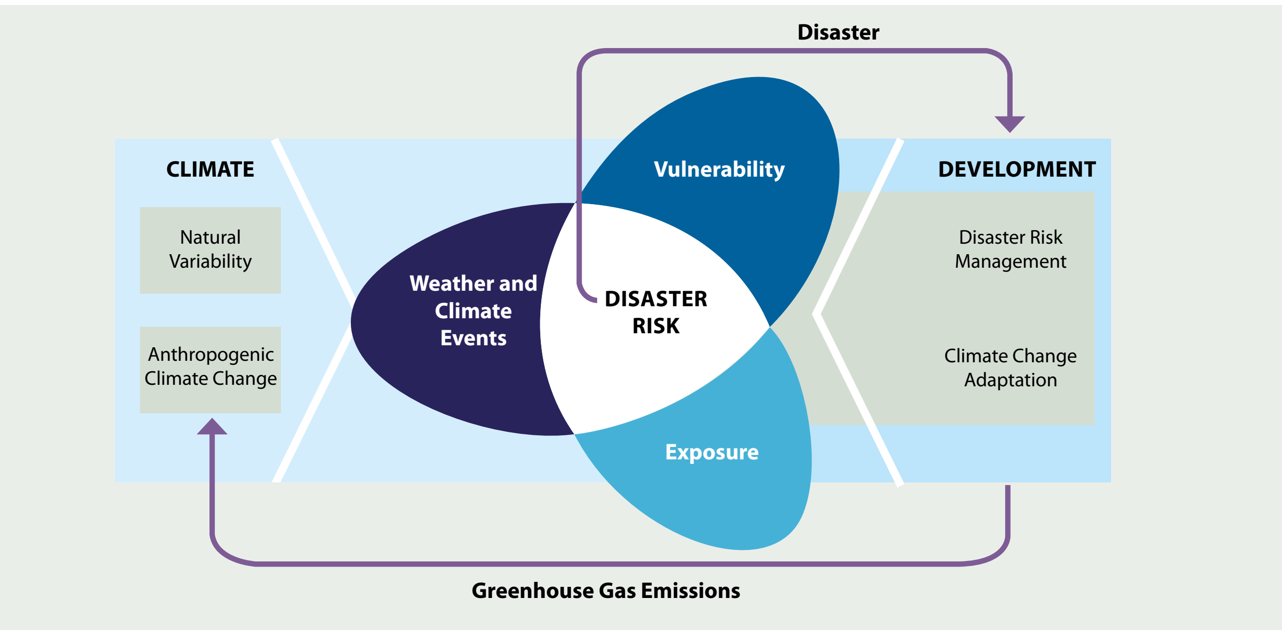
Response
Actions taken directly before, during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Preparedness
The knowledge and capacities developed by governments, response and recovery organisations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.

Recovery
The restoring or improving of livelihoods and health, as well as economic, physical, social, cultural and environmental assets, systems and activities, of a disaster-affected community or society, aligning with the principles of sustainable development and "build back better", to avoid or reduce future disaster risk.

Mitigation
The lessening or limitation of the adverse impacts of hazards and related disasters which involves sustained expenditures on structural and non-structural efforts to reduce or eliminate future risks.

Figure 10.1: Framework of Disaster Risk Management and Climate Change Adaptation



Source: IPCC, 2012

of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

Disaster risk management is the application of risk reduction policies and strategies to prevent new disaster risks, reduce existing risks and manage residual risk, contributing to the strengthening of resilience and reduction of losses. IPCC defines disaster risk management as a processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development.

What are the linkages between disaster risk and climate change?

Climate change and disaster risk are inherently connected. Firstly, climate change results in an increase in extreme events and hazards which may result in disasters. Secondly, climate change is increasingly exposing the communities to hazards because of ecosystem degradation and loss of natural resources. Thus, there are linkages between disaster risk management and climate change adaptation.

What are the linkages between disaster risk management and climate change adaptation?

One important component of both disaster risk management and adaptation to climate change is the appropriate allocation of efforts among disaster management, disaster risk reduction, and risk transfer (SREX, IPCC 2012). The framework for making judgments about such an allocation, suggests why climate change may complicate effective management of disaster risks, and identifies potential synergies between disaster risk management and adaptation to climate change.
Disaster risk management is concerned with both disaster and disaster risk of differing levels and intensities. In other words, it is not restricted to a 'manual' for the management of the risk or disasters associated with extreme events. It includes the conceptual framework that describes and anticipates intervention in the overall and diverse patterns, scales, and levels of interaction of exposure, hazard, and vulnerability that can lead to disaster. A major recent concern of disaster risk management has been that disasters are associated more and more with lesser-scale physical phenomena that are not extreme in a physical sense (SREX, 2012). It is crucial to understand that disaster risk management for climate change adaptation requires consideration of future impacts and vulnerabilities based on projections and accordingly have response mechanisms in place.

10.2 Vulnerabilities towards disasters in IHR

There are certain inherent mountain characteristics, which make the region susceptible to hazards like earthquakes and landslides. However, with the changing climate (altering rainfall patterns and increase in temperatures), there are increasing instances of intense rainfall causing extreme events. The communities are being increasingly exposed to geophysical, socio-economic and environment vulnerabilities causing loss of lives and livelihoods. Over the years, ancestors of these communities have adapted to changing environment through cultural responsiveness and individual creativity.

Major hill stations like Shimla and Mussoorie, as well as once-small villages like Kullu and Manali, have experienced tremendous expansion of population and unregulated growth, most of it occurring in areas vulnerable to seismic activity. Similarly, the once remote Leh town is now under extreme pressure from tourist influx and unplanned development. Uttarakhand has been subjected to construction activities, including dams and road networks, completely neglecting the fault lines, causing the region to become a perfect recipe for major disasters.

The negative impacts of unplanned development, insensitive to mountain specificities, are already becoming common, the most frequent being regular incidences of landslides, river obstructions and flash floods in the mountain regions. Casualties and damage due to hazards in mountains will increase irrespective of the global warming, especially where populations are expanding and infrastructure is developed in hazard-prone locations. The Himalayan region has experienced on an average 76 disaster events each year (EM-DAT). On an average, more than 36,000 people are killed and 178 million affected each year. IHR is one of the most vulnerable regions with the occurrence of 532 events between 1990 and 2012 (Table 10.1). A number of these extreme events happen in the western Himalayan region,

Table 10.1: Major Disasters in the Indian Himalayan Region

Type	Occurrence	Affected area	IHR	Impact
GLOF/Flash Flood	July, 1991	Maling, Himachal Pradesh	Western	Death: 32 persons and 35 cattle Houses: 15 houses, 35 bigha of land
Landslide	February, 1993	Jhakri, Himachal Pradesh	Western	Infra: 500m road section of NH-22 lost with a damage of around Rs. 10 million
Flash flood	August, 1997	Himachal Pradesh	Western	Death: 124 Huge damage to infrastructure including roads & brides
Cloudburst	June, 1997	Chandmari, Sikkim	Central	Death: 50 Infra: Many Houses were devastated and damages to property
Cloudburst/ landslide	July, 1998	Rudraprayag, Uttarakhand	Western	Death ~350 persons and ~500 animals Infra: ~900 houses
Cloudburst	July, 2003	Kullu, Himachal Pradesh	Western	Death: 35 persons
Extreme rainfall	July, 2004	Pasighat, Arunachal Pradesh	Eastern	Damage to houses, roads and bridges.
Earthquake	September, 2005	Kashmir, J&K	Western	Death: 953 persons and 418 injuries Infra: 23,782 houses
Cloudburst	August, 2010	Leh, Ladakh, J&K	Western	Death: 255 persons Infra: 1749 houses
Earthquake	September, 2011	Sikkim, West Bengal, Bihar	Central	Deaths: 77 people in India with around 60,000 affected Infra: US$16 billion loss
Flash Floods	Aug- Sep, 2012	Uttarakhand	Western	Death: 100 persons and 500 animals Infra: 591 houses
Flash Floods/ Landslides	June, 2013	Uttarakhand	Western	Death: ~7000 persons Many missing and 4200 villages affected
Floods	October, 2014	Jammu & Kashmir	Western	Deaths: 277 persons 2,550 villages affected

Source: EM-DAT, 2016

which is characterized by steep slopes, deep gorges and narrow valleys. The 2013 calamity in Uttarakhand is considered as India's worst natural disaster since the December 2004 Indian Ocean Tsunami.

Eastern Himalayas have also been affected by an increased number of climate related hazards, mainly linked to water, exaggerated by the fragile environment. The communities in the region are extremely vulnerable to water-related natural hazards. Over the past three decades, the region has witnessed an increased frequency in events such as floods, landslides, mudflows, and avalanches affecting human settlements (ICIMOD, 2009).

Uttarakhand Flash Floods Disaster 2013 (DMCC, Govt of Uttarakhand)

Uttarakhand, the origin of river Ganga is one of the most landslide prone regions in the Himalayas. Incessant rainfall in June 2013 caused landslides that led to unprecedented damage. The scale of devastation and death toll was enormous. Between 2001 and 2014, a total of 5181 death toll were reported from various landslide and flash floods related disasters in the state, with an average of 74 deaths every year. There has been an increase in the extreme weather events since 2010, with 2013 being the worst disaster in the history of Uttarakhand.

In the recorded history of Uttarakhand, rainfall in excess of 300 mm within a time span of 48 hours' was not a normal occurrence as it did during June 2013. Geological Survey of India (GSI) mentioned heavy rainfall and glacial melting as the main cause of the disaster. Intense rainfall and already saturated Chorabari glacier lake, caused the eruption of river Mandakini leading to heavy floods in the downstream areas. The gush of water through narrow valley brought huge amounts of sediments consisting of big rocks and boulders. This enormous volume of water induced tow erosion along the river valley and triggered widespread landslides at a number of places, causing widespread damage.

Further, cloudburst events at isolated places caused extensive damage to the villages. For several days, a number of remote villages and affected people remained disconnected in this highly connected modern world and there was no system in place to receive the aid and distribute commodities to people affected by the disaster.

Immediate response was a mammoth task for the National Disaster Response Force (NDRF) and the Army. Extensive damage to roads and bridges made it extremely difficult to reach out to the affected communities. The incident is a reminder of the scale of vulnerabilities of the region to extreme events and an urgent need for enhanced preparedness.

What are the challenges of managing disaster risks in the IHR?

As indicated in the India's Initial National Communication (NATCOM) (2012) the costs associated with climate-induced events has risen sharply in the IHR. This is despite significant efforts at fortifying infrastructure and enhancing disaster preparedness in the recent decades. Part of the observed upward trends in disaster losses over the last 50 years is linked to socio-economic factors, such as population growth, increased wealth, and urbanization in vulnerable areas. Moreover, climate change induced events have long term impacts, and thus a sustained level research to enhance preparedness requires enormous resources in developing capabilities in knowledge and infrastructure.

10.3 Mainstreaming Climate Change Adaptation in DRR in IHR

According to NATCOM (2012), climate change action plan envisages an effective disaster management strategy that includes:

- Mainstreaming disaster risk reduction into infrastructure project design;
- Strengthening communication networks and disaster management facilities at all levels;
- Protecting the Himalayan region;
- Providing enhanced public health care services'; and
- Assessing increased burden of disease due to climate change.

These are essential to understand the inherent vulnerabilities of the region and to plan the conservation and development interventions in a sustainable manner.

Disaster risk reduction (DRR) is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development (UNISDR). With the changing climate, it is essential that disaster risk management must drive development and not vice versa. It has to be clearly understood that disaster risk management, mitigation and response are at the very foundation of economic development, built into the understanding of disasters.

There are overlaps between Disaster Risk Management (DRM) and climate change adaptation. Both aim to build resilience towards hazards and to reduce socio-economic impacts. The main elements of disaster risk management including risk analysis, disaster prevention and mitigation, disaster preparedness and reconstruction contribute towards reduction and prevention of losses from natural hazards amplified by climate change.

Thus, DRM can also contribute towards adaptation to climate change. Although DRR and climate change adaptation have similarities/overlaps in term of building resilience in the context of hazards and reduce the vulnerabilities, there are also differences in terms of the approach. DRR focusses on present day vulnerabilities based on the past trends and addresses multiple hazards even those not related to climate change.

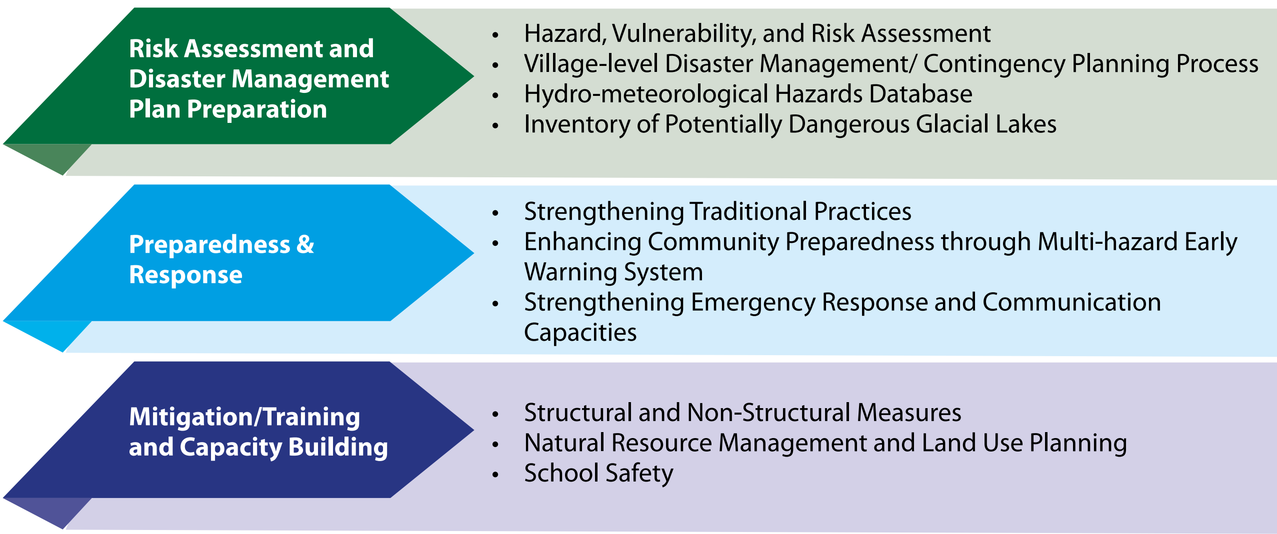
Adaptation to climate change should be planned for multiple hazards including extreme events as well as for long term projected impacts. DRR for adaptation to climate change requires a long term approach considering the climate scenarios and likely future climate variability. Climate change may lead to changes in the frequency and severity of existing risks or may give rise to new risks in the IHR. In such cases, appropriate DRR strategies need to be formulated and also mainstreamed into development planning taking robust understanding of projected trends in climate change into consideration. In case of absence of reliable high-resolution long-term data, identification of win-win or no-regret options may be beneficial in enhancing the resilience towards a disaster risk.

The framework in Fig. 10.2 gives a broad understanding of the disaster risk reduction followed by certain examples from the IHR, which have been implemented through close consultation and participation of the community.

Example of DRM in IHR: CEE Initiative in Managing Disaster Risk in the IHR (NATCOM, 2012)

The Centre for Environment Education (CEE), has been working on awareness generation towards disaster risks. It reached out to diverse stakeholders on location-specific scoping, mitigation, and adaptation measures. Some of the activities undertaken are as follows.

Figure 10.2: Disaster Risk Reduction in IHR



1. CEE Himalaya held a series of teachers training workshops on disaster risk reduction and climate change adaptation in Baramulla, Kupwara, Srinagar, and Gandarbal districts of Jammu and Kashmir. The programme aims at capacity development of teachers as "Green Ustads", who have the basic understanding of climate change scenarios at the local and global level and mitigation of risks caused by them.
2. As a part of the "Disaster Risk Reduction Awareness and Preparedness Campaign in Schools in the Kashmir Valley", students from around 2000 schools are learning about the disasters and their preventive measures. These schools were also a part of CEE's "Pick Right" and "Kaun Banega Bharat ka Paryavaran Ambassador" campaign. Schools from Ladakh, Himachal Pradesh, and Uttarakhand also participated in this campaign.
3. Community-based disaster preparedness initiative has been taken up in 50 villages falling in five districts of Jammu and Kashmir. The villagers analyse local climate change, availability of water, and seasonal variations along with other risks and hazards. They map availability of natural resources and develop contingency plans.

Integrating Disaster Management & Climate Change Adaptation with Sustainable Development

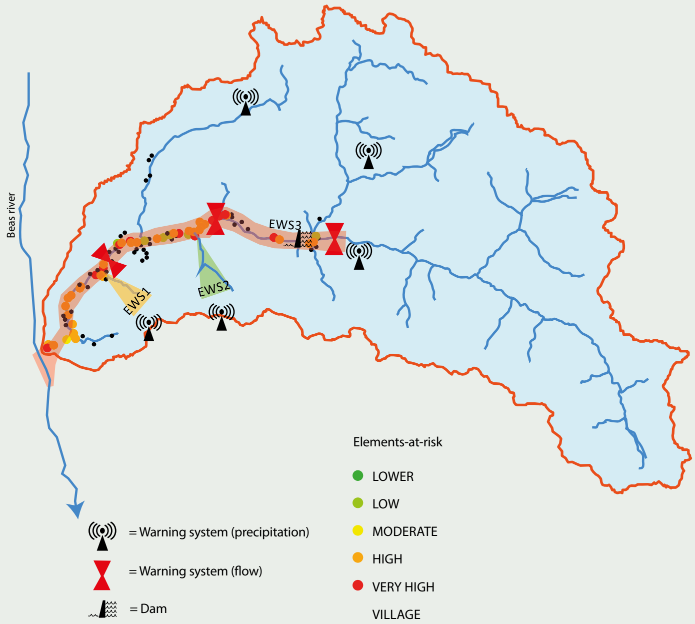
It is evident that disaster risk reduction, climate change adaptation and sustainable development are linked to each other. Many evidences of linkages between the three agendas are observed while studying the Sendai Framework for Disaster Risk Reduction (SRDFF): 2015-2030, Sustainable Development Goals (SDGs): 2030 and the Paris Climate Agreement: 2015. All of them share a common aim of making the development sustainable. To ensure the achievement of SDGs, it is imperative to consider current and future challenges caused by disasters and climate change.

Adaptation Concept: Reducing Flood Risk in *Parvati* Valley

Parvati valley in Himachal Pradesh has been identified as a major risk hotspot for monsoon floods, cloudburst events and potential Glacier Lake Outburst Floods (GLOFs). Development of an integrated monitoring and early warning system to deal with flood risks would therefore be an adaptation response. The integrated system will include implementation of state-of-the-art catchment-scale and long-term monitoring system to assess hydro-meteorological conditions. Further, it will be implemented through a modern EWS with the goal to protect the identified "risk hotspots" along the valley.

The long-term monitoring of hydro-meteorological conditions would facilitate early detection of relatively slowly as well as rapid onset flood threats and warning of the subsequent risk to downstream areas. It would also help in providing agro-meteorological advisories in the short term. The EWS would comprise of three components aimed at generating warning in the most critical risk hotspot areas in the Parvati valley. The approach would include establishing monitoring system (flow and rain gauge stations); a data management centre; and warning systems along with raising awareness.

Figure 10.3 shows the schematic hydrological information about Parvati valley, highlighting the three components of EWS. Two of the components are for the warning of flash floods in small torrent catchments above the villages of Shat (EWS 1) and Kasol (EWS 2). Third component (EWS 3) is aimed at flood warnings along the main Parvati River channel. Apart from the technical measures, the intervention would ensure last mile connectivity with local communities to enhance preparedness towards flood events. The proposed EWS would be integrated into the existing Disaster Response System of the District Disaster Management Centre of Kullu.



Source: IHCAP, 2017.

Case Study

Kashmir Floods

J&K witnessed intense rainfall during the week of 01-07 September 2014 due to the combined effect of Western Disturbances (WD) and their interaction with monsoon rains. Mismanaged and urbanized flood plains of the river Jhelum further aggravated the situation. This was also exacerbated by the prolonged extreme precipitation events observed over the entire Kashmir valley during the first week of September and snowmelt runoff from the extensive snow–packs observed in the mountainous regions in 2014.

There are two major reasons behind the flood vulnerability of the Kashmir valley –

- Inadequate carrying capacity of the river Jhelum from Sangam (Anantnag) to *Khandanyar* (Baramulla), and
- The natural flat topography of the Jhelum basin

The capacity of flood spill channel in Srinagar has reduced from its original 17,000 cusecs to 5,000 cusecs. The Jhelum channel (capacity 35,000 cusecs) and flood spill channel proved insufficient to accommodate the enormous discharge of floodwater in September measuring more than 1, 20,000 cusecs. The floodwater of such enormous volume led to inundation in Srinagar. Four tributaries of the Jhelum simultaneously brought water with enormous force and high speed at Sangam near Ananatnag. With unplanned development not only within the boundary of Srinagar city, but all along the Kashmir Valley, natural water bodies had lost their carrying capacity over decades. Lakes and the nearby wetlands, which could have absorbed much of the floodwater and balanced the deluge, had declined in the area.

Kashmir floods highlight the vulnerability of the region to extreme events which are likely to be aggravated by climate change. There is an urgent need to have robust adaptation plans implemented to respond to such disasters. As communities are the first responders, a comprehensive community-based disaster risk reduction plan needs to be prepared at the district level on priority. Community trainings on how to handle such emergencies must be undertaken to create a cadre of trained response team.

Source: Arora et al., 2016

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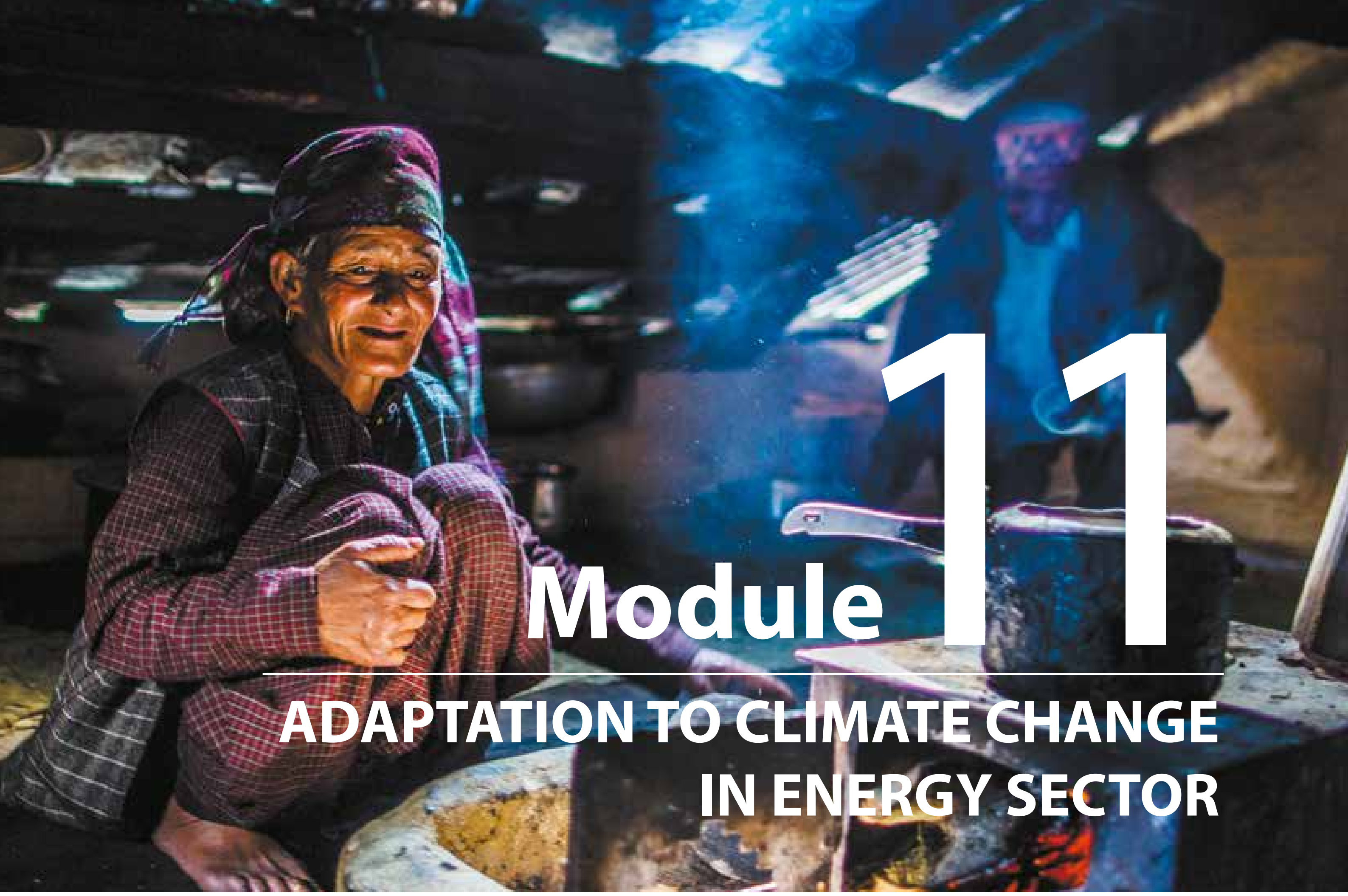

Module 11

ADAPTATION TO CLIMATE CHANGE IN ENERGY SECTOR

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change related to energy efficiency and adaptation.

11.1 Introduction

Driven by economic growth, urbanisation, rising incomes and industrial activity, India's energy demand is expected to rise significantly in the coming decades. India's energy consumption is projected to rise at around 4.5% annually by 2035 (up from 3.5% from 2000–2017). However, India has the potential to improve its energy use efficiency.

There is a high potential for generation of renewable energy from various sources, particularly wind and solar, as well as biomass and small hydropower. The Government of India (GoI) is increasingly emphasising on renewable energy, including grid-connected and off-grid systems. The NDC of India, which outlines the post-2020 climate actions under the Paris agreement, is centred on its policies and programmes on promotion of clean energy, especially renewable energy, enhancement of energy efficiency. India's NDCs clearly highlights that harnessing renewable sources will put the country on the path to a cleaner environment, energy independence and, a stronger economy. The share of renewable grid capacity of India has increased over 6 times, from 2% (3.9 GW) to around 13% (36 GW) from a mix of sources including Wind Power, Small Hydro Power, Biomass Power / Cogeneration, Waste to Power and Solar Power between 2002 and 2015. The Government of India is taking a number of initiatives like up-scaling of targets for renewable energy capacity addition from 30GW by 2016-17 to 175 GW by 2021-22 to accelerate development and deployment of renewable energy in the country (GoI, 2015).

The energy generated by the Himalayan mountain systems could be a low-carbon alternative to meet renewable energy targets as outlined in India's NDC. India has massive potential to become a foremost contributor in producing eco-friendly and cost effective geothermal power from Himalayan mountain system. However, power generation through geothermal resources is still in nascent stage. Geological Survey of India has identified about 340 geothermal hot springs in the country. Some of the prominent geothermal resources are in the Himalayas in locations such as Puga Valley and Chhumathang in J&K, Manikaran in Himachal

Pradesh, and Tapovan in Uttarakhand (PRAGYA, 2015). Similarly, the Himalayan region has a huge potential for hydropower and other renewables. In remote hilly areas, development of hydro-based power generation of up to 25 MW capacity, classified as small hydropower, leads to rural electrification and local area development. The gestation period of the technology is low and the indigenous manufacturing base is strong. Micro-hydro system is a viable mechanism for energy production in the Himalayan region, where flowing water is an easily available resource. These systems are easy to use and unlike wind and sun, hydro resource can be accessible 24 hours a day, 365 days a year. Micro-hydro pumps can enable running of irrigation pumps and grain mills, thereby raising agricultural productivity (PRAGYA, 2015).

Despite having huge potential for renewable energy, the Himalayan region is energy-poor. A broad range of barriers, including policy and regulatory obstacles, outdated technology and a lack of capacity and of finance have prevented the region from taking full advantage of existing and potential renewable energy sources for decentralized sustainable energy solutions in off-grid mountain areas (Dhakal et al., 2018).

Significant fraction of rural households in IHR still largely depend on biomass fuel for cooking and heating and lack a modern energy source for cooking. Moreover, it's mainly the women who are responsible for collection of fuelwood as they need energy inputs for their household chores such as cooking, space heating, post-harvest processing, and small enterprises. According to WHO, this collection of fuel takes an average of 1.5 to 2 hrs per day (TERI, 2012). This time spent in collecting wood and other fuels could alternatively be used for economic activities that have monetary value attached to them. Use of fuels such as biomass leads to indoor air pollution mainly affecting women because they remain indoors and are directly exposed to the harmful fumes while cooking. While supply of energy in IHR remains a challenge, demand has been growing significantly.

Barriers in harnessing Renewable Energy RE in IHR

According to the Ministry of New and Renewable Energy (MNRE), Government of India, the total cumulative installed capacity (MW) of renewable energy in the country as on April 2015 was 35,503 MW. There are several factors which hinder the uptake potential of REs in the Himalayas, these are: small size of transactions; narrow penetration of financial institutes; lack of replicable models for stand-alone projects; lack of awareness amongst public about renewable energy; and underdeveloped value chain. In addition, to the above there are specific financial, infrastructural and regulatory issues that hinder the growth of RE technologies in rural areas. The primary reason for the lack of interest in RE investment cited is administrative hurdle. Clearance has to be taken from several agencies such as SERC, wildlife department, pollution board, state nodal agencies (PRAGYA, 2014).

11.2 Climate Change Impacts on Energy in IHR

As discussed in section 11.1, the Himalayan region is energy poor and vulnerable despite its vast potential for hydropower and other renewables. Climate change can potentially have impacts on the energy security in the region. Production of hydropower, primarily run-of-river types, could be adversely affected. The Himalayas are crucial for providing water for the several hydropower projects in the region. IHR has seen a growth in large and small scale hydropower projects over the past decade with significant investments. These projects rely on snow and glacier melt to sustain inflows during dry seasons or weak monsoon years. Although there are uncertainties regarding the extent of impacts of climate change on glaciers and water reserves in IHR, the potential changes in rainfall timing and distribution will have implications on the quantity and quality of run off from mountain catchments.

Climate change can also result in increase in energy intensity due to the need to pump water because of declining water tables in some of the low lying areas. The impacts of changing climate on forest species together with land degradation could affect the supply of biomass. This would increase the burden on women as they will have to fetch firewood from far-off places. The huge dependence of primary energy supplies on biomass indicates high risk of fuel security in the extreme climatic events.

Challenges of energy demand and climate change in IHR

IHR has very low level of per capita energy consumption owing to low population density, difficult terrain and the grid connected villages are often without electricity. The region faces technology gap and its associated problems. Moreover technologies for energy are designed for plain areas and are not well suited to face climatic conditions of the Himalayas.

Communities in IHR are still dependent on methods that are largely resource inefficient, leading to unsustainable use of land, forest and water resources of the region. Several rural areas in IHR lack access to electricity. Fuelwood use for energy is leading to widespread deforestation and poor health among Himalayan communities. This is further increasing the vulnerability of the region to climate change as the ecosystems are getting degraded. Also, with rising temperatures, the demand for energy or fuelwood is increasing which will have further implications on forest resources. Measures to enhance energy supply have had less than satisfactory results because of low prioritization and a failure to address challenges of remoteness and fragility. Without massive investments now, energy poverty and its effects will persist in the region for the foreseeable future (Dhakal et al., 2018).

11.3 Addressing the energy demand in IHR and adaptation to climate change

Addressing the existing energy poverty in the Himalayan region, it is imperative to improve access to cleaner energy sources. Access to electricity and clean energy can improve livelihoods and economy which could in turn increase the adaptive capacity of mountain communities towards climate change risks. Promotion of clean bio-energy and Improved Cook Stoves (ICS) technologies could reduce biomass consumption significantly, leading to a reduction in emissions of Short Lived Carbon Pollutants (SLCPs) (Dhakal et al., 2018). Usage of modern fuels such as electricity helps reduce malnutrition related mortality by boosting food production and household incomes. Replacement of traditional stoves that burn wood and dung with more modern appliances further reduces the health risks to women and children by reducing air pollution.

Improving energy efficiency can bring additional energy to meet the increasing demand for energy services. Given the excessive traditional biomass usage for cooking, space heating, and the resulting deforestation and widespread biomass loss in IHR, there are huge opportunities for improving the efficiency of biomass use, particularly for household use. The need is to make it more sustainable or substitute it completely by moving away from the highly inefficient combustion of biomass fuels primarily used in this sector. By tapping into the full potential of hydropower and other renewables, the Himalayan region can overcome its energy poverty and attain energy security, while mitigating and adapting to climate change. Success however will depend on removing barriers (Dhakal et al., 2018).

There is a need for specific interventions designed for the Himalayas. Inadequate data and analyses are a major barrier to designing context specific interventions. This underlines the need for improved data and assessments on the energy scenario in IHR. Quantitative targets and quality specifications of alternative energy options, based on an explicit recognition of the full costs and benefits, should be the basis for designing policies and prioritizing actions and investments (Dhakal et al., 2018). There is a need to prioritize use of locally available energy resources such as solar energy for cooking and heating.

Examples of Clean Energy Initiatives in IHR

Tapping the potential of solar energy: Micro grids Lighting up Villages, and lives in India's Himalayas – In remote villages of Kargil and Ladakh, solar storage micro-grids have been installed by GHE, an IEEE Global Partner. Solar-energy storage micro grids are improving the lives, and livelihoods, of some 5,130 Himalayan region residents.

Pradhan Mantri Ujjwala Yojana (PMUY) was launched by Hon'ble Prime Minister Shri Narendra Modi on May 1st, 2016 in Ballia, Uttar Pradesh. Under this scheme, five crore LPG connections are provisioned for BPL families with a support of Rs.1600 per connection in the next 3 years.

PMUY aims to safeguard the health of women & children by providing them with a clean cooking fuel – LPG (GoI, 2018). The initiative helps in reducing the dependence on biomass and the exposure to indoor air pollution due to burning of traditional fuels for cooking. LPG connections to BPL households ensure universal coverage of cooking gas in the country. This initiative of the government will empower women and safeguard their health. It will reduce drudgery and the time spent on cooking. It will also create livelihood options for the rural youth in the supply chain of cooking gas. Following table information indicates the supply of LPG connection in the IHR states.

Electricity Generation using Pine Needles in Uttarakhand

Avani Bio Energy, an NGO based out of Uttarakhand used the locally available pine needles for power generation using biomass gasification technology for its conversion into electrical energy. This initiative provided much needed relief to the villagers to get rid of the problems of unreliable power supply. This initiative was also a step towards minimizing the menace of fire hazards in hot dry summer season in hills of Uttarakhand. In 2009, the first small scale gasifier of 9 kW capacity was set up in the NGO campus at Pittorgarh. About 1.5 kW

Table 11.1: Ujjwala Yojna, supply of LPG connection in IHR states

S.No.	IHR State	Number of connections released as on 31-03-2017	Number of connections released as on 03-12-2018
1	Arunachal Pradesh	-	35,839
2	Assam*	2	23,43,033
3	Himachal Pradesh	1,601	86,315
4	Jammu and Kashmir	265,787	8,00,559
5	Manipur	25	96,639
6	Meghalaya	-	1,30,929
7	Mizoram	-	25,051
8	Nagaland	-	45,087
9	Sikkim	-	5,095
10	Tripura	-	1,86,493
11	Uttarakhand	1,13,866	2,64,237
12	West Bengal*	2,520,479	67,80,740

**Figures for entire state including plain areas*
Source: Government of India, 2018. (Accessed at http://www.pmujjwalayojana.com/released-connections.html)

Table 11.2: Source-wise and State-wise Potential of Renewable Power in India as on 31.03.2013 (In MW)

States	Wind Power	Small Hydro Power	Biomass Power	Co-generation Bagasse	Waste to Energy	Total	
						Estimated Reserves	Distribution (%)
Arunachal Pradesh	201	1341	8	0	0	1550	1.65
Himachal Pradesh	20	2398	142	0	2	2562	2.72
Jammu & Kashmir	5311	1431	43	0	0	6785	7.21
Sikkim	98	267	2	0	0	367	0.39
Uttarakhand	161	1708	24	0	5	1898	2.02
West Bengal	22	396	396	0	148	962	1.02

(Source: Government of India)

is consumed for running the system and rest 7.5 kW of energy is used for productive applications such as welding, calendaring etc. Over the years, this gasifier has continued to generate electricity for the centre. With this success, in 2012, to scale this innovation and bring it to the surrounding communities, Avani Bio Energy got established as an independent power company. In 2014, Avani set up another plant of 120 kW in 2014 at Chachreda village in Pithoragarh. The electricity generated through the biomass gasification plant was sold to the state grid through a 20 year Power Purchase Agreement between Avani and Uttarakhand Power Corporation Limited (UPCL).

Renewable Energy Potentials in IHR

The national energy policies and plans should set annual investment goals and strategies for the RE technologies deployment in remote mountain regions. There should be dynamic participation of energy planners at national and regional levels for the integration of these technologies in development plans. Infrastructure barriers should be tackled with investments for communications in the mountainous regions. The key pre-requisite for RE installation is an in-depth understanding of the RE technology. Energy strategies should integrate RE within the larger supply chain of the local economy, such as agriculture, sericulture, and tourism (PRAGYA, 2015).

Each RE source, whether solar, wind or hydro, has its own technological specifications. R&D should be tailor-made to the needs of the mountain communities - creating integrative energy system that is stand-alone or off-grid technologies.

Streamlining bureaucratic processes for clearances and approvals, and advancing towards a unified regulation for RE that would help to tackle administrative and operative hurdles. There is a further need to create an enabling environment where the key stakeholders are aware of the renewable energy technologies and its benefits. For this, awareness and sensitization programmes for the citizens as well as other key stakeholders are must to understand the usefulness of RE technologies.

Providing access to clean energy fuels keeping in mind the risks of climate change can reduce the vulnerability of communities in IHR and also provide benefits for meeting the energy demand. Designing mountain specific technologies for clean energy access and addressing barriers to tap the full potential of renewable energy can help in improving the energy security while adapting to climate change risks in the Himalayan Region.

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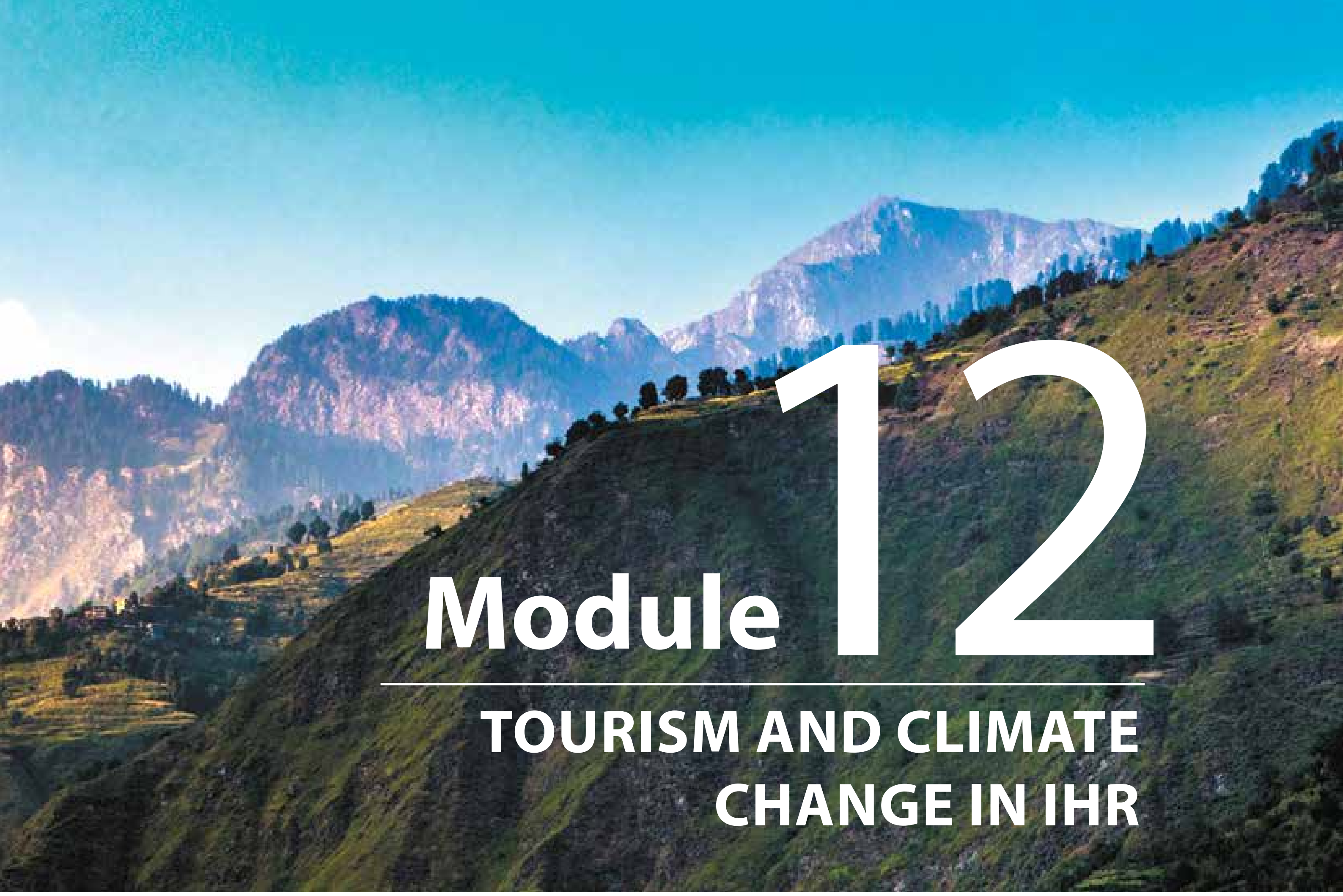

This module provides an overview of the key impacts, vulnerabilities and adaptation strategies to climate change related to tourism sector in IHR.

12.1 Introduction

The huge Himalayan range is picturesque, abound with natural beauty. Its ice-capped hill peaks, scenic lakes and valleys, flourishing forests, fruit orchards or lush green meadows are a major tourist attraction. The entire region encompassing 12 states attracts tourists for its immense natural beauty, serene ambience, relaxed atmosphere and the delightful climate. Needless to say, there lies a great potential for the growth and development of tourism sector in IHR, thereby compelling the respective state governments to boost and prioritize its tourism infrastructure for its tremendous livelihood opportunities.

The tourism infrastructure makes direct contribution to industries like accommodation services, transportation services, food and beverage services, retail trade, cultural, sports and recreational services. There is also an indirect contribution to Travel & Tourism (T&T) investment spending and government collective T&T spending; and induced contribution to clothing, housing and household goods; thereby contributing to the country's Gross Domestic Product (GDP) and employment.

Tourism in the north-western IHR persisted for several decades in the form of pilgrimage to the sacred and religious spots high in the mountains. But over time, the hill towns originally established by British during the colonial times became gateways of urban commercial tourism that served towards spectacular growth of tourism. In more recent years, the number of tourists from all over India and the world visiting the IHR is increasing rapidly. To accommodate the tourists, the region has been experiencing rapid infrastructural growth. An associated effect has been observed on the local economy in terms of generating employment and demand for related materials. The growth of tourism sector is however at the cost of immense pressure on natural resources. Moreover, the infrastructure is not well-suited to accommodate to the huge inflow of tourists.

Impacts of tourism in IHR

The fragile Himalayan ecosystem has undergone major changes in the last century. Rapid exploitation of resources and land use change have increasingly led to decreased thick forest cover, intensified soil erosion, enhanced silting of water bodies, drying-up of springs and disappearance of many species of flora and fauna. There has also been an increase in the ratio of energy expended in fodder, fuel collection and agricultural activity. Economic prosperity, increase in population, urbanization and a consistent increase in tourism to the remotest corners have further taken their toll on this region. As tourism industry in the IHR has flourished, mass tourism in the Indian Himalayas has proved to be a narrative of negatives.

There has been rapid degradation of mountain slopes, trail pollution with garbage, eutrophication of waters and overburdening of landscape (Singh 1999). Construction in fragile land areas, poorly designed roads, degradation of water bodies and loss of natural resources and ecosystem services have been observed as a result of expansion of tourism industry in IHR.

Tourism development has increased consumption in areas where resources are already scarce. The limited water resources are now used by a substantially higher number of persons - in hotels, eateries and other personal and commercial institutions. This results in water shortages and degradation of water supplies, as well as generating a greater volume of waste-water. The capital city of Himachal Pradesh, Shimla, faced acute water crisis over 18-20 May 2018, forcing the locals to wait for tankers in long queues for hours, leaving them helpless and angry, and requesting tourists not to visit the hill city. Tourism also creates great pressure on local resources like energy, food and other raw materials that may already be in short supply in difficult terrains. Tourism is known to cause air emissions, noise, solid waste and littering, sewage, even architectural and visual pollution. Similarly, increase in transport by air, rail and road is continuously contributing to severe local air pollution. Noise pollution from airplanes, cars, and buses as well as recreational vehicles is an ever-growing problem, causing distress to wildlife. In areas with high concentration of tourists and tourist activities, waste disposal is also increasingly becoming a serious problem. In the IHR, trekking is gaining popularity and poorly managed and unguided trekking tourists generate a great deal of waste. Garbage, oxygen cylinders and even camping equipment have been recovered from such sites. Tourists leave behind quintals of plastic and glass waste in the mountains, like bottles, packets of chips, biscuits, candies, medicines and trekking equipment. Even though there are codes to prevent littering, but there is no strict enforcement. This current trend will lead to solid waste generation in sensitive tourist areas of IHR that could be comparable to metro cities of the country.

In the absence of appropriate infrastructure for sustainable growth of the tourism industry, the rich, unique and diverse Indian Himalayan ecology is distressed, facing a crisis and is at the risk of being over exploited at the hands of impoverishing consumerism.

12.2 Climate Change and Tourism in IHR

Impact of climate change on tourism in IHR

For economic development, IHR needs tourism which is least damaging to its eco-systems and its environment. Owing to climate change, there is a general increase in temperature and changes in humidity and rainfall patterns. The summers in the mountains will now be warmer, winters at higher latitudes and altitudes will be warmer, rainfall (monsoonal) will be erratic and frequency and intensity of climate based extreme events will increase. This may alter composition of the community, pattern of vegetation, habitats of species, increased competition for resources and extinction of species, and in turn affect the cultural practices, traditions, knowledge and institutional settings of the region. These changes will have implications for the tourism industry as well. With increasing temperatures, the window for tourists to visit is likely to expand which will result in increased number of tourists and associated demand for resources.

During the recent past, the number of people affected by climate disasters - droughts, flash floods, debris-flow and storms - has been rising tremendously in the IHR; these disasters have possible links to climate change. Extreme events pose severe threat that can completely wipe away the tourism resources and settlements, forest & biodiversity, infrastructure, transport & communication network, support facilities and service sectors. Such incidents also involve risk of life for tourists and host communities and service providers in destinations and vulnerable areas in transit locations. Events like cloud burst and heavy rains can aggravate the flood risk associated with melting glaciers, and also adversely affect the biodiversity based tourism in remote locations as a result of wiping out and successional loss of biodiversity. In 2013, a flash flood devastated the Himalayan town of Kedarnath, which is situated at an elevation of 11,500 feet in the valley of Uttarakhand, the destination of half a million Hindu pilgrims annually. It was India's worst disaster in a decade where several thousand people drowned, dozens of bridges and roads were damaged. The early and heavy monsoon rains possibly triggered by changing climate, railed against poorly built homes, unregulated development along the Mandakini River running through Kedarnath, and soil erosion caused by thousands of pilgrims trekking on foot and on donkeys to reach this remote town in the northern Indian state of Uttarakhand, contributed to the tragic deluge. The recurrence of a similar event can have long-term detrimental impacts on tourism. Such direct or indirect climate-change induced alterations to the ecosystem of IHR may further impact the touristic experience and slow down the growth of the tourism industry leading to stagnation and decline at a later stage. This signifies the lifespan and quality of tourism characteristics governed by the physical, social, and biological carrying capacity of the tourist destinations. Suitable management interventions to enhance the growth of tourism industry, without environment degradation and promoting the construction of safe infrastructure are required.

12.3 Adaptation in IHR in context of Tourism

What can be done to ensure resilience of tourism to climate change?

Tourism has a significant contribution in the economy of IHR. It provides opportunities for the growth of small scale enterprises and generates livelihoods for the local communities. This calls for a need to develop tourism in a sustainable manner.

Eco-tourism: Mass tourism cannot be averted. But it needs locally relevant and sustainable policies for managing tourism growth in at-risk destinations. The need for innovation and promoting the concept of eco-tourism will help move towards creating a sustainable tourism industry.

Ecotourism is defined as "responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education" (TIES, 2015).

According to Hector Ceballos-Lascuráin "ecotourism is environmentally responsible travel to relatively undisturbed natural areas in order to enjoy and appreciate nature that promotes conservation, has low negative visitor impact, and provides for beneficially active socioeconomic involvement of the local populations." It implies low impact behavior towards both the environment and the culture of the local community. The ecotourism activities should have minimal to no degradation on the part of the environment or the culture of the locals.

The main characteristics of eco-tourism are:

- It focuses on local cultures, wilderness adventures and volunteering,
- Helps in minimizing the adverse effects of traditional tourism on the natural environment,
- Enhances the cultural integrity of local people.
- Promote recycling, energy efficiency, water reuse, and the creation of economic opportunities for local communities.

As mass tourism often ends up with destruction of natural resources, ecotourism can reduce the negatives associated with mass tourism and help in conservation. On the other hand, it will also create avenues for employment opportunities, income generation and education of the host communities.

Ecotourism has an educational concept in which both the visitor and the local community is enlightened on positive environmental activities so as to instil the preferred environmental friendly values in participants. This also enhances the general environmental awareness of the participants and provides direct finance for conservation efforts.

Community based Eco-Tourism (CBET) ensures that the benefits, both social and economic, are realized by local communities. As a conservation tool, can be a powerful incentive to protect the environment. It can reduce pressure on protected areas by providing the local communities with less-consumptive options for income and employment. If local people receive direct economic benefits from a protected area, they are less likely to resent its presence and more inclined to support management activities. CBET can also act as a deterrent to animal and plant poaching by increasing the presence of outsiders (making it more difficult to carry out these activities without being detected) and by shifting the value of wildlife to being worth more alive (as a tourist attraction).

Outside of protected areas, CBET offers a sustainable land use that can support the broader goals of forest, agriculture, and open space preservation. By upgrading local infrastructure to meet the needs of tourists, the living standards and resource use practices of local communities can also be improved, especially in the areas of public health, sanitation, energy, and waste management. In this way, CBET can function both as a conservation and rural development strategy. For example, home stays in villages are geared toward families and focus on enjoying the peaceful, unpolluted surroundings and experiencing village life. Recreational activities include day hiking, fishing, and mountain biking. Thus, it will be beneficial to have ecotourism integrated and developed in IHR.

Several measures are required in terms of policies and plans to ensure that the tourism in IHR grows sustainably. A recent report by NITI Aayog on Sustainable Tourism in IHR recommended consideration of climate change mitigation and adaptation actions in state and national policies and strategic plans and investments for sustainable tourism in the IHR. The report also suggested utilization of revenues generated from tourism for the development of this sector and creating enabling conditions for the business sector to invest in conservation and in inclusive tourism business with local stakeholders as key partners (NITI Aayog, 2018).

Case Study

Sikkim is one of the very popular tourist destinations in the Himalayan Region. It is one of the key economic sectors of the state crucial for growth and livelihood. As a pioneering step towards making this growth sustainable, Sikkim launched a State Tourism Policy in 2018.

The policy aims to develop the state a highly valued responsible tourism destination with tourism contributing significantly to the state economy while conserving its natural and cultural heritage. The policy has been drafted on the principles of environmental sustainability, cultural integrity, equity inclusiveness, and social justice. It is an outcome of a participatory process comprising of a series of brainstorming and periodic meetings with the tourism stakeholders, scholars, experts and officers from various line departments and the public at large.

The key goals of the policy are i) developing tourism as a key sector in Sikkim's economy, ii) promoting low impact sustainable tourism iii) making Sikkim a prime 'round the year' destination for nature, adventure and culture based tourism within India and globally, iv) ensuring tourism benefits are broad based to support local, social and economic development and also ensure social justice, and v) ensuring all tourism infrastructure and services shall be of the best standards and quality delivering a consistent high level of satisfaction and hospitality to tourists.

The policy mentions about promoting sustainably managed tourism destinations by addressing overcrowding in ecologically sensitive high altitude wetlands such as Gurudongmar and Tsomgo (WWF, 2018).

Historically, Sikkim has been the first Indian state to take several initiatives towards promoting ecotourism. The South Asian Regional Conference on Ecotourism organised in Sikkim in 2002 served as a milestone in introducing the concept of ecotourism and community-based tourism to Sikkim. Several ecotourism sites in different parts of the Kewzing, Yuksam, Dzongu and Pastanga were some of the first Community-based Tourism (CBT) sites that evolved and established on its own. The core components of these CBT initiatives have been the village homestay, a model that benefitted the local communities.

Since then the Government has taken several initiatives to promote village tourism and ecotourism including:

- The notification of the Sikkim Ecotourism Policy in 2011;
- The Sikkim Registration of Homestay Establishment Rules 2013; and
- The construction of 736 homestays (Hospitality Division, Department of Tourism, GoS) under the rural tourism programme funded by the XIII Finance Commission in different villages all over Sikkim (Government of Sikkim, 2018).

Sikkim has successfully developed tourist destinations & circuits to popularize less developed areas, without burdening the sensitive ecology of Himalaya, by developing local infrastructure and planning activities to attract tourists.

Sikkim simplified the procedure for registration and notification of village/home stay tourism. Concessions and tax waivers were provided for small industries, village tourism & home stay, adventure, eco-tourism, wellness tourism, transport, publicity, promotion and marketing etc. Under the scheme called "Sikkim Tourism Development Scheme" concession or assistance up to certain percentage of project cost was provided for homestays.

The Sikkim Ecotourism Policy, 2011, identified the need to encourage cooperation between the key stakeholders such as entrepreneurs such as homestay operators; tour operators and tour agents; government organizations; and other key players in the development of ecotourism infrastructures and promotion of ecotourism products.

This has resulted in the setting up of many village homestays in different parts of the state. The village or community based tourism gives the visitor a chance to interact with locals and participate in their daily lives. It also helps local communities protect their cultural and natural heritage for future generations. The state of Sikkim has recognized all these opportunities and implemented them effectively for the betterment of their own people and becoming a role model for the rest of the country. Local voluntary bodies have also made consistent efforts to supplement the government's initiative.

Sikkim has led the way in community based tourism initiatives, and has models that showcase good practices of revenue generation and sharing. It has been a pioneer in promotion of homestays which ensures tourism benefits directly for communities. An interesting state policy ensures that each one of the participating household benefits from tourism. Hence a rotation policy is practiced under which tourists are sent to homes one by one on turn basis. The money spent by the tourists is also equally distributed among the service providers, which supports capacity building trainings and programmes for the community and for the local children's educational facilities.

The success of the homestay movement in the Himalayan state of Sikkim is categorized by a sustainable operations model that enables the local communities to build their capacity vis-à-vis communication skills, hospitality management and demonstrating arts and crafts.

The initiatives undertaken by Sikkim are an example of how tourism can be a key driver for economic growth in a sustainable manner. The approach can be adopted by other Himalayan States as a model

Module 5-12 provided information on sectoral adaptation. The next three modules (13-15) deal with issues such as gender, finance and monitoring and evaluation which are cross-cutting and would be relevant in all sectors where adaptation actions are required.

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13.1 Introduction

This module explores the gender dimensions of climate change in IHR and presents a case for integration of gender aspects in adaptation planning.

Gender is a social, cultural and personal construct, and not a biological construct; separate from the sex-based categories of male/female. Gender is determined by the conception of tasks, functions and roles attributed to women and men in society in public and private life. There is a misconception that 'gender' refers solely to women. Profiles of at-risk populations throughout the Himalayan region generally underscore how myriad factors intersect to create the conditions of social exclusion and marginality that render some more vulnerable than others. Men and women from ethnic minorities and socially marginalized populations are highly vulnerable, in many respects more so because their cultural and linguistic marginality reinforces their socio-political marginality (ICIMOD, 2017).

Social factors are important factors determining the strength and vulnerability to the impacts of climate change. Gender is a key determinant of vulnerability to climate change. Women often face social constraints, have limited opportunities for education and are excluded from political and household decision-making processes that affect their lives. Further, they tend to possess fewer assets than men and depend more on natural resources for their livelihoods.

The projected impacts of climate change are such that the adaptation efforts need to address the relationship between climate change and the extensive socioeconomic sources of vulnerability, including poverty and gender inequality. In addition, women's unique knowledge and skill set concerning development and environmental management could greatly benefit adaptive efforts. As the need for adapting to the unavoidable changes in climate continues to become more and more urgent in national policy processes, it is important to ensure that adaptation responses are pro-poor and gender-aware, informed both by gender-based vulnerabilities as well as the unique contributions of women.

13.2 Impact of Climate Change on Gender

It is increasingly evident that women are at the centre of the climate change challenge. The impacts of climate change on natural resources have direct repercussions for women, who have to spend long hours to fetch water and fuel wood. At the time of disasters, women are more exposed to risk due to less adaptive capacity in terms of resources such as financial, natural, institutional or social (UNDP, 2013). Women are disproportionately affected by climate change impacts, such as droughts, floods, and other extreme weather events, but they also have a critical role in combating climate change (UNFCCC, 2014). The intersections of climate change impacts, poverty, and gender-based inequalities are complex and require continued attention. It has also been argued that within the poor and marginalized groups, women often experience more severe forms of poverty relative to men, due to underlying gender inequalities (Demetriades and Esplen, 2010). Climate change is "not gender neutral as women and men's decisions differ on risk taking lines, use and type of coping strategies, adaptability and advice taking and information seeking behaviours" (Nursey-Bray 2015:1).

Consequently, in many communities, climate change will have a disproportionately greater effect on women. Many factors contribute towards this disparity-

- Inequitable distribution of rights, assets, resources and power
- Repressive cultural rules and norms,
- Greater responsibilities, making them often poorer and less educated than men and
- Exclusion from political and household decision-making processes that affect their lives

Climate change impacts will have detrimental effects on gender divisions of labour and access to and control over resources and intensify the existing gender vulnerabilities.

13.3 Linkages of Gender with sectors

Gender and water resources in Himalayan Region

As discussed in module 1, there is evidence of rising temperatures, variability in rainfall and longer and more intense periods of drought and floods in IHR. An increase in the severity and frequency of monsoonal storms and flooding in the region is expected, exacerbating the incidences of landslides in Himalayas. The broad implication of this pattern means inadequate access to water for meeting household, agricultural and other needs. There will be shorter periods of intense and sometimes devastating water flows in the form of flash floods, riverine floods and waterlogging. Water holds very different significance for women and men. "Women are intrinsically tied to water" in ways that don't necessarily hold for men (WHO 2011: 21). As in other regions, women and men participate in use, management, benefit sharing and decision of water, but with different degree of needs, problems, and access to and control over water resources. It is women and their daughters who carry the main responsibility for collecting, storing, protecting and distributing water within the household for drinking, cooking and washing, as well as for animal husbandry. With declining water availability, the drudgery of women increases as they have to fetch water from far off places.

Gender and Agriculture in Himalayan Region

Agriculture is particularly sensitive to climate-induced changes as availability and access to water is affected due to changing rainfall patterns. Agriculture is expected to be affected differently throughout the region, with some places projected to experience a decline in potentially good agricultural land, while others will benefit from substantial increases in suitable areas and production potentials. In the Indian Himalayas and across very different agro-ecological zones and production systems, women have historically played a central role in subsistence economies, whether in farming or forest-related work, in pastoral economies or in shifting cultivation systems. Women are involved in major labour intensive activities across the Himalayan region. Women's roles as primary supporters of homesteads and family farms in IHR have intensified over the past few decades. Lack of employment opportunities in rural areas have pushed men into seeking alternative livelihoods in the urban centres near or far-off places. With the current and projected impacts of climate change on agricultural productivity adding to the increased trend of migration, the challenges for women only seem to get aggravated.

Energy and Gender

As indicated in Module 11, energy poverty has a strong gender dimension. Women are primarily responsible for collection and management of energy fuels. In IHR, dependence on firewood for fuel is significant and it is mainly women who carry firewood and fodder from forest. Energy demand for household chores such as cooking and space heating are mainly managed by the women. Extensive use of biomass as fuel has been resulting in indoor air pollution which significantly impacts the health of women. With increasing forest degradation, the drudgery of women will increase as they will have to fetch firewood and fodder from far off places.

Migration and Gender

Conditions of uncertainty created by unpredictable weather patterns characterised by unseasonal temperatures and extreme events have a significant role to play in migration. Floods, acute water stress, landslides, and accumulating changes such as land degradation, and declining freshwater resources exert relatively more permanent and dispersed effects. Added to these are factors are multifarious issues vis-à-vis the lack of development, dependency on the natural resources for livelihood, high population density and growth, and income inequality.

An important characteristic of migration in the IHR is its gender specificity, limited to men they leave varying degrees of time, moving to other lowland areas or migrating across geo-political boundaries in search of work; while women remain in the villages to maintain homesteads and family farms. A major reason for this is "migration requires economic and physical capacities that are not available to everyone", particularly women who do not have these due to the social constructs of gender.

13.4 Integrating Gender in Adaptation in IHR

Owing to the gender sensitivities related to the impacts of climate change on different sectors in the Himalayan region, it is imperative that adaptation planning addresses these gender specific issues.

Research and policy collaboration with local institutions is important not only for policy outcomes but also for "expanding forms of social capital and networks of support the face of livelihood uncertainty and ecological change" (Ogra and Badola, 2015). Some of the factors to be considered while addressing gender specific issues for climate change adaptation are:

- Community-based self-help group (SHGs) networks and collectives have a vital role in strengthening the capacity of communities in general and women in particular. This enables participating in collective measures to create new, or strengthen existing, safety nets.
- SHGs facilitate participation of women in livelihood activities and reduce their financial risks, though on a small scale. There is tremendous potential to scale the initiatives such groups engage in, ranging from participation in adaptation-related activities to documenting local-level practices and knowledge.
- Identify, acknowledge, replicate and adapt productive livelihood contributions of mountain women.
- Identify other informal social support systems (e.g. systems through which exchange labour is shared) that could be leveraged to enable women and men to access skills, resources and information.

Women's Role in adaptation to Climate Change

As hills are fragile and women are more at-risk to the climate change, there is a need to prioritize adaptation measures. This would require developing a framework to guide adaptation projects through participatory approach. Women possess invaluable indigenous knowledge and skills that should be recognized and mainstreamed into programs to develop resilience. This knowledge is important to manage climate-related risks regarding agricultural production and inform adaptation policies. Women have better access to social networks which is important for disseminating adaptation practices.

A **gender-sensitive approach** means understanding the complexity in how gender currently affects vulnerability to climate risks, and the ability of both men and women to cope with and adapt to climate variability and change. The active contribution of men and women in building resilience will mean that practical issues need to be addressed across sectors affected by climate change. Women's participation, in particular, will help make a substantial contribution to impact and sustainability. This includes how well committees function, access to potable water and public services; and the uptake of climate-resilient agricultural techniques.

Gender blind may be described as the inability to perceive that there are different roles of gender, needs, responsibilities of men, women, boys and girls and others. This leads to a serious lack of understanding of factors that impact the policies, programmes and projects.

Mainstreaming of Gender in Adaptation Funding

The Green Climate Fund (GCF) is the first climate finance mechanism to mainstream gender perspectives at the outset of its operation. This is as an essential decision-making element for the deployment of resources. GCF has placed gender as a key element of its programming architecture, and its commitment to gender equality centres on gender-responsive climate action programmes and projects, benefiting women and men. Gender mainstreaming is the central theme of the GCF's objectives and guiding principles, through engaging women and men of all ages as stakeholders in the design, development and implementation of strategies and activities to be financed (GCF 2012).

Gender equality is increasingly recognized as a crosscutting issue in major adaptation planning. The 1992 Rio Declaration on Environment and Development acknowledged in Principle 20 women's "vital role in environmental management and development" with Agenda 21 focusing in its Chapter 24 on women's considerable knowledge and experience in managing and conserving natural resources. In 2014, Lima decision 18/CP.20 established a two-year work program on gender in the UNFCCC to "advance gender balance, promote gender sensitivity in developing and implementing climate policy and achieve gender responsive climate policy in all relevant activities under the Convention."

Mainstreaming of gender is globally accepted strategy for promoting gender equality. It involves the process of assessing the implications of planned action, including legislation, policies or programmes, in any area and at all levels. It is a strategy that includes experiences and concerns of women as well as men an integral part of the design, implementation, monitoring and evaluation of policies and programmes. This is done to ensure that women and men benefit equally and inequality is not perpetuated. The targeted actions ensure that woman's voices as important actors are heard.

Understanding of issues that affect the differentiated relationship women and men and their ability to cope up with disasters is still at a nascent stage. There is a need to develop an understanding how women and men adapt to climate change in rapidly changing environments and different socio-cultural contexts across the region. While climate variability and environmental changes clearly affect both women and men, gender inequities ranging from divisions of labour to lack of ownership of land and access to critical resources differentially shape coping strategies and ability to adapt. And, while women play a vital role in maintaining the biodiversity upon which subsistence livelihoods depend, there are still serious lacunae in our understanding of their skills, capacities, knowledge and the range of competencies in their day-to-day tasks.

Following are some of the approaches through which gender can be mainstreamed while responding to climate change through specific activities:

Key Activity	Measures
Establishment and strengthening of Institutions (State/District/Panchayat level) for climate change action	• Seek to ensure gender balance in composition/staffing of the institution. • Ensure that representatives of women's groups are involved in stakeholder consultations. • Raise awareness and provide training to women's groups regarding climate finance.
Developing strategic frameworks for state level engagement	• Ensure that representatives of women's groups are equally involved in stakeholder consultations regarding the development of the strategic framework. • Identify a range of desired gender-related development impacts of climate change programming in the state and make sure those are incorporated in the strategic framework.
Selection of implementing entities or intermediaries	• Support implementing entities in preparing gender assessments and action plans. • Provide guidance and training to potential implementing entities on gender-responsive project design and implementation.

Adopted from NABARD, 2015

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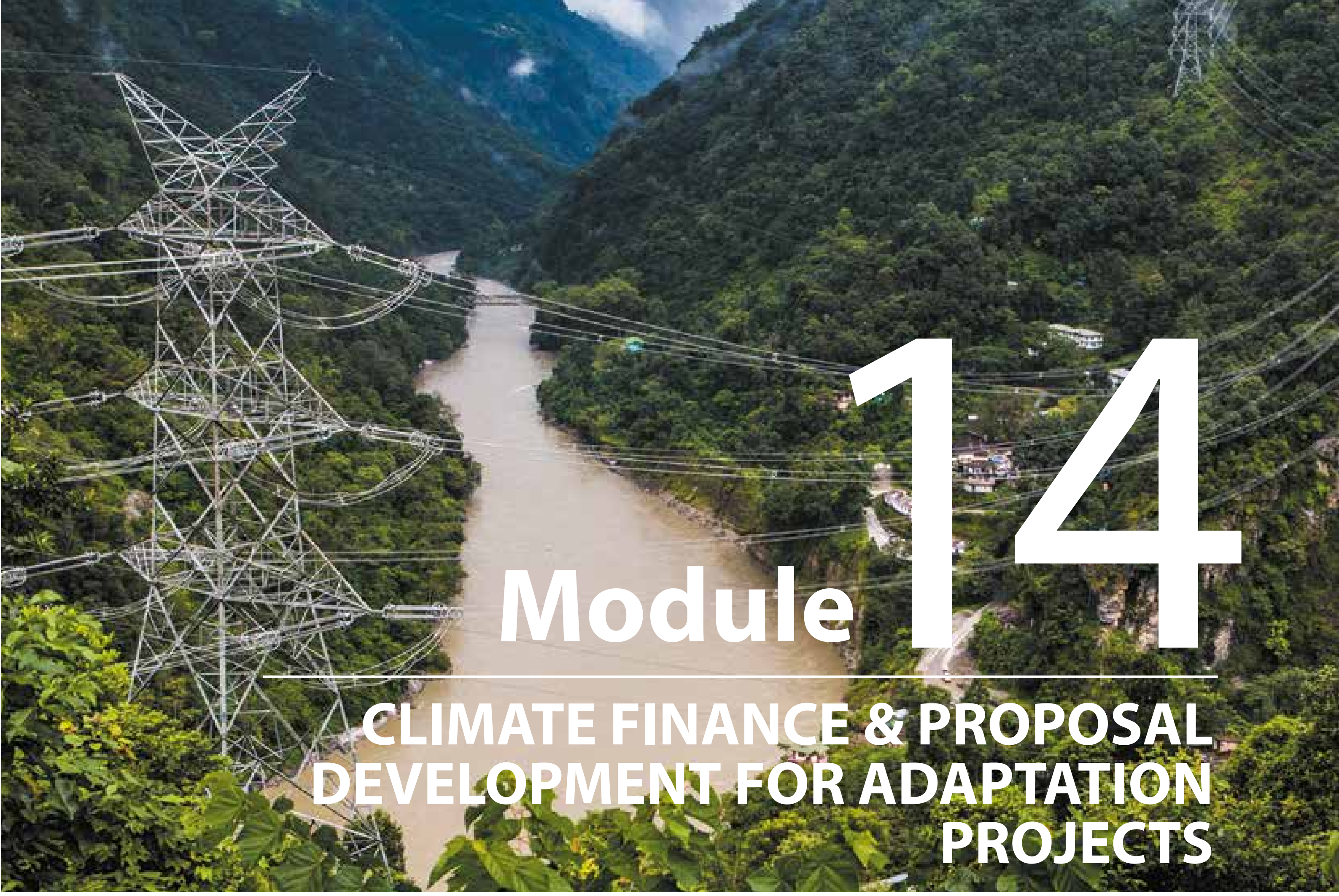


Module 14

CLIMATE FINANCE & PROPOSAL DEVELOPMENT FOR ADAPTATION PROJECTS

14.1 Introduction

Planning and implementing adaptation requires financial resources. This module discusses some of the international and domestic funds available for adaptation in IHR. It also provides guidance on development of proposal for receiving adaptation funding.

Climate finance refers to the financial resources mobilized to help least developing countries, local government and communities to mitigate and adapt to the impacts of climate change, including public climate finance commitments by developed countries under the UNFCCC (2012). According to UNFCCC, it is the "finance that aims at reducing emissions and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts". The necessity of climate finance has been recognized in the global climate deal adopted at the COP21 session of the UNFCCC in Paris on 8th December 2015.

Climate Finance in India

The scale and scope of climate finance required in India is huge and the financing architecture is complicated. India's multi-pronged approach to deal with this crowded institutional space for climate finance leverages private finance and uses fiscal instruments and market mechanisms to generate public finance. Thus, the NAPCC and the SAPCCs are not backed by a coherent climate finance strategy. Climate finance was first addressed in India's Economic Survey 2011-12. This was confined to the estimated cost of the NAPCC. The cost for the NAPCC was estimated at Rs 251,350 (about USD 38 billion). The subsequent economic survey 2012-13 put this figure at Rs 230,000 crore (approx USD 35 billion). The consecutive economic survey 2013-14 gave a financial outlay of Rs. 256, 836 crores (approx. USD 42 billion) for the NAPCC during the 12th Five-year Plan (2012-2017).

India has put forward a figure of USD 2.5 trillion (at 2014-15 prices) in its NDC as its price for achieving its mitigation and adaptation targets by 2030. Implementing climate change mitigation and adaptation actions defined in India's NDC would require domestic and additional funds from developed countries in view of the resource required and the resource gap. Financing for SAPCCs in the country was to be made available in the course of implementation of state plans in various sectors with the resources being mobilized through budgetary support (Planning Commission 2011).

Moreover, state climate plans were initially developed under the promise of substantial funds under the 12th FYP. But, in the course of the plan development the amount of funding available for states was very modest. This in turn has led to a greater emphasis on attracting donor funds to support the implementations of state climate plans. Engagement with the private sector, both as a recipient and provider of climate finance, has been growing but primarily in an ad hoc manner.

14.2 International and Domestic Funding Mechanism

What is the Green Climate Fund?

The GCF is a fund within the framework of the UNFCCC (2012) founded as a mechanism to assist developing countries in adaptation and mitigation practices. GCF resources are deployed for climate resilient development and low emission strategies to counter climate change. GCF as the main arm of global, multilateral climate finance, it is also accessing climate-related funds administered by the World Bank, the Asian Development Bank and other multilaterals and bilateral organisations. India is among the largest recipient of multilateral climate finance for mitigation. India has favoured grants as climate finance but is not averse to concessional loans, in contrast to island states and LDCs. The designated national authority to disperse the fund in India is NABARD. Currently, there is a single project in India which has got approval under the GCF. The project aims to promote groundwater recharge and less water-intensive irrigation in Odisha. The total funding available for this project is USD 34–36 million.

Read more about GCF at https://www.greenclimate.fund/home

What is the Adaptation Fund?

The Adaptation Fund (AF) was set up by the UNFCCC in 2001 to finance adaptation programmes in non-annex countries. However, the first operative recognition of the importance of climate finance with goal of investments towards building resilience and de-carbonisation came quite late in 2009. During COP15 held at Copenhagen, it was promised to mobilize USD 100 billion a year by 2020 for post-2020 long-term financing of developing countries to reduce potential emissions and adapt to climate change impacts. The adaptation fund is financed with a share of proceeds from the Clean Development Mechanism (CDM) project activities and other sources of funding. The share of proceeds amounts to 2 per cent of Certified Emission Reductions (CERs) issued for a CDM project activity.

India is taking an innovative approach to combating climate change by establishing six small-scale adaptation fund projects on the ground in diverse regions of the country across a variety of adaptation sectors. Developed through the fund's national implementing entity in India, NABARD, and implemented with support from local organizations, projects are implemented in the north-western Himalayas, central Madhya Pradesh region, eastern region, Rajasthan in the west and the eastern and southern coasts. The projects interventions are tailored to the local adaptation need, from climate-smart agriculture to food security, fisheries, forestry, managing coastal zones, and collecting and conserving water.

National Adaptation Fund for Climate Change

The Government of India has established a National Adaptation Fund for Climate Change (NAFCC) to support adaptation actions to combat the challenges of climate change in sectors like agriculture, water, and forestry. NABARD has been designated as National Implementing Entity (NIE) for implementation of adaptation projects under NAFCC by MoEF&CC, GoI. Under this arrangement, NABARD facilitates identification of project ideas and concepts from SAPCC, project formulation, appraisal, sanction, disbursement of fund, monitoring and evaluation and above all capacity building of stakeholders including state governments. The projects under NAFCC prioritize the needs that build climate resilience in the areas identified under the SAPCC and the relevant Missions under NAPCC. During the year 2016-17, nine projects were sanctioned under NAFCC, with an outlay of INR 207.70 crore. Cumulatively, 27 projects with a total amount of INR 660.0 crore have been sanctioned by NSCCC under NAFCC till 2018.

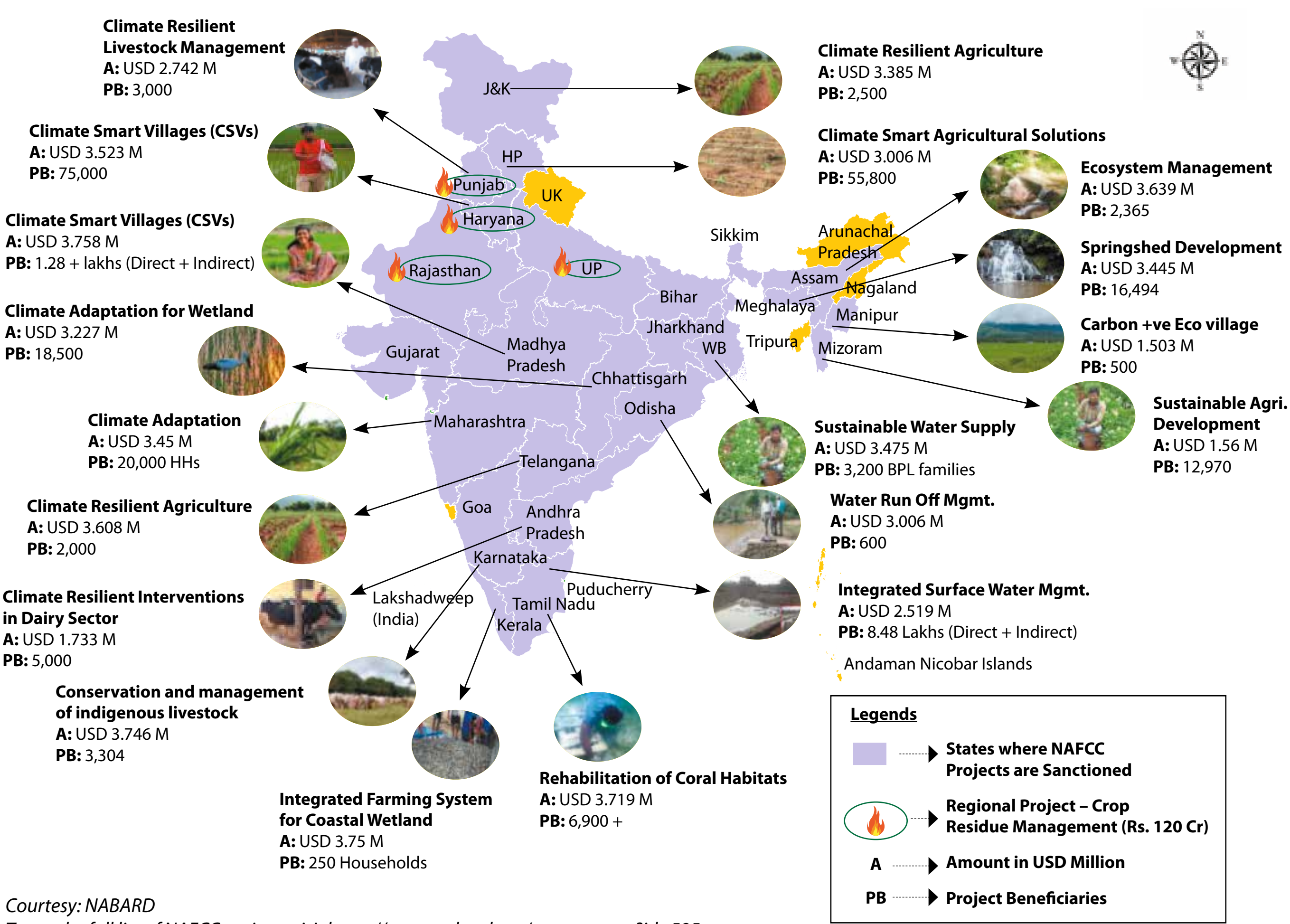
NABARD as National Implementing Entity

India is clear on its approach to international climate finance and has been quick to set up systems to access the AF and the GCF by appointing NABARD as the NIE. As NIE, NABARD can access two global funds and is accredited as Direct Access Entity (DAE, National) for NAFCC. It is responsible for the overall implementation of the project through its regional offices located in the states & UTs. Ministries / departments of government

List of Adaptation Fund Projects in India

Name of project	State	Project outlay (US $)
Climate Smart Actions and Strategies in North Western Himalayan Region for sustainable livelihoods of agriculture-dependent hill communities	Uttarakhand	969,570 (2015–19)
Building Adaptive Capacities in Communities, Livelihoods and Ecological Security in the Kanha Pench Corridor in Madhya Pradesh	Madhya Pradesh	2,556,093 (2016–21)
Building Adaptive Capacities of Small Inland Fishers for Climate Resilience and Livelihood Security in Madhya Pradesh	Madhya Pradesh	1,790,500 (2015–18)
Conservation and Management of Coastal Resources as a Potential Adaptation Strategy for Sea Level Rise	Andhra Pradesh	689,264 (2015–19)
Climate Proofing of Watershed Development Projects in the States of Rajasthan and Tamil Nadu	Tamil Nadu Rajasthan	1,344,135 (2015–18)
Enhancing Adaptive Capacity and Increasing Resilience of Small and Marginal Farmers in Purulia and Bankura Districts of West Bengal	West Bengal	2,510,854 (2015–19)
TOTAL		**9.8 million**

Figure 14.1: NAFCC Coverage in India (2018-2019)



Courtesy: NABARD
To see the full list of NAFCC projects visit https://www.nabard.org/content.aspx?id=585

of India and states government department are the executing entities eligible to submit proposal for accessing fund from NAFCC.

State level Climate Change Finance in India

The SAPCCs identify priority actions for responding to climate change. A range of actions under various themes and sectors are identified. The identified actions are anywhere between 50 and 150 representing about 10 themes or sectors. Some of these actions address climate change specifically through research studies. Many are 'mixed actions' that contribute to sustainable development while also responding to climate change. State governments are already undertaking many activities to help reduce the impact of climate change. For e.g. on farming systems, water security and disaster management. There is some evidence that the current spending on such adaptation actions will reduce climate change damage and loss by between 10% and 20%. This will have a positive direct impact on state's GDP, depending on factors such as level of vulnerability and adaptation spending.

All Indian states including the ones in IHR have provided estimates of the costs of SAPCC actions. These have been produced mostly through bottom-up exercises which calculate how much is required to implement the actions. The new climate funds provide opportunities to boost the importance of adaptation and to pilot new adaptation approaches. The states are in the process of preparing adaptation strategies and activities to access climate funds. However, it is important to ensure that the mixed actions are not neglected in the budget as a result of the international and national climate funding.

Accountability of India's expenditure on adaptation

The NAPCC in 2008 put 2.63% of the GDP in 2006-07 as India's spend on 'adaptation to climate variability. The identified 'adaptation' programmes in the NAPCC spanned eight areas - (a) crop improvement and research (5.93%); (b) drought proofing and flood control (3.04%); (c) forest conservation (0.49%); (d) poverty alleviation and livelihoods preservation (44.65%); (e) rural education and infrastructure (26.85%); (f) health (10.75%); (g) risk financing (4.83%); and (h) disaster management (3.46%). Subsequently, no new figures were given until the INDC document. The INDC revised downward the adaptation expenditure to 1.45% of the GDP in 2000-01 and then increased it to 2.82% of the GDP in 2009-10, higher than the 2006-07.

Climate Finance for IHR

The urban and rural areas of IHR are at an all-time risk to climate change-induced disasters like cloud bursts, flash floods, and glacier lake outburst floods (GLOF) and landslides. The Himalayan glaciers, feeding nine of India's largest rivers, are retreating threatening food and water security of millions of people in the downstream areas of India and its neighbouring countries in South Asia. It also reduces power generation capacity from dams and micro-hydro projects. India is among the world's 10 most disaster-prone countries and climate change is projected to worsen the situation, and therefore financial requirement of NAFCC / AF /GCF is pressing need for investments in disaster preparedness and restoration and addressing social and economic impacts of loss and damage.

14.3 Proposal development for adaptation project

Concrete adaptation project is defined as a set of activities aimed at addressing the adverse impacts of risks posed by climate change. The activities aim at reducing vulnerability and enhancing the adaptive capacity of communities and natural system to respond to the impacts of climate change and variability. The project activities should align with its overall goal and objectives hence ensuring the cohesion of the components, clearly demonstrating that the proposed adaptation measures are best suited or adequate for the identified climate threats. The project proposal should clearly articulate the project rationale in relation to the climate scenarios outlined in the background and context section.

The proposal should include information on the expected beneficiary of the project, with particular reference to the equitable distribution of benefits to vulnerable communities, household, and individual. In targets areas where minority groups and indigenous communities have been identified specific benefits provided by the project to those groups should be outlined. The estimated benefits will have to be quantified, whenever possible. Fig 14.2 and the following steps summarize the major steps involved in the project proposal development for the GCF. The steps can be replicated for the preparation of any other proposal for an adaptation project.

Figure 14.2: Stages of Proposal Development

STEP-1 Defining the project scope.

The first step is to define the scope. A scoping analysis will enable better understanding of the strategic context in which the project will take place, and will inform the description of the baseline scenario in the project proposal.

STEP-2 Developing a logic framework

The logic framework (log frame) is one of the most often-used methods to articulate and clarify how a set of activities will achieve a project's desired outcomes and objectives (its theory of change). The theory of change represents the long-term vision of the project and how this can be achieved through short-, medium- and long-term changes. Hence the log frame serves as a results map that also captures the basic monitoring and evaluation (M&E) requirements. The project's log frame is critical to determine the costs at the activity level, the overall budget, the timeline and key milestones.

STEP-3 Assessing the project risks and identification of mitigation measures

Under this step, the project managers are required to identify any substantial technical, operational, financial, social and environmental risks that the project/programme may face, and propose respective risk mitigation measures.

STEP-4 Gender mainstreaming

Gender mainstreaming in the project requires developing a gender assessment and a gender action plan (GAP). This entails undertaking a comprehensive socio-economic and gender assessment, including relevant gender-equitable stakeholders' consultations and engagement.

STEP-5 Measuring progress through indicators

An indicator is a quantitative or qualitative factor that provides simple and reliable means to measure achievement, to reflect the changes connected to an intervention, or to help assess the performance of a development actor. The adaptation projects will use indicators to evaluate the progress and performance of a project.

STEP-6 Aligning a project against the GCF investment criteria

The fund's investment framework details possible indicators (or indicative assessment factors) that may help entities to quantify impact potential. For example, a renewable energy project may wish to provide the expected number of beneficiaries or MW of low-emission energy capacity installed, generated and/or rehabilitated.

STEP-7 Identifying rationale

This step describes how to justify the rationale in a project or programme. In addition, the funding proposal should demonstrate how the project's sustainability (exit strategy) will be ensured in the long run, after the project is implemented with support from the external funding and other sources.

STEP-8 Monitoring and evaluation

This step provides an overview of the Monitoring and Evaluation (M&E) and reporting responsibilities to the GCF. The Accredited Entities (AEs) are primarily responsible for the M&E of their funded projects or programmes, and will report accordingly to the fund available.

Monitoring and evaluation requirements for the project or programme include:

- Log-frame and identification of indicators in the funding proposal
- Annual performance reports from the project or programme
- Interim and final evaluations at the project or programme level

STEP-9 Budgeting

This is required for the entire project cost (including co-funding), and is used to inform the level of concessionality the project proponent will request from the funders. It is important to conduct an economic analysis to identify and asses the social and economic cost–benefits of the project or programme. Although there is no specific guidance available from GCF on discounting and other approaches, best practice project financial and economic analysis procedures should be followed. A sensitivity analysis of critical elements (including discount rate) and other cost parameters should be performed.

STEP-10 Justification of the level of concessionality of a project

The adaptation fund projects applies a 'least concessional' approach whereby it will seek to provide the least possible concessional funding that makes the proposed project or programme viable. The reason for this is to avoid crowding out other sources of finance that are readily available.

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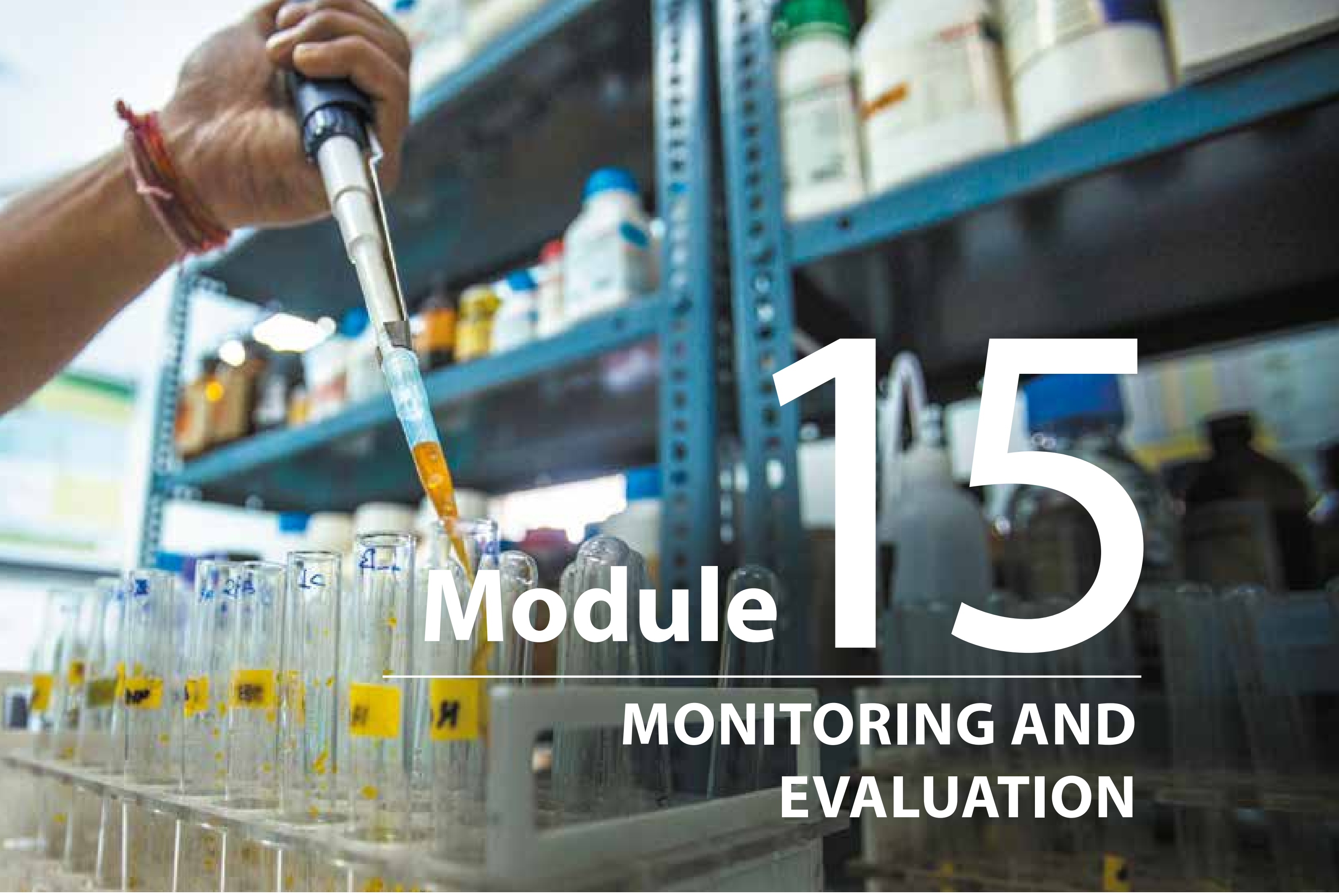

Module 15

MONITORING AND EVALUATION

15.1 Introduction

Module 4 discussed about the concepts of adaptation and guidance for planning and implementing adaptation. Monitoring and evaluation (M&E) is one of the key requirements to ensure that the interventions are effective in achieving adaptation goals. This module focusses on M&E concepts and approaches.

M&E are different processes, which work together to assess the performance of an intervention over time. Monitoring refers to an on-going assessment of the intervention and progress made in achieving set milestones and targets. Evaluation, on the other hand, examines if a system got better adapted to climate change as a result of the interventions, and the extent to which they are now resilient to climate change. Characteristics of climate change, such as uncertainty, non-linearity of climate change patterns, and long-time horizons, pose challenges for monitoring and evaluating (OECD, 2015).

M&E has multiple purposes and benefits, including raising awareness, learning and accountability - it is a tool not an end in itself. Learning is a key in M&E and should be encouraged through creating the necessary enabling environment, drawing from different sources of knowledge, establishing respective communication channels and incentives, building in and budgeting for learning and involving all relevant stakeholders. Peer-to-peer learning and participatory approaches can be effective and help to reveal underlying factors (such as inequality/rights/ structural causes) for vulnerability. M&E helps in the identification of successes and good practices as well as capturing failures and reasons for non-delivery.

Why M&E is important tool?

M&E plays an essential role in understanding where to focus investments, what is working and what is not, why this is the case, and how to learn from experience to know how to maximize impact. M&E can (and should) support strategic and effective investments in climate change adaptation. M&E focuses on prioritization as a strategic toolset for identification of strategies that are not working as well as a tool for ongoing learning and improvement for better results and overall impact.

Basic Components of M&E (STAP, 2017)

Monitoring- Used extensively by national and state level development agencies and financial institutions to assess the progress and effectiveness of projects and programs. M&E of adaptive management practises are processes, tools and techniques that systematically and periodically measure and analyse the processes, outcomes and impacts of adaptation programme activities to achieve the intended objectives. It is the routine collection and analysis of information to track progress against set plans and check compliance to established standards.

Evaluation- is the systematic investigation of the merit, worth or significance of an object. As climate change adaptation funding scales up, it is more critical than ever to ensure the effectiveness, equity and efficiency of climate change adaptation interventions (UNEP, 2012) and to ensure they are readily adopted. Main component of M&E are mentioned below:

- **A results framework**—result-based M&E is a management tool used to systematically track progress of project implementation, demonstrate results on the ground, and assess whether changes to the project design are needed to take into account evolving circumstances through the theory of change and use of log frame model..
- **Indicators** are the parameters of measuring progress toward the intended results (outlined in the results framework) as well as to demonstrate the status of project activities,
- **Monitoring** generally refers to the systematic and continuous collection of data, quantitative and/ or qualitative, about the progress of a project or program over time.
- **Reporting**, alongside monitoring, often at periodic intervals, serve to take stock of progress and support routine management and accountability purposes.
- **Evaluation** is a separate analysis that draws upon all these components, but also involves additional independent data collection and analysis. It is in essence concerned with valuing. The OECD defines evaluation as "The systematic and objective assessment of an ongoing or completed project, program, or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability" (OECD 2002).

15.2 M&E and Climate Change Adaptation

Climate change adaptation poses challenges of unprecedented scale and scope, which cut across normal programming sectors, levels of intervention, and time frames. Climate adaptation exhibits a number of characteristics, not necessarily unique to adaptation, but requires specific consideration for monitoring and evaluation to be effective. These characteristics include:

- **Long-time frames:** Climate change is a long-term process that stretches far beyond the span of programme management cycle. The real impact of climate change adaptation may not be apparent for decades. Then how then to define and measure achievements?
- **Uncertainty about actual climate change patterns and their effects in a given locale:** While we are confident that climate change will trigger more severe adverse weather events globally, it is unclear exactly how and when changes will unfold, and what their consequences will be in site. Some locations are also likely to be affected very deeply, but by indirect means. For example, drought exacerbates rural-to-urban migration. Even if a city is not at all affected by increased frequency and severity of drought, an influx of rural poor from a neighbouring region may overwhelm the city's functioning and services.

The basic structure of a Log-Frame appears like this:

	Description	Verifiable indicator	Responsible parties	Assumptions/Risks
Outcome 1				
Output 1.1				
Output1.2				
Outcome 2				
Output 2.1				
Output 2.2				

- **Shifting baseline data and changing contexts:** This issue is of particular interest to M&E specialists, and is related to the above two points. The normal approach to programme evaluation includes collecting baseline data against which progress can be tracked. However, climate change itself is both unpredictable and taxing on local ecosystems and populations. Comparison of pre- and post-intervention data thus loses validity.
- **Measuring non-events:** Particular adverse weather may not occur during the programme cycle, and 'success' may constitute stabilization or preparedness rather than improved conditions. For example, a programme to improve the capacity of a flood-prone region's administration to cope with disasters will not be tested if no flood hits during the actual programme cycle. Meanwhile, in a context of increasing drought, maintaining rather than improving a community's level of water security may constitute considerable achievement. While this may be widely understood among practitioners, it may be difficult to convince donors or policymakers to approve these kinds of results.
- **Inappropriateness of universal indicators:** While there are clear-cut indicators for climate change itself, adaptation must be grounded in the context, scale, sector, and nature of the endeavour, all of which vary widely. Moreover, many aspects of adaptation are 'soft' (e.g. institutional capacity, behaviour change), and for some key dimensions qualitative assessments are most appropriate. It may be difficult to aggregate community-level programme indicators at higher scales or, conversely, for national- or international-level ones to capture the effectiveness of interventions at the individual or household level.
- **Contribution vs. attribution:** M&E approaches usually seek to demonstrate that changes can be attributed specifically to a project: for example, that a village's improved food security is due to an agency's agricultural extension programme. However, the complexity, multi-sectoral nature, scales, and long time frames of climate change require a modified approach to M&E. Stakeholders instead need to demonstrate how their policy or programme contributes to an overall adaptation process that is largely shaped by external factors. This may require the appropriate and judicious use of process and proxy indicators.
- **Diversity of key definitions and terms:** There has been a proliferation of climate change adaptation technical terminology. Basic concepts like "adaptation" and "vulnerability" are being defined in different ways by different agencies. There is considerable overlap and duplication of key terms; meanwhile more specialized ones (e.g. "transformative resilience") may be essential to one agency or document but poorly understood beyond it. There can also be confusion about some of the nuances (e.g. "adaptive capacity" vs. "ability to adapt").

Additionally, further challenges become evident, including lack of consensus on key concepts and definitions, lack of clarity on what constitutes achievement, and the extent to which climate change adaptation is mainstreamed into existing efforts or constitutes a discreet area of intervention. Traditional approaches to M&E need to be modified to meet the unique needs of climate change adaptation programming. Different climate change adaptation M&E initiatives, guidelines, and frameworks exist with important differences in approach, methodology, and intended audience.

Strengthening CCA M&E

Climate change adaptation action plans are affected by uncertainties and focus on valued objectives, and involve risks. According to the Fourth Assessment Report, the IPCC has endorsed iterative risk management as a suitable decision-support framework for climate change adaptation. It offers standardized methods for addressing uncertainty, involving stakeholder consultation, identifying potential policy responses, and evaluation of those responses (IPCC 2007).

Monitoring, evaluation and learning is also one of the key principles of effective decision support, where learning outcomes and review become important to track the progress of the project. In an unprecedented scenario desired outcomes may not be achieved, then reframing of the decision criteria, process and goals may be required. This is the central idea underlying adaptive management.

Challenges in CCA and M&E (STAP, 2017)

Challenge 1: Evolving knowledge on key concepts and constructs

A particular challenge for M&E in the context of climate change adaptation lies with the definitions and theories of the core terminologies. For example, the starting point of M&E is the results framework – which signifies expected results and the objectives to be achieved. In climate change adaptation, questions about what adaptation is or what constitutes "successful" adaptation are still widely debated – and this poses an obvious challenge for M&E efforts.

Challenge 2: Lack of suitability of many conventional M&E approaches for climate change adaptation

Conventional M&E approaches assume that the interventions are relatively standard, with a relationship where a known type of intervention will result in known outcome, and this pattern can be repeated consistently. CCA is typically a much more complex, long-term, uncertain and unpredictable undertaking. As a result, this requires alternative and creative M&E process. Mixed methods, systems approaches, innovation, and learning approaches are favoured over single-method M&E designs.

Challenge 3: Identifying indicators and establishing baseline target

There is a lack of widely agreed indicators to determine the effectiveness of climate change adaptation interventions for context specificity, difficulty in identifying meaningful impact indicators, and challenges with aggregation. Setting baselines and targets is highly complex in nature owing to rapidly changing nature of climate vulnerability, risks and impacts, and our inability to predict how climate change adaptation will materialize in the future

Challenge 4: Assessing attribution

Due to the many natural, social, and economic influencing factors affecting climate change adaptation, the reality that many donors or other contributors are supporting the same resilience intervention, and methodological challenges surrounding attribution in complex systems change scenarios, it is often hard or impossible for evaluations to directly attribute results to a particular intervention. For this reason, establishing contribution to a particular change or result, not attribution solely to one intervention, is typically more realistic.

Challenge 5: Connecting M&E across scales

Climate change adaptation at one scale—such as the local level—may not equate to adaptation at a regional or national scale. The lack of predictable comparability, replicability, and scalability of climate change adaptation create practical methodological challenges for M&E—pointing to creative and mixed-method approaches—as well as calling into question the external validity of evaluation findings.

Challenge 6: Lack of M&E expertise and capacity

Countries and other entities implementing CCA measures often do not have institutional structures, technical capacity or the resources to carry out M&E activities. It is a resource-intensive activity which requires sound technical, financial and trained human resources. From a developing country perspective, putting together these resources may be a challenge. Moreover, climate change adaptation M&E requires specialized training in cross-disciplinary expertise. The resources and capacities needed to undertake this successfully are not often present. Starting with simple M&E, investing in building M&E capacity, and expecting M&E to evolve and improve over time are ways to manage this challenge, which cannot be entirely avoided.

15.3 Applying M&E for CCA

Project-level CCA M&E

Project-level M&E is standard for most internationally and nationally funded climate change adaptation projects such as GCF and NAFCC respectively. The key steps of M&E requirements involve (i) developing a results framework (ToC, logic model, log frame, or equivalent), (ii) identifying indicators to match the results framework, and (iii) monitoring and reporting on the indicators on a routine—often annual—basis.

Mid-term evaluations and terminal (final or ex-post) evaluations are also common, though many climate change adaptation projects are still in the early stages of implementation and as such have not undergone these evaluations.

Why M&E for adaptation?

There are many reasons why M&E should be incorporated as an integral part of the adaptation intervention, some of which are as follows:

- Projections on climate change have a varying level of uncertainty and it requires further adjustments so that more reliable information is made available;

- The monitoring and evaluation indicators help to track and examine the progress of the intervention and measure the achievement towards the desired goal;
- Critical success factors for an adaptation program can be identified through M&E processes;
- When working within a limited pool of resources, M&E mechanisms can help in better allocation of resources to achieve maximum performance. Sometimes efficient use of a critical resource is a key success factor for measuring the effectiveness, under which the M&E plays a vital role to ensure that the use of resources follows the intended path;
- M&E indicators can be useful in designing a good mix of mitigation and adaptation strategies which can be complemented in the best possible way;
- Monitoring and evaluation indicators can help identify target groups and other vulnerable groups, and the indirect beneficiaries of the adaptation intervention;
- The M&E indicators allow comparison with respect to a baseline for different time periods, as well as comparisons between different interventions;
- M&E indicators helps in identifying problems during the project which further helps in undertaking corrective action;
- M&E process helps in identifying the areas that need improvement and which are good, so that the future decision for any new program can be made wisely.

Key questions to consider in setting up and using an adaptation M&E system include:

- Does the M&E system incorporate all the major dimensions of the project and clearly outline timing and responsibilities for specific people to monitor specific indicators, factors affecting results, and other relevant dynamics?
- Does the monitoring system include appropriate windows for reporting on specific RBM criteria, such as funding, iterative results and learning to improve the adaptation process?
- How are the intervention partners involved in the monitoring and verification of results?
- Given early evidence of results, how will the stakeholders and implementers revisit the adaptation hypothesis and periodically check whether the intervention approach remains valid to the adaptation objectives?
- Does the M&E system generate information in a way that can be fed into a policy process or used by other partners or interventions to improve their efforts?
- Does the M&E system generate information in a way that can answer evaluation questions pertaining to the relevance, effectiveness, efficiency, impact, and sustainability of the intervention?

Key points to learn from M & E

This learning of fundamental theory of change will develop an understanding of the M&E aspects of adaptation implementation; identify key barriers to progress and key enabling conditions for specific interventions. This enhances understanding of past performance and help in designing appropriate future interventions.

It is imperative to understand the context in which implementation activities are operated and make trainees familiar with rationale, potential and challenges of M&E. In the long run, it enables developing effective M&E system as part of adaptation planning and approaches for M&E at the national and project level.

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Annexures

Annexure 1

Training Needs Assessment conducted in Himalayan States – Summary

Training Needs Assessment

Training is a means to ensure that the trainees have the knowledge and right skills to their work effectively and competently. Training may be required to address the knowledge gaps. For training to be effective, it is important to understand the problem and do an analysis of how it can be addressed. The overarching objectives of the training and its usefulness need to be defined beforehand. This process is called training needs assessment or training needs analysis.

"Training Needs Assessment" (TNA) seeks to identify the current knowledge level through target surveys, interviews, observation, secondary data and workshops. The identified gaps can be translated into a training need.

The first step in a systematic process of capacity building for adaptation planning and implementation under NMSHE in Himalayan states was carrying out a TNA. A rapid TNA helps in assessment of organization's needs vis-à-vis training. It identifies the present and expected operations and the workforce necessary to carry them out. This helps in identifying the numbers and categories of employees who need training.

TNA was done for 11 Himalayan states (Jammu & Kashmir, Himachal Pradesh, Sikkim, Meghalaya, Manipur, Tripura, Mizoram, Arunachal Pradesh, West Bengal, Uttarakhand and Nagaland) where the SCCC under NMSHE have been established.

Methodology

TNAs were conducted by NABCONS in coordination with the respective SCCC by undertaking the following steps:

- Discussions with the officials of SCCC and officials from various state departments, and
- Collation of responses regarding capacity building needs gathered from the relevant departments through a questionnaire.

The aim was to understand whether the training programmes on climate change have been conducted previously and if it fulfils the requirements of NMSHE and IHCAP. In this regard, the following points were discussed with the SCCC and other line departments:

- Focus areas in which capacity building is required
- Identification of participants for capacity building
- Developing a training calendar
- Modalities for partnering with an anchor institution for implementing capacity building programmes on a long-term basis.
- Identification of resource person for training programmes
- Building capacities for identifying climate change, variability signals, assess vulnerabilities in the region and amongst the communities and plan for Climate Change adaptation

Results

Key sectors and areas identified for capacity building

Based on the discussions with the SCCC and the other departments, key sectors for capacity building on climate change were identified in each state (Table 1). Subsequently, the training topics were identified department wise under major sectors and certain sub-sectors.

The areas in which the capacity building requirements have been indicated by the Himalayan states are:

Table 1: Key sectors identified for capacity building for each of the Himalayan States

State	Key Sectors
Arunachal Pradesh	Forests & Environment
	Horticulture
	Disaster Management
	Water Resources
Himachal Pradesh	Water
	Forestry & Biodiversity
	Agriculture and Horticulture
Jammu and Kashmir	Water
	Agriculture
	Sustainable Habitat
Meghalaya	Water
	Disaster Management
	Agriculture and Horticulture
Mizoram	Water
	Agriculture
	Forest
	Energy
	Health
	Sustainable Habitat
Sikkim	Water
	Forest
	Disaster Management
Uttarakhand	Water
	Forest
	Disaster Management
	Energy

State	Key Sectors
Manipur	Water Resources
	Agriculture
	Health
	Forest resources
	Energy efficiency
	Urban planning and Sustainable habitat
Nagaland	Forests & environment
	Horticulture
	Water resources
	Land resources
	Sustainable habitat
	Livelihoods
Tripura	Agriculture
	Biotechnology
	Forest Health
	Renewable Energy
	Revenue
	Social Education and Social Welfare
West Bengal	Agriculture
	Biodiversity and Forests
	Energy efficiency and Renewable Energy
	Human Health
	Water resources

- Climate change concepts
- Vulnerability Assessment
- Knowledge and practices on adaptation options related to other sectors and cross cutting themes
- Monitoring & evaluation framework for Climate Change projects/programmes
- Understanding for accessing climate change finance
- Proposal writing skills

Training programme structure

Based on the discussions with the key departments, it was agreed that the programmes will be conducted at five levels with specific participants identified for each level. The agreed structure of the training programmes is as follows:

- **Level 1: Orientation of legislators & senior officials (2 to 3 hours session)** - Orientation of decision makers such as legislators and senior level officials is imperative in addressing climate change issues. Providing exposure to policy makers and planners on climate change issues and latest developments in relevance to global, Indian and the State Context will enable them to develop and support policies that will lead to climate resilient adaptation and disaster risk reduction.
- **Level 2: Orientation programme for State level officials (1 day session)** - The next target group in a state are the directors, engineers, divisional officers, deputy directors and district in-charge of various line departments. Since these officials would be the key functionaries to be involved in

project implementation, thorough knowledge of the approaches is a must.

- **Level 3: Training programme for district level officials (3 to 4 day session)**-The third target group are district officials from various line departments. These training programmes for duration of 3-4 days are in-depth trainings and focus on enhancing knowledge on climate change impacts and vulnerabilities at a micro level. It is expected to train participants in identification of appropriate adaptation interventions required specific to key sectors such as forests, biodiversity, agriculture and water. It also strengthens the capacities of district officials in adaptation planning.
- **Level 4: Training of trainers programme (3 to 4 day session)**- The objective of ToT programmes is to create a pool of master trainers drawn from training cells of each key department. It also includes experts from universities, institutes and other departments. The pool of master trainers will train mid- and senior-level officials in the state departments and district departments and field-level officials in blocks and panchayats. The master trainers have an overall responsibility of creating awareness & sensitisation at the field level.
- **Level 5-Inter State exposure visits**- Inter-state exposure visits are organized for better insight on how climate change projects are being implemented. It also serves as an opportunity to learn from other state's experiences. Hence exposure visits could be organised for senior officers in the states to showcase some successful initiatives.

Training programme modules and content

Based on the capacity building requirements indicated by the different departments in the Himalayan States, the modules for conducting training programmes for respective participants have been indicated in Table 2, Table 3 and Table 4.

Table 2: Modules for legislators & senior officials (Level 1)

S. No	Topics
1	Climate Change: global, national, and state level
2	Actions, solutions, programmes related to climate change
3	Climate finance

Table 3: Modules for State level officials (Level 2)

S. No	Topics
1	Climate science/impacts and vulnerability assessment
2	Ongoing policy initiatives related to climate change (SAPCC, NAFCC etc.)
3	Linkage of state initiatives to national and international policy
4	Mainstreaming climate change adaptation into development

Table 4: Modules for District level officials (Level 3) and Trainers (Level 4)

	Day 1
Sessions	**Topics**
Session 1 (30 minutes)	Inauguration
Session 2 (120 minutes)	• **CC Science, impacts, and vulnerability assessment** climate change in Himalayan context.

	Day 1
Session 3 (60 minutes)	• Climate policy Relevance of CC policy • NAPCC & highlights from SAPCC (respective states) • State Initiatives on addressing climate change
Session 4 (90 minutes)	• Understanding adaptation • Identification of adaptation options & selection of adaptation measures
	Day 2 Sector wise assessment of Adaptation process
Sessions	**Topics**
Session 5 (90 minutes)	Identification of adaptation options & selection of adaptation measures in **Forestry and Biodiversity Sector**
Session 6 (90 minutes)	Identification of adaptation options & selection of adaptation measures in **Water Sector**
Session 7 (90 minutes)	Identification of adaptation options & selection of adaptation measures in **Agri-culture Sector**
Session 8 (90 minutes)	Identification of adaptation options & selection of adaptation measures in **Urban Resilience (Optional)**
	Day 3
Sessions	**Topics**
Session 9 (90 minutes)	**Disaster Management**
	Field Visit to demonstrate adaptation interventions
	Day 4
Sessions	**Topics**
Session 11 (90 minutes)	**Project Planning, accessing climate finance and M&E Framework**
Session 13 (90 minutes)	**Group exercise on adaptation planning**

Annexure 2

Guidelines for trainers

These guidelines are meant for the trainers to conduct in-depth training programmes for the government officials at the district and block level. The broad session plan given in annexure 1 can be used as template for designing the agenda of the training programme.

The trainers are suggested to use the structure and content of the modules in this manual as the basis for designing the respective sessions. The manual has been developed broadly for the IHR. The trainers can add the specific state context with respect to the climate change impacts on the specific sector, specific vulnerabilities and adaptation measures required with some examples.

The modules are designed to guide the trainers in delivering the training through following means:

- **Presentation:** A presentation can be designed on specific topics on the basis of the modules. As the training programmes are meant to facilitate climate change adaptation, the focus should be on adaptation measures and practical solutions that can be implemented, while highlighting the key impacts and vulnerabilities. Sharing examples of some success stories of climate change adaptation followed by a discussion will be of great help. The focus should be on identifying some points for discussion to make the sessions more interactive.
- **Quiz Sessions:** These sessions assess the understanding of key concepts and learnings from the module.
- **Group exercise:** Group exercise facilitates interaction between the participants from diverse backgrounds and multi sectors. It helps in application of the knowledge on planning for adaptation and formulating strategies. The participants present their key discussion points which helps in sharing knowledge. Trainers can organize group exercises during the trainings. Some suggestions are provided in this annexure.
- **Case studies:** Case studies are examples from the field that connects knowledge with the ground reality. It helps in providing a wide spectrum of learning and understanding of the key concepts.
- **Exposure visit:** Field visits helps to understand the ground realities, learn from the good practices of adaptation projects implemented and develop understanding on pragmatic ways of mainstreaming adaptation in project implementation. The trainers can organize exposure visits for the participants to enable a better understanding of the concepts and good practices.

Suggestions for Reflection Questions:

As a method to engage the participants, the trainers can use some reflection questions during the sessions. Some reflection questions are suggested as follows:

Module 1

- What climatic changes do you experience in your region/state?
- How is climate-change induced temperature rise projected in mountains vis-à-vis global average?
- Will climate change have impacts on precipitation? If yes, how?

Module 2

- Do you feel the need for revision of the SAPCC? Why?
- How do you feel the Himalayan states can contribute to NDCs?
- How does your SAPCC links with NMSHE?

Apart from the above mentioned tools, the trainers can also use a number of participatory methods to design the sessions and make them more interactive. Each of the sessions can be made more effective in terms of achieving the session objectives by making the participants more engaged. The 'TRAINING METHODOLOGY MANUAL: Practical guide for climate change trainings' by Helvetas (2019) may be used as a guidance document to design the sessions for a training on climate change adaptation. The manual is available at: http://ihcap.in/wp-content/uploads/2019/08/Manual-Training-Methodologyclimate-change2019.pdf

Module 3

- What are some examples of vulnerability from your districts which requires urgent attention and probable interventions to address the climate change.
- How are vulnerability and risk related to each other?
- Identify any one sector from your state which tends to be utmost vulnerable and also has more economic value for the development.

Module 5

- What are the climatic risks for agriculture in your region/state?
- Give two examples of adaptation measures for agriculture sector suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 6

- What are the climatic risks for water in your region/state?
- Give two examples of adaptation measures for water sector suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 7

- What are the climatic risks for forests in your region/state?
- Give two examples of adaptation measures for forestry sector suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 8

- What are the climatic risks for health sector in your region/state?
- Give two examples of adaptation measures for health sector suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 9

- What are the climatic risks for urban areas in your region/state?
- Give two examples of adaptation measures for urban areas suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 10

- What are the climatic risks related to disasters in your region/state?
- Give two examples of adaptation measures for disaster risk reduction suitable for your state/region.
- How are these options suitable from an economic and social context of the region/state?

Module 13

- What are the gender related vulnerabilities in your region in the context of Climate Change?
- How would you induct gender action planning in your project management of sustainable development and adaptation?
- In an on-going state level project of adaptation, how would you engage women as participants for community development in your village?

Module 14

- What are the various sources of climate finance?
- What is additionality?
- How is mainstreaming climate change in development policy related to climate change finance?
- What are the options for climate change finance within your state?

Module 15

- Why is M&E required for adaptation projects?
- List M&E tools that you know?
- What is the difference between outcome and output?
- Give examples for indicators for an outcome related to policy influence.

Group Exercise

Module 4

Exercise 1: Preparation of adaptation plan

The objective of this group exercise is to identify and prepare an adaptation plan for the identified system of interest. The participants are to be divided into groups. Each group will discuss the following:

- Select a system of interest
- Select Impacts and key vulnerabilities that have been rated as high to medium vulnerability
- Identify through brainstorming all possible adaptation options to address the impacts and reduce the vulnerabilities identified.
- Prioritize the adaptation options on the basis of agreed criteria (eg. Cost effectiveness, scalability or feasibility)
- Prepare a plan for the prioritized adaptation option by identifying major activities, scope, beneficiaries and expected outputs and outcomes

Annexure 3

How to conduct Vulnerability Assessment

Prepared by
Indian Institute of Technology Mandi, Indian Institute of Technology Guwahati and Indian Institute of Science Bangalore

This is a summary of the Vulnerability and Risk Assessment Framework, prepared by Indian Institute of Science, Bangalore for the Indian Himalayas Climate Adaptation Programme (IHCAP). More specifically, this document is a summary of the "Manual and Guidelines" Section of the mentioned framework. While you are requested to go through the detailed manual, the summary document will be handy when you are actually performing the analysis. The detailed manual is available at http://ihcap.in. The main aim of this summary is to provide a brief sketch of the entire methodology for the vulnerability assessment and also to help you in brushing up the concepts and steps.

Contents

1 What is vulnerability?

Intergovernmental Panel on Climate Change (IPCC) conceptualizes vulnerability as the propensity or predisposition of a system to be adversely affected. It includes sensitivity or susceptibility to harm and lack of capacity to cope and adapt. It is an internal property of a system and dynamic in nature. It has significant implications when discussed in the context of susceptibility of fragile ecosystems, such as the Himalayan Region, to climate stimuli. IPCC 4th Assessment Report (2007) considered 'exposure' as one of the three elements of 'vulnerability' other two being sensitivity and adaptive capacity. However, post 2007, this conceptualization of vulnerability has been modified and 'exposure' is no longer considered to be a component of 'vulnerability'. The IPCC 5th Assessment Report (FAR, 2014) has adopted this conceptual construct of vulnerability and presented 'exposure' separate from 'vulnerability' while representing 'risk'. Risk arises from interaction of hazard, exposure and vulnerability. The post-2007 framework has been followed in this manual.

Basically Risk is a function of hazard, exposure and vulnerability. In notations, it can be written like the following:

Risk = *f* (Hazard, Exposure, Vulnerability); where *f* depicts the functional relationship.

Vulnerability thus is a component of risk. In this section, to assess the risk we will focus on the 'vulnerability' component, particularly current vulnerability. Vulnerabilities can be of different types.

2 Why Current Vulnerability Assessment (VA)?

Vulnerability assessments help us to:

1) Identify the areas/systems/communities that are vulnerable.
2) Create demand among stakeholders for adaptation action.
3) Assess the extent of vulnerability.
4) Identify the drivers of vulnerability.
5) Plan adaptation strategies
6) Disseminating awareness among the stakeholders.

It is useful to assess vulnerability under both the scenarios i.e. under current climate change and future (long-term) climate change scenarios. In the current assessment, we focus on the assessment of current climate vulnerability, as evolving adaptation strategy based on the current climate vulnerability assessment is a reliable and 'no-regret' approach to reduce current vulnerability and build long-term resilience under climate change. This is, in fact, the first step of any vulnerability assessment undertaken with the aim to reduce the risk under uncertain future.

3 What are the main steps in VA?

The main steps involved in VA are explained by taking an example of an assessment done at State level for the 12 states of IHR.

Fig.1: Steps involved in vulnerability assessment

Step 1: Scoping and objectives of vulnerability assessment

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Step 2: Selection of type of vulnerability assessment

↓

Step 3: Selection of tier method

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Step 4: Selection of sector, spatial scale, community/system and period of assessment

↓

Step 5: Identification, selection and defining of indicators for vulnerability assessment

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Step 6: Quantification and measurement of indicators

↓

Step 7: Normalisation of indicators

↓

Step 8: Assigning weights to the indicators

↓

Step 9: Aggregation of indicators and development of vulnerability index

↓

Step 10: Representation of vulnerability: spatial maps, charts and tables of vulnerability profiles and indices

↓

Step 11: Vulnerability ranking of sectors, regions, communities, cropping systems, river basins, watersheds, forest types, etc.

↓

Step 12: Identification of drivers of vulnerability for adaptation planning

Step 1: Scoping and Objectives

First we need to identify the objective or purpose of the assessment and the target audience of any particular VA (Table 1).

Step 2: Selection of VA Type

All VA studies come under one of the following three categories.

i) Biophysical vulnerability study (e.g., VA for Himalayan sub-tropical pine forests in India)
ii) Socio-economic vulnerability study (e.g., VA for freshwater fishermen community in Himalayan river basin).
iii) Integrated vulnerability study (A combination of the above two categories).

It is easily understood that integrated studies are most common, as they provide a comprehensive picture compared to the other types. The present example focuses on integrated vulnerability study where both bio-physical and socio-economic indicators of each of the states have been considered.

Step 3: Selection of Tier Methods

A VA study can be done by using primary or secondary data or by using a possible combination of the two. Also, GIS data, climate model outputs or other spatial remote sensing data can be used. The methodological rigor employed and the type of data used defines the tier level of a VA study. The three tier levels for undertaking VA studies are presented in table 2.

The state-level VA map for IHR developed in the example is based on Tier 1 approach. The choice of tier for any VA study depends on the objective of the study, availability of skills, time, funding and data.

Step 4: Restricting Area of Application

This stage is very crucial to make the study practically doable and useful. We fix the points mentioned in Table 3 prior to indicator selection.

Table 1: Scoping and Objectives of VA

Steps of Scoping	Explanation	State Level VA example
Identifying the need of VA	VA is required under following conditions: a) Exposure to climatic stressors. b) Importance of the (vulnerable) system c) Ability to take adaptive measures d) Persistence of vulnerable conditions and degree of irreversibility (of consequences) e) Presence of factors making societies vulnerable to cumulative stressors. We must remember that there is no hard and fast rule that all the five conditions must be present.	Indian Himalayan Region (IHR) is vulnerable to natural disasters, coupled with the impact of climate change and climate variability. This calls for the development and implementation of an immediate framework for VA in the area.
Region & unit of VA	The geographical area where VA is carried out and the units of assessment	Region: IHR; Unit of VA: State (all 12 states in IHR)
Defining the objectives	a) Identify the most vulnerable areas (i.e. regions/ communities/systems) b) Gain direction for adaptation planning. A well-defined set of objectives is needed before framing the study procedure.	Prepare a state level vulnerability map for IHR
Identifying the stakeholders	VA studies are done for several stakeholders. And they actually influence the objectives, types and rigor of the VA. So prior to any study it is must to identify the target audience and later the study must be confined in that domain.	Stakeholders are respective state governments

Table 2: Different Tier Methods for VA

Different Methods	Definition	Advantages/Disadvantages
Tier 1	It is a top down approach based largely on secondary data.	Data can be collected easily, in less time and at less cost. However, data accuracy or relevance may be low. Useful preliminary level assessment can be undertaken using Tier 1 methodology. In fact it is easiest to follow, as only elementary level of skills and least resources are required.
Tier 2	It involves both top down and bottom up approaches. So both secondary and primary data is needed. It requires higher level of skills and resources.	Data is more accurate but takes more time and is more costly. VA results provide useful inputs for evolving adaptation strategies/approach.
Tier 3	It involves both top down and bottom up approaches along with GIS data and spatial remote sensing. It is most rigorous and requires high level of skills and resources.	Data is more accurate and multidimensional but takes more time and is more costly. VA results provide detailed and direct inputs for developing adaptation plans and measures.

Table 3: Area of Application in a VA

Particularities of Study	Idea	State Level VA example
Sector	VA study is carried out for particular sector(s) (e.g., Forestry, watershed, agriculture). A sector can be divided in several subsectors (e.g., Agricultural sector can be divided into subsectors such as cash crop, fruit, horticulture etc.).	Multi-sector
Scale	VA study can be carried at a micro scale (e.g., household) or at a macro scale (e.g., country). It is feasible to do it for a scale in between.	Current VA focuses on state level
Period	Under climate change scenario vulnerability can be measured for current or future climate.	Since here our objective is to study current climate vulnerability, the time scale is not considered

Step 5: Identify the Necessary Indicators

In any VA we have indicators of different types (i.e., Bio-Physical, Socio-economic and Institutional). Considering the objectives and scale of the study, adopted tier method, availability of necessary data, indicators are carefully chosen. One has to be absolutely clear about the rationale behind selecting a particular indicator. Usually, a longer list of indicators can be chosen to begin with, which is reduced to 8-10 indicators finally to undertake the study. Selection of appropriate indicators is the art of and central to a VA study. Indicators may capture 'sensitivity' or lack of 'adaptive capacity' of a system. Higher the sensitivity, higher will be vulnerability and lower the adaptive capacity higher will be the vulnerability. Table 4 presents the indicators chosen to carry out a state-level VA in IHR. It shows the various indicators used, the category to which particular indicator belongs to, its relation with the vulnerability, the way it is defined and the data sources. (This is only for demonstration purpose.)

Step 6: Quantification of Indicators

We must express all indicators in terms of numbers so that we can apply mathematical operations to these. As such, reliable sources of secondary data are used to quantify the indicators selected. For example, the indicator percentage of area with slope >30% is quantified by using the data published by the National Remote Sensing Center.

Table 4: Indicators for State Level VA in Indian Himalayan Region

Indicators	Sub-indicators	Rationale for selection	Functional relation with Vulnerability	Source of data
Socio-economic, demographic status and health	Population density (Total population of a state divided by the total geographical area)	Population density determines the extent of dependency and per capita availability of finite resources. High density could lead to degradation of resources, further increasing sensitivity. Further, higher the population density, higher the exposure of community to climatic hazards.	Positive	Calculated using Geographic Area and population data from Census of India (2011)
	Percentage of marginal farmers	Marginal farmers (land holding <1 ha) are known to have low social and economic capital and thus are inherently more sensitive and have lower adaptive capacities.	Positive	Agriculture Census - State Tables (2010-11) accessed at, http:// agcensus.dacnet.nic.in/ DatabaseHome.aspx
	Livestock to human ratio (Total livestock population in a state divided by the total population of that state)	Livestock provides an alternate source of income and assists in crop production, also sale of livestock during distress provides households with a coping strategy in the context of climatic hazards.	Negative	Estimated using Census of India (2011) and 19th Livestock Census (2012)
	Per Capita Income (2014-15) at current prices as on 31.03.2017	A direct indicator representing the inherent sensitivity of people in a region. Higher per capita income provides higher capacity to cope with any damage or loss arising out of climatic hazard.	Negative	Press Information Bureau, GoI, Ministry of Statistics &Programme Implementation[1]
	Number of Primary Health Centres per 100,000 Households (2017)	Access to primary healthcare centres is pivotal for the wellbeing of households. An indication of adaptive capacity.	Negative	NITI Aayog, http://niti.gov.in
	Percentage of women in the overall workforce	Women are known to be more sensitive to climate risks. Regions with a greater number of women in gainful employment would signify gender equality, enhanced purchasing power and independency, thus lower vulnerability due to reduced sensitivity of women in these regions.	Negative	Census of India (2011)
Sensitivity of agricultural production	Percentage area irrigated (2010-11)	Crop production with irrigation is less sensitive to delayed rainfall or droughts.	Negative	Table 6.7: Percentage of net irrigated area to net sown area of All Social Groups, 2005-06 and 2010-11, All India Report on Agriculture Census 2010-11
	Yield variability of food grains (2005-2015) - Coefficient of variation calculated for 10 year food grain yield data	A stable food production system with little to no variation in yield is inherently resilient to climate shocks and. Thus, has high adaptive capacity.	Positive	Calculated using Table 4.1.4: Total food grains - State-wise yield, Agricultural Statistics at a Glance 2016
	Percentage area under Horticulture Crops (2016)	Fruit trees are hardier than field crops when sensitivity to climate shocks is considered. A larger area under horticulture tree crops providing an alternative source of farm-based income reduces sensitivity to climate variability and increases adaptive capacity.	Negative	Computed using Horticultural Statistics at a Glance 2017 and geographical area of states.

[1] Estimates for the State of West Bengal are at base year 2004-05, the remaining states are for 2014-15 at current prices, as on 31.03.2017. Data for the same can be accessed at http://pib.nic.in/newsite/PrintRelease.aspx?relid=169546

Indicators	Sub-indicators	Rationale for selection	Functional relation with Vulnerability	Source of data
Forest Dependent Livelihoods	Percentage area under open forest	Large tracts of open forests indicate a higher level of forest disturbance and degradation. Forest is a major source of livelihood in the Himalayan states. Forests provide vital environmental services and thus degradation of forests indicate higher sensitivity.	Positive	State of Forest Report 2017 – Forest Cover
	Percentage area under forests per thousand rural household (2017)	Availability of alternate livelihood options through extraction of fodder, fuelwood, and non-timber forest products (NTFPs) from forests.	Negative	State of Forest Report 2017 – Forest Cover
Access to information services and infrastructure	Percentage crop area insured under all Insurance Schemes (2015-16)	Crop insurance helps farming households mitigate losses due to climate risks, thereby enhancing their adaptive capacity.	Negative	Table 14.16(a): State-wise crop area insured under all Insurance Schemes, Agricultural statistics at a Glance 2016
	Percentage farmers taking crop loans (2015-16)	Farmers with access to crop loans can invest in essential agronomic practices to lower yield variability, thus enhancing resilience of cropping systems.	Negative	Table 14.9(b): State wise Agriculture Loan disbursed during 2015-16, Agricultural Statistics at a Glance 2016
	Average person days per Household under MGNREGA (2006-2016)	Non-climate sensitive wage labour under MGNREGA provides households with income security, especially during the years of droughts and floods.	Negative	Calculated using DMU report – MGNREGA Website
	Percentage area with >30% slope	Areas with high slope can be inaccessible, highly unstable and be prone to landslides. This sub-indicator is a hazard-specific indicator that determines the sensitivity of a region, hampering access to information services and infrastructure.	Positive	Computed using GIS tools and NRSC Data at a district level and averaged for states.
	Road Density (surfaced roads in km divided by total geographic area in sq. km)	Direct indicator representing accessibility, which is essential in regions that are exposed to climate and disaster risks.	Negative	Total and Surfaced Road Length - State-wise Table-21.1(B), accessed at, http://www.mospi.gov.in/statistical-year-bookindia/2017/190

Step 7: Normalization of Indicators

Different indicators are expressed in different units (e.g., MGNREGA is measured in terms of person-days/household/year; per capita income is measured in Indian National Rupee/year while area under forest in terms of sq. km), thus we cannot simply add them up. Furthermore, VA is also about ranking. If we say that vulnerability of A is 70, vulnerability of B is 65 and so on, standalone it will imply nothing, unless we find a way to compare those units of VA i.e. A, B etc. We must develop a framework where we can say A is more (or less) vulnerable than B. Basically we need to rank those units of VA study according to their respective degrees of vulnerabilities (i.e., value of the vulnerability indices). To address these issues, we have to normalize the indicator values

Normalization yields two advantages. Firstly, normalized values are unit free, which can be readily combined to arrive at the Vulnerability Index (VI) value. Secondly, they all lie between 0 and 1 (0 implies least vulnerability and 1 implies the highest vulnerability) and can be related to ranking thus enabling comparison and prioritization

The formula used for normalization depends on whether the indicator has positive or negative relationship with vulnerability.

Case I: The indicator has positive relationship with vulnerability

$$\text{Normalized value} = \frac{(\text{Actual indicator value} - \text{Min indicator value})}{(\text{Max indicator value} - \text{Min indicator value})} \quad \text{................(1)}$$

Case II: The indicator has negative relationship with vulnerability

$$\text{Normalized value} = \frac{(\text{Max indicator value} - \text{Actual indicator value})}{(\text{Max indicator value} - \text{Min indicator value})} \quad \text{................(2)}$$

Applying the above rule we calculate the normalized value of each indicator for all the states.

To clearly demonstrate the process of transforming actual values into normalized values, let us consider the following two indicators.

Normalization of Population Density indicator for J&K (Positively related to vulnerability)

The maximum and minimum values are respectively 589 (West Bengal) and 17 (Arunachal Pradesh).

So, the denominator is (X_{max} - X_{min}) = (589-17) = 572. [Note that the denominator will be identical for all states under consideration]

The numerator for J&K is (X_{actual} -X_{min}) = (56-17) =39. Hence, the normalized value of the indicator POP for J&K = 39/572 = 0.068. Note that the normalized value is between 0 and 1 and is unit free.

Similarly, we can calculate the normalized values of each of the positive indicators for each of the states by applying the same normalization method given above.

Normalization of Per Capita Income indicator for West Bengal (Negatively related with vulnerability)

The maximum and minimum values are respectively 210394 (Sikkim) and 52436 (Manipur).

So, the denominator is (X_{max} - X_{min}) = (210394-52436) =157958. [Note that the denominator will be identical for all states under consideration]

For West Bengal the numerator is (X_{max} - X_{actual}) = (210394-78903) = 131491.

Hence, the normalized value of PCI for West Bengal is (98538/157958) = 0.832.

Similarly, we can calculate the normalized values of all the negative indicators for all the states by applying the same normalization method given above.

Following above method we have calculated the normalized values of all six indicators.

Step 8: Assigning Weights to Indicators

Weights are assigned to each indicator according to their importance in determining vulnerability of a system. The total weight always should add up to 1. Assigning proper weights is very crucial for obtaining reliable (reflecting the reality most) results. We often consult experts or survey the stakeholders to judge

Table 5: Actual (AV) and Normalized Values (NV) of all Indicators

State	Socio-economic, demographic status and health											
	Population density (2011) Person/sq. km		Percentage of marginal farmers (2011-12)		Livestock to human ratio (2017-18)		Per Capita Income (2014-15)		Number of Primary Health Centres per 100,000 Households (2017-18)		Percentage of women in the overall workforce (2011)	
	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV
Arunachal Pradesh	17	0.00	18	0.175	1	1.000	103633	0.676	53	0.000	40	0.165
Assam	398	0.67	67	0.772	2	0.790	54618	0.986	16	0.765	29	0.734
Himachal Pradesh	123	0.19	70	0.801	1	0.860	124500	0.544	36	0.343	43	0.059
Jammu & Kashmir	56	0.07	83	0.964	1	0.877	62857	0.934	30	0.471	26	0.857
Manipur	128	0.19	51	0.573	4	0.000	52436	1.000	15	0.778	43	0.024
Meghalaya	132	0.20	49	0.549	2	0.828	68202	0.900	20	0.682	41	0.153
Mizoram	52	0.06	55	0.617	4	0.188	85659	0.790	26	0.564	40	0.172
Nagaland	119	0.18	4	0.000	2	0.619	78526	0.835	32	0.435	44	0.000
Sikkim	86	0.12	54	0.607	2	0.643	210394	0.000	19	0.708	37	0.333
Tripura	350	0.58	86	1.000	2	0.706	71666	0.878	11	0.868	29	0.723
Uttarakhand	189	0.30	74	0.847	2	0.640	134784	0.479	12	0.834	34	0.470
West Bengal*	589	1.00	82	0.950	3	0.351	78903	0.832	4	1.000	23	1.000

* The population density was considered only for Darjeeling and Kalimpong districts of West Bengal

State	Agri-based livelihoods					
	% Area Irrigated (2010-11)		Yield Variability of Food Grains (2005-2015)		% Area Under Horticulture Crops (2016)	
	AV	NV	AV	NV	AV	NV
Arunachal Pradesh	26.8	0.65	18	0.37	1	1.00
Assam	5.5	1.00	15	0.29	9	0.60
Himachal Pradesh	19.9	0.77	11	0.14	6	0.76
Jammu and Kashmir	45.8	0.35	13	0.20	2	0.96
Manipur	18.8	0.79	14	0.26	5	0.81
Meghalaya	23.4	0.71	16	0.32	6	0.75
Mizoram	10.0	0.93	38	1.00	6	0.73
Nagaland	22.6	0.72	16	0.30	6	0.74
Sikkim	22.3	0.73	13	0.20	11	0.52
Tripura	24.0	0.70	6	0.00	14	0.36
Uttarakhand	47.5	0.32	8	0.06	5	0.79
West Bengal	67.1	0.00	11	0.15	21	0.00

AV = Actual value and NV = Normalized value

State	Forest dependent livelihoods			
	Percentage area under open forest		Area under forest/1,000 rural households	
	AV	NV	AV	NV
Arunachal Pradesh	23	0.049	334	0.000
Assam	54	0.715	5	1.000
Himachal Pradesh	35	0.310	12	0.981
Jammu and Kashmir	46	0.537	15	0.970
Manipur	57	0.789	45	0.879
Meghalaya	43	0.474	40	0.895
Mizoram	67	1.000	172	0.494
Nagaland	53	0.698	45	0.879
Sikkim	21	0.000	36	0.907
Tripura	24	0.065	13	0.978
Uttarakhand	27	0.128	17	0.964
West Bengal	58	0.797	7	0.995

State	Access to information services and infrastructure									
	Percentage crop area insured under all Insurance Schemes (2013-15)		Percentage farmers taking loans (2015-16)		Average person days per household under MGNREGA (2006-2016)		Average Percentage area with >30% slope		Road Density	
	AV	NV	AV	NV	AV	NV	AV	NV	AV	NV
Arunachal Pradesh	0	1.00	1	0.98	25	1.00	70.5	0.99	0.18	0.95
Assam	1	0.97	0	1.00	30	0.87	3.7	0.02	0.76	0.61
Himachal Pradesh	6	0.77	6	0.77	43	0.57	26.4	0.35	0.72	0.64
Jammu and Kashmir	0	1.00	6	0.79	34	0.78	24.6	0.32	0.10	1.00
Manipur	4	0.83	1	0.96	45	0.53	3.9	0.02	0.60	0.71
Meghalaya	0	0.99	3	0.89	41	0.63	9.5	0.10	0.40	0.82
Mizoram	0	1.00	2	0.94	52	0.36	71.4	1.00	0.35	0.86
Nagaland	0	1.00	1	0.96	45	0.52	52.7	0.73	1.08	0.43
Sikkim	0	1.00	3	0.91	55	0.30	21.1	0.27	0.82	0.58
Tripura	0	0.99	14	0.47	68	0.00	2.5	0.00	1.82	0.00
Uttarakhand	26	0.00	18	0.34	35	0.76	23.3	0.30	0.63	0.69
West Bengal	9	0.64	27	0.00	29	0.89	17.9	0.22	1.24	0.33

AV = Actual value and NV = Normalized value

Table 6: Weight assigned to the indicators and sub-indicators

Indicator	Indicator Weights (WI)	Sub-indicators	Sub- indicator Weights (Wi)	Weights to be multiplied with normalizes scores (WI*Wi)
Socio-economic, demographic status and health	0.345	Population Density	0.17	(0.35*0.17) = 0.06
		Percentage marginal farmers	0.15	(0.35*0.15) = 0.05
		Livestock to human ratio	0.09	(0.35*0.09) = 0.03
		Per Capita Income	0.26	(0.35*0.26) = 0.09
		Number of Primary Health Centre per 100,000 HH	0.18	(0.35*0.18) = 0.06
		Percentage of women in overall workforce	0.15	(0.35*0.15) = 0.05
		Total	**1.00**	
Sensitivity of agricultural production	0.271	Percentage area irrigated	0.38	(0.27*0.38) = 0.10
		Yield variability of food grains	0.42	(0.27*0.42) = 0.11
		Percentage area under horticulture crops	0.20	(0.27*0.20) = 0.05
		Total	**1.00**	
Forest Dependent Livelihoods	0.194	Percentage area under open forests	0.58	(0.19*0.58) = 0.11
		Area under forests/1,000 rural households	0.42	(0.19*0.42) = 0.08
		Total	**1.00**	
Access to information services and infrastructure	0.19	Percentage crop area insured under all Insurance Schemes	0.20	(0.19*0.20) = 0.04
		Percentage farmers taking loans	0.14	(0.19*0.14) = 0.03
		Average person days per household under MGNREGA	0.24	(0.19*0.24) = 0.05
		Average Percentage area with >30% slope	0.34	(0.19*0.34) = 0.06
		Road density	0.08	(0.19*0.08) = 0.02
Total	**1.00**	**Total**	**1.00**	**1.00**

the actual importance of different indicators. In case of assessments with composite indicators, as presented here in the example, where each indicator may have two or more sub-indicators, weights are to be assigned in the following manner. If the weights of the sub indicators of indicator i are added then one should get the weight assigned to indicator i itself. For example, suppose, an indicator, say indicator 1 has three sub-indicators with assigned weights W11 ,W12 and W13, then it should be the case that W11 + W12 +W13 = W1 = weight assigned to indicator 1.

Step 9: Aggregation of Indicators and Developing Vulnerability Index (VI)

The normalized indicators can be aggregated to come up with a VI. If different weights are attached to different indicators then a weighted average will be taken to calculate the VI (i.e. normalized values are to be multiplied by their respective weights and then added up). However, if equal weights are given, a simple arithmetic mean will do.

In this example, Normalised values of the sub-indicators are multiplied by their respective average weights to obtain the vulnerability score of the sub-indicator itself for each state. The vulnerability scores of all sub-indicators under one indicator is summed up to obtain the vulnerability score for the respective indicator. For example, the vulnerability scores of the three sub-indicators - percentage area under irrigation, yield variability and percentage area under horticulture crops are added to obtain the vulnerability score of the main indicator 'sensitivity of agriculture'. Vulnerability scores of all four main indicators obtained in this manner are added up to arrive at the composite vulnerability index. This is basically same as taking the weighted sum of all 16 sub-indicators under consideration.

For example let us consider the case of Meghalaya (See Table 7). So, VI =1/4 (0.57+0.56+0.65+0.58) = 2.36/4 =0.59.

Step 10: Vulnerability Ranking

Once VIs are calculated for all the states, a comparative ranking is carried out based on the index value. Higher

Table 7: Vulnerability Ranking of States in Indian Himalayan Region

State	Vulnerability Index Values of the four main Indicators				Composite Vulnerability Index	Ranking of the States
	Social - economic, demographics status and health	Sensitivity of agricultural production	Forest dependent livelihoods	Access to Information Services and Infrastructure		
Assam	0.80	0.62	0.83	0.60	0.721	1
Mizoram	0.45	0.92	0.79	0.82	0.715	2
Jammu and Kashmir	0.69	0.41	0.72	0.69	0.619	3
Manipur	0.52	0.57	0.83	0.49	0.588	4
Meghalaya	0.57	0.56	0.65	0.58	0.583	5
West Bengal	0.89	0.07	0.88	0.45	0.581	6
Nagaland	0.38	0.55	0.77	0.74	0.570	7
Himachal Pradesh	0.44	0.50	0.59	0.57	0.510	8
Tripura	0.81	0.34	0.45	0.27	0.507	9
Arunachal Pradesh	0.32	0.61	0.03	0.99	0.466	10
Uttarakhand	0.58	0.30	0.48	0.39	0.449	11
Sikkim	0.35	0.46	0.38	0.54	0.422	12

the value of VI of a particular state, higher will be the vulnerability. These vulnerability rankings are usually presented in tabular form. Here, we have ranked the 12 states according to their VI based on the six indicators that we have considered.

From the ranking we know which state is relatively more vulnerable. For example, we can see while Assam is the most vulnerable state in the IHR, Sikkim is the least based on the indicators considered. Also, Tripura (rank 9) is less vulnerable than Meghalaya (rank 5) but more vulnerable than Arunachal Pradesh (rank 10).

Step 11: Representation of Vulnerability

The basic idea behind representation of vulnerability is to convey the information about the state of vulnerability and the associated risks to the policy making bodies and other stakeholders. The most common way is to use spatial map with a gradient of colours indicating the level of vulnerability. Graphs, charts or tables too are widely used. Here, we are showing the 12 IHR states under study according to their vulnerability ranking (Map 1) and grouping of states according to their vulnerability (low, medium and high) (Map 2).

Calculations for Categorization

Max VA index value = 0.76 & Min VA index value = 0.38.

Range = 0.76 - 0.38 = 0.38. We want to categorize all states in three categories. 0.38/3 = 0.1267(Approx.)

Category 1: High Vulnerable: 0.76 - 0.6333 (= 0.76 – 0.1267) i.e. for our purpose: 0.76 - 0.63

Category 2: Medium Vulnerable: 0.6333 - 0.5066 (=0.6333 – 0.1267) i.e. for our purpose: 0.63- 0.51

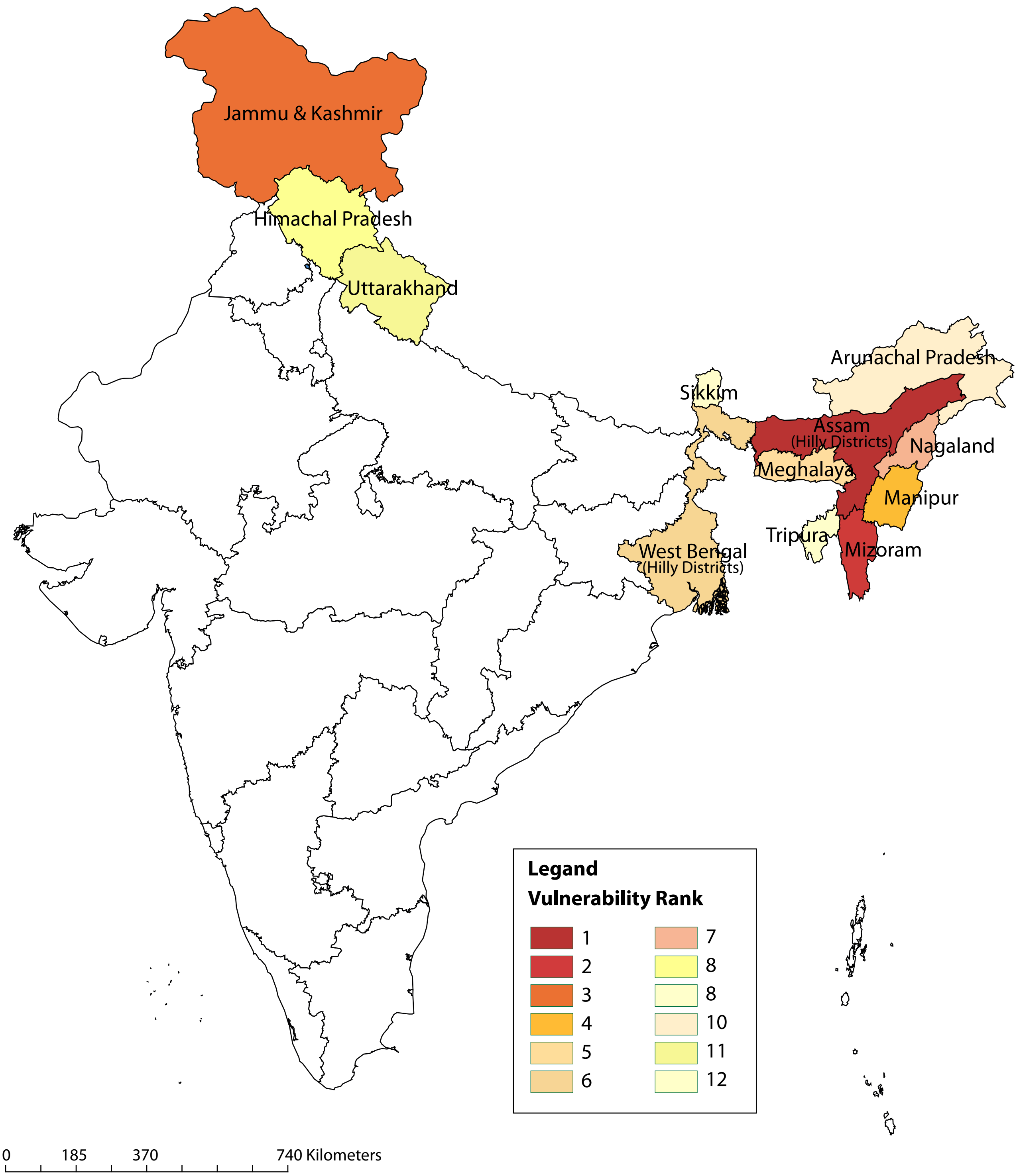
Category 3: Low Vulnerable: 0.5066 – 0.38 i.e. for our purpose: 0.51- 0.38

Step 12: Identification of Drivers of Vulnerability

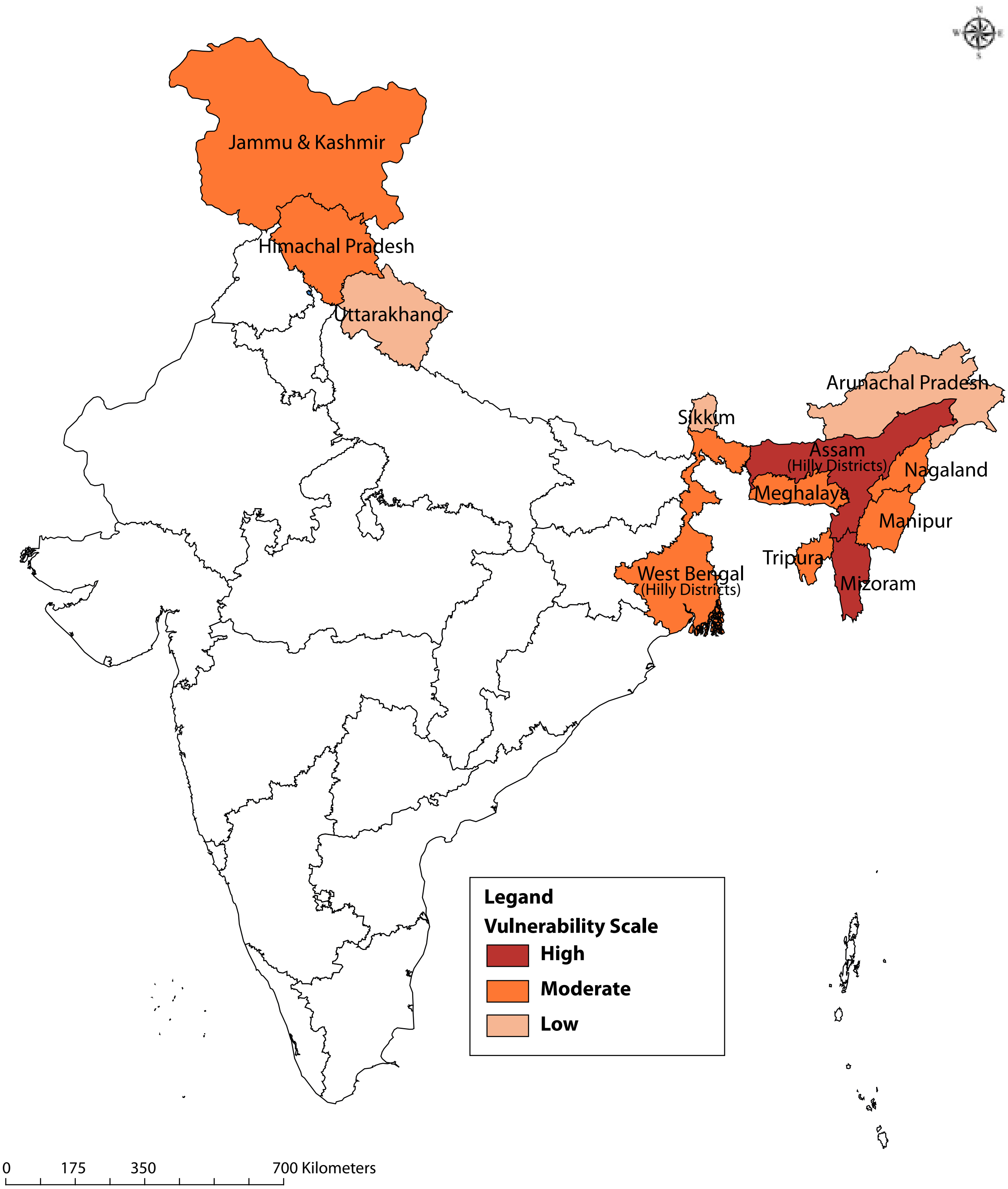
Most vulnerability studies are conducted as a prerequisite of making policies to prevent further degradation of environmental assets. To develop efficient adaptation planning technique, identifying the main drivers behind vulnerability is crucial. VA helps in selecting adaptation measures based on the assessment of the drivers of vulnerability.

Now we will show how to find main drivers of vulnerability with the help of our VA study of twelve Indian Himalayan Region (IHR) states based on six chosen indicators.

Map 1: Vulnerability ranking of different States in the IHR under current climate



Map 2: Vulnerability category for different States in the IHR under current climate



Rank	State	Drivers of Vulnerability
1	Assam	The normalised values of all sub-indicators (Table 2-5 in Appendix) show that Assam, as a state falls in the higher side of vulnerability index. Other than three sub-indicators, namely, population density, yield variability of food grains and average % area with slope greater than 30 degree, the normalised values of all other indicators are above 0.5. Among them, six major drivers of vulnerability are: least area under irrigation; least forest area available per 1,000 rural households; and least number of farmers taking loans as compared to other states. It also has the second lowest per capita income; low percentage area covered under crop insurance and low MGNREGA participation. In fact, other than population density, this state has relatively high vulnerability with respect to all sub-indicators under socio-economic, demographic and health indicator. Similarly, since Assam has more flat lands relative to other states, which suggest lower sensitivity to natural disaster, lack of access to information and infrastructure puts this state into a situation where it would be extremely difficult to cope with any climate extremes.
2	Mizoram	The state has very high sensitivity of agriculture sector along with poor connectively, access to information and infrastructure. The state has seven major drivers of vulnerability – highest yield variability, no area under crop insurance, largest area under open forests, and largest area under slope >30% as compared to other states. It also has the second lowest percentage area under irrigation and the third lowest road density among the 12 states. A glance at the normalised values to the sub-indicators show that agricultural sensitivity and lack of access are two major divers leading to lack of adaptive capacity of the state.
3	Jammu and Kashmir	Several drivers of vulnerability are evident for the state of J&K. These include, in the order of significance: least road density; no area under crop insurance; low area under forests per 1,000 rural households; high percentage of marginal farmers; low percentage area under horticulture crops; low livestock to human ratio; and low percentage of women in the overall workforce. This implies that four out of six sub-indicators under the socio-economic indicator, one out of three under the agricultural sensitivity indicator, one out of two forest-related sub-indicators and all access-related sub-indicators, barring the average slope, exhibit high degree of sensitivity and lack of adaptive capacity of the state. In fact, this state is in the most difficult situation with respect two important factors that increase the adaptive capacity – road density and crop insurance. Similar to Assam, Jammu & Kashmir also ranks high with respect to vulnerability, generally lagging in terms of most of the sub-indicators considered. So, similar to Assam, in this state also, the vulnerability is rather composite in nature and not explicitly sector-specific.
4	Manipur	Manipur has three major drivers of vulnerability – lowest per capita income, low percentage of farmers taking loans and low area under forests per 1,000 households. Interestingly, other than income, and the availability of healthcare facilities to some extent, the performance of this state with respect to other socio-economic, demographic and health indicators are relatively better than other states. However, the vulnerability of the state arises from other indicators as well.
5	Meghalaya	The vulnerability of this state arises from the socio-economic indicators and lack of access to information and infrastructure. The state has four major drivers of vulnerability: very low area under crop insurance; low per capita income; low area under forests per 1,000 households; and low percentage of farmers taking loans.
6	West Bengal	The mountain region of West Bengal stands almost at the middle of the ranking. This state has the highest population density, least number of primary healthcare centres per 100,000 households, least percentage of women in the overall workforce, second lowest area under forests, high percentage of marginal farmers and low MGNREGA participation as compared to other states. Given highest/close to highest normalised values of almost all socio-economic, demographic and health indicators, one would actually expect the state to have higher vulnerability ranking, however, extremely resilient agricultural sector with maximum irrigation facilities and horticulture, along with access to information, services and infrastructure helped the state to have relatively higher adaptive capacity.

Rank	State	Drivers of Vulnerability
7	Nagaland	No coverage under crop insurance, low percentage of farmers taking loans and low area under forests per 1,000 rural households are the three major drivers of vulnerability in the state. However, this state has high per capita income, low population density, lowest prevalence of marginal farmers and highest women participation in the labour force that make the state relatively resilient.
8	Himachal Pradesh	Himachal Pradesh is an interesting case to observe. This is one of the rare states that is neither best, nor worst with respect to any of the sub-indicators under each category and the overall vulnerability is at the lower side. Relatively high vulnerability arising out of lack of irrigation and horticulture has been compensated by the fact that the yield variability of food grains is much lower in the state, leading to not so high sensitivity of agricultural production. Similarly, while per household availability of forest land is relatively lower in the state, there is no predominance of open forest. While the first lowers the adaptive capacity, the second leads to lower sensitivity, cancelling each other in a way. The state is not doing particularly well in terms of creation of its adaptive capacity through access to information and infrastructure, it needs to be observed that the weight assigned to this indicator is quite low (19%) to determine the magnitude of the VI alone. Coming to the sub-indicators under the category of socio-economic, demographic and health (weight = 34.5%), the performance of this state is consistently better with very low population density, availability of healthcare centres and very high participation of women in the labour force. Only low livestock to human ratio and presence of marginal farmers are the two major drivers of vulnerability in the socio-economic sector.
9	Tripura	Although Tripura has the highest percentage under marginal farmers, low per capita income, low percentage area under forests and under crop insurance, it has the highest road density, lowest area under slope >30%, highest MGNREGA participation and lowest yield variability when compared to other states.
10	Arunachal Pradesh	One would expect Arunachal Pradesh to appear more vulnerable when compared to the other states in the IHR, owing to the fact that it has a large area under slope >30%, low road density, least livestock to human ratio, lowest percentage of area under horticulture crops, least participation in MGNREGA, no crop area under insurance and low percentage of farmers taking loans. However, similar to Himachal Pradesh, most of the high vulnerability sub-indicators in this state fall under the indicator – access to information services and infrastructure. This indicator, in itself carries only 19% of weights. On the other hand, socioeconomic, demographic structure and health, as an indicator carries a much higher weight (34.5%). Arunachal Pradesh has been found to be doing relatively well with regard to the subindicators under this indicator. For example, this state has the least population density and the most densely available healthcare facility among all the 12 states. It also has a relatively low % of marginal farmers and high women participation in labour force that reduces the vulnerability of the state. However, the per capita income is not among the best. Besides, the state has the largest area under forests per 1,000 households and moderate area under open forests as compared to other states. Low vulnerability with respect to socio-economic, demographic and health sub-indicators, along with these other sub-indicators highlight the state's adaptive capacity, which offset the many sensitivities and thus the state scores a lower vulnerability index value.
11	Uttarakhand	Only one major driver of vulnerability for the state of Uttarakhand – low area under forests per 1,000 households.
12	Sikkim	Although Sikkim has three major drivers of vulnerability – low area under forests per 1,000 households, low percentage area covered by insurance and low percentage of farmers taking loans, it has the highest per capita income and the lowest area under open forests, which relatively lowers vulnerability of the state when compared to the other states in the IHR.

Annexure 4

Climate Change Profile of 12 Himalayan States

This section provides a brief snapshot of the profile, key interventions identified in the SAPCC, SCCC and key drivers of vulnerability of each of the 12 Himalayan States which are as follows:

1. Arunachal Pradesh
2. Assam
3. Himachal Pradesh
4. Jammu and Kashmir
5. Manipur
6. Meghalaya
7. Mizoram
8. Nagaland
9. Sikkim
10. Tripura
11. Uttarakhand
12. West Bengal

Note: The section on State Vulnerability in this Annexure presents results of the Vulnerability and Risk Assessment conducted for the Himalayan Region under NMSHE with support from IHCAP. The assessment was done with participation from the State Governments of all Himalayan States and used a common framework for vulnerability and risk assessment to generate a vulnerability profile of the entire Himalayan Region. The indicators for district level assessment done for Himalayan States were as follows:

1. % area under slope>30 degree
2. % area under forest cover
3. Yield variability of food grains
4. Population density
5. Female Literacy Rate
6. Infant Mortality Rate (IMR)
7. Below Poverty Line (BPL) Households/ Per capita Income
8. Average man-days under MGNREGA

To see the comparative vulnerability map of the states and read more about the assessment login at http://himalayageoportal.in/

1. Arunachal Pradesh

Arunachal Pradesh attained its statehood on 20th February 1987. It is the largest state in the north-east region of India with an area of 83743 sq. km and shares a long international border with Bhutan (160 km), China (1,080 km) and Myanmar (440 km). It stretches from snow-capped mountains in the north to the plains of Brahmaputra valley in the south. The state is situated between latitude 26°30'N and 29°31'N and longitude 91°30'E and 97°30' E. Arunachal Pradesh is characterised by rugged & undulating topography and rivers and streams that originate from the Himalayas and Arakan ranges.

Demographic Profile

The state has a total population of 13.83 lakh, spread over 20 districts, 27 census towns and 5589 inhabited villages. The state of Arunachal Pradesh has the lowest record of population density having just 17 per square kilometre. The rural population accounts for 77% of the total population. The decennial rate of growth of population stands at 25.92% and a literacy rate of 65.38 as per 2011 Population Census. As on date there are 25 districts in the state. Out of 5589 villages, 5258 are inhabited while remaining 331 are uninhabited. However, the number of towns in the state is 27 out of which 26 are statutory and 1 is census towns with least residing population. Dibang Valley is the largest district in the state with an area of 9129 sq. km. followed by West Siang (8325 sq. km.) and West Kameng (7422 sq. km.). The state is home to around 20 major tribes (Nishis, Apa Tanies, Hill Miris, Idu Misshmis, Miju Mishmis, Digaru, Mishmis, Khamtis, Noctes and 7-8 other tribes) and many sub tribes. Most of these tribes are ethnically similar but have distinctive characteristics in customs, costumes and language.

Climate Profile

The climate of Arunachal Pradesh varies from sub-tropical to temperate depending upon the altitude. The regions in the lower belts of the state experience hot and humid climates, with a maximum temperature in the foothills reaching up to 40 °C (during the summer). The average temperature in this region in winter ranges from 15° to 21 °C while that during the monsoon season remains between 22° to 30°C.

The areas around the middle belt of Arunachal Pradesh are relatively cooler. The middle belt in Arunachal Pradesh experiences micro thermal climate. Moreover, Arunachal Pradesh possesses an alpine climate in the higher altitudes of the state. The higher regions of Arunachal Pradesh witness snowfall during winter. The snowfall draws large number of tourists to the state from all across the world.

Arunachal Pradesh experiences heavy rainfall during May to September. The average rainfall recorded in Arunachal Pradesh is 300 cm, varying between 80 cm and 450 cm.

Arunachal Pradesh being essentially hilly with deep valley and high mountain peaks traversed by number of rivers and rivulets, has varying agro-climatic zones which can broadly be classified as:

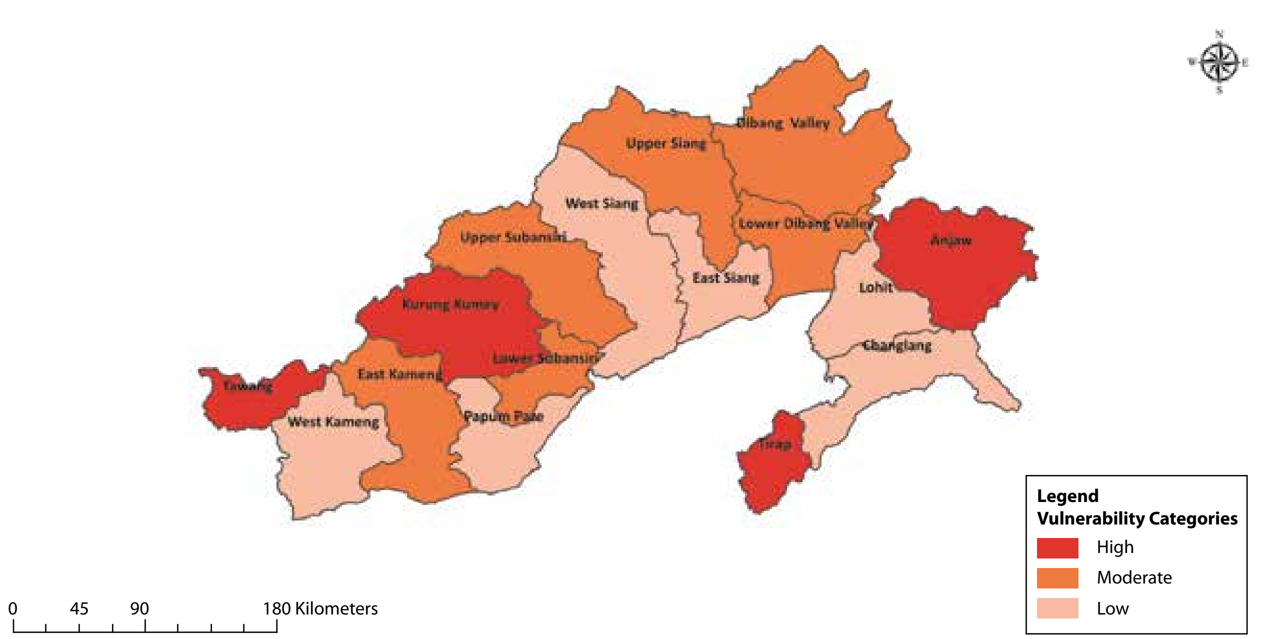
i. **Tropical Zone:** With high rain-fall and humidity, temperature ranges from 22°-36°C in summer and 10°-25°C in winter and elevation range is 80-900 m MSL.
ii. **Sub-Tropical Zone:** A. With moderate rain-fall and humidity, temperature ranges from 15°-30°C in summer and 14°-21°C in winter and elevation range is 900-1800 m MSL.
iii. **Temperate Zone:** With less rain-fall, temperature ranges from 0°-22°C and elevation range is from 1800 m to 3500 m MSL.
iv. **Alpine Zone:** Essentially cool temperature from 0°-20°C with snow-fall and elevation above 3500 m MSL.

Arunachal Pradesh State Action Plan on Climate Change

Department of Environment and Forests, Arunachal Pradesh acts as the State Nodal Agency for the preparation of SAPCC. Arunachal Pradesh SAPCC was prepared in consultation with the various line departments dealing with the sectors sensitive to climate change. The SAPCC priorities have been set up based on the analysis of past climate data and state of emission of GHGs and its negative impact on various sector and vulnerabilities. SAPCC of Arunachal Pradesh also synergies sustainable development and adaptation to climate change, with focus on the following areas:

- Forestry
- Agriculture
- Horticulture
- Energy
- Urban Development
- Water Resources
- Health
- Capacity building
- Gender sensitivity

Vulnerability category map of Arunachal Pradesh



Arunachal Pradesh State Climate Change Cell

The state has the least population density as well as it also has a relatively low percentage of marginal farmers and high women participation in labour force that reduces the vulnerability of the state that reduces the vulnerability of the state. However, the per capita income is not among the best. Besides, the state has the largest area under forests per 1,000 households and moderate area under open forests as compared to other states. Low vulnerability with respect to socio-economic, demographic and health indicators, along with these other sub-indicators highlight the state's adaptive capacity, and offset the many sensitivities giving it a lower vulnerability index value.

State Vulnerability on Climate Change

The state has the least population density as well as it also has a relatively low percentage of marginal farmers and high women participation in labour force that reduces the vulnerability of the state that reduces the vulnerability of the state. However, the per capita income is not among the best. Besides, the state has the largest area under forests per 1,000 households and moderate area under open forests as compared to other states. Low vulnerability with respect to socio-economic, demographic and health indicators, along with these other sub-indicators highlight the state's adaptive capacity, and offset the many sensitivities giving it a lower vulnerability index value.

2. ASSAM

Assam, the gateway to the North East Region of India, has 33 districts, 80 sub-divisions, 219 Blocks, 2202 Gram Panchayats and 26395 revenue villages. It is bordered by seven states, namely, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and West Bengal and two countries viz., Bangladesh and Bhutan. The state is divided into four major divisions: The Brahmaputra Valley, the Barak/Surma Valley or Cachar Plains, the Karbi plateau and the Barail and Southern Hill Ranges. Four districts fall under the Bodoland Territorial Council [BTC] area viz., Kokrajhar, Baksa, Chirang and Udalguri. Less densely populated are the two hill districts of Karbi Anglong and Dima Hasao, set in the low-lying hills that separate the two valleys. The state is the largest tea producing region in the country with 765 tea gardens. It is also the largest producer of "Eri" silk in the country and enjoys global monopoly in terms of Muga or golden silk production.

Demographic Profile

Home to 31.2 million people, of which 86% reside in rural Assam, the population density is 398 persons per sq.km. The literacy level is 72.19%. Out of the total population, SC & ST population is 7.15% & 12.45%, respectively. The workforce (119.69 lakh) constitute 38.35% of the total population in Assam.

Amongst the workers, the share of main workers and marginal workers is 86.87 lakh (72.57%) and 32.82 lakh (27.42%), respectively. Workforce engaged in agricultural activities is 33.76% (cultivator + agriculture labourers) whereas 2.02% and 36.78% of the total workforce are engaged in household industries and other works, respectively.

Climate Profile

The climate of Assam is humid sub-tropical with warm humid summer & cool dry winter. Assam has six agro-climatic zones - North Bank Plains Zone, Upper Brahmaputra Valley Zone, Central Brahmaputra Valley Zone, Lower Brahmaputra Valley Zone, Barak Valley Zone and Hill Zone. The state normally receives 2% rain in winter season [January-February], 25% in summer season [March-May], 65% in monsoon season [June-September] & 7% in post monsoon season [October-December].

The State is severely affected by floods during rainy seasons causing enormous damage to crops, livestock, land, property and bringing untold miseries to the people at large. Both the Brahmaputra and Barak Valley witness devastating floods every year, which not only wash away valuable life and crops, but also lead to bank erosion and drainage congestion. In fact, the successive waves of devastating floods almost every year have severely affected the economy of the state, more particularly, the rural economy. Flood waters inundate vast tracts of forest land in most of the national parks and wildlife sanctuaries, including the world heritage sites - Kaziranga National Park and Manas Tiger Reserve. Tea gardens, particularly in the Barak valley in southern Assam, have been hit hard by the floods.

Assam State Action Plan on Climate Change

The climate of Assam is characterised by high rainfall and a subtropical climate. It gets annual floods and frequent droughts, where severity of both has risen due to adverse climatic conditions. The SAPCC has been prepared with the objective of identification of adaptation strategies that will make the State resilient, to the extent possible, and to the ongoing climate variability, climate change and associated extreme events. It is perceived that developing climate resilience would not hamper the State's developmental aspirations. It aligns itself with the guidance provided by the missions of the National Action Plan on Climate Change and the principles of Adaptation followed while developing the Assam SAPCC, which are as follows:

- Ensuring sustainability of water resources: Water being essential to all economic activities, the SAPCC looks at how water resources can be augmented and best utilized in a changing climate scenario and what necessary institutional changes will be required to make these strategies come to affect.
- Ensuring sustainability of agriculture systems: Major concerns are sustainability of critical ecosystems including agro-ecosystems (agriculture, fishery, and livestock) to ensure livelihood security in a changing climate scenario.
- Protection and conservation of forests and bio-resource within: Focus areas are sustainable management of Forest, Wild Life and biodiversity and developing resilience of eco-system services.
- Making habitats climate resilient: Major concern is the expanding and high density urban human settlements where proving sanitation, drinking water, transportation, health, waste management and other amenities will be a challenge in the future changing climate scenario.
- Ensuring energy sufficiency and efficiency: Major concerns will be technological initiations and

intervention with more focus on harnessing new and renewable energy, energy efficiency and conservation.

- Addressing enhanced impacts of anticipated extreme events: Adaptation planning in anticipation of intensification of extreme events to ameliorate the exacerbated impacts will be the underlying motto here.

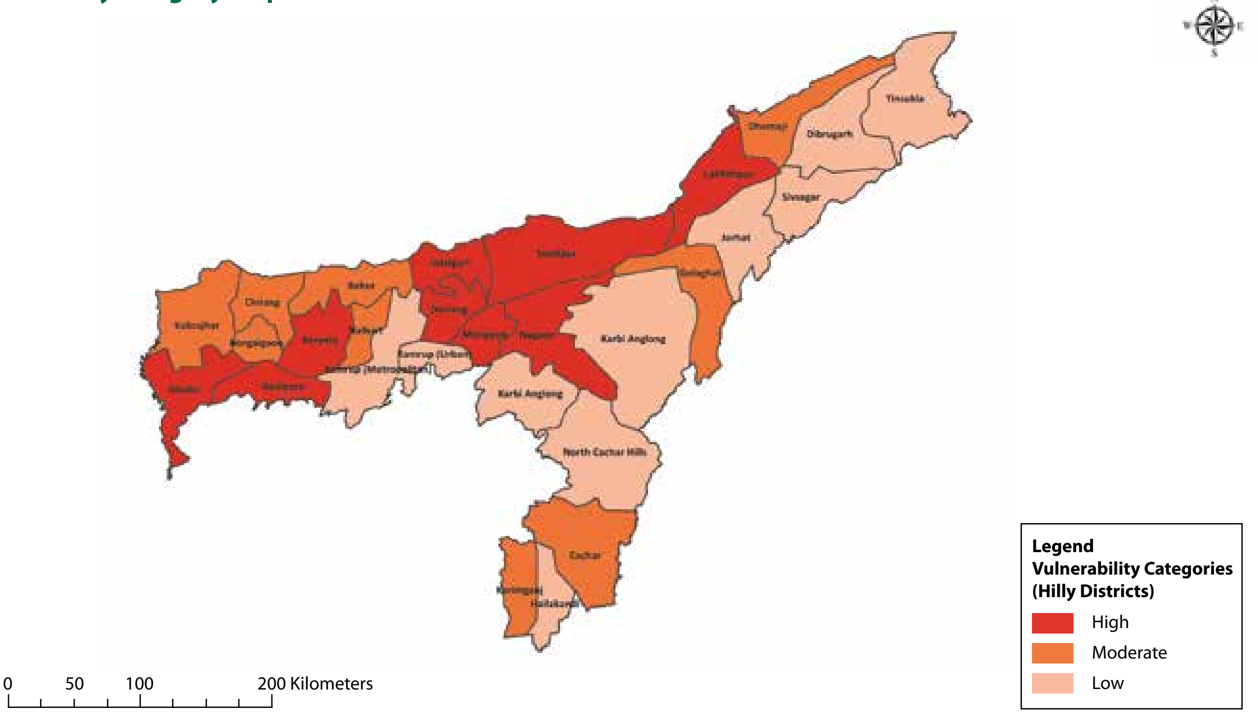
Assam State Climate Change Cell

The Govt. of Assam has decided to set up Assam State Climate Change Cell (ASCCC) to formulate policies, action plan and prioritize research activities including actions in the subject of weather and climate based on the recent changes in the patterns of temperature and rainfall condition in the state. The ASCCC will be equipped with experts and networking facilities with various stakeholder departments, educational institutions, central government agencies, research laboratories, etc. this will also help in formulating actions while implementing the NAPCC formulated by Government of India.

State Vulnerability on Climate Change

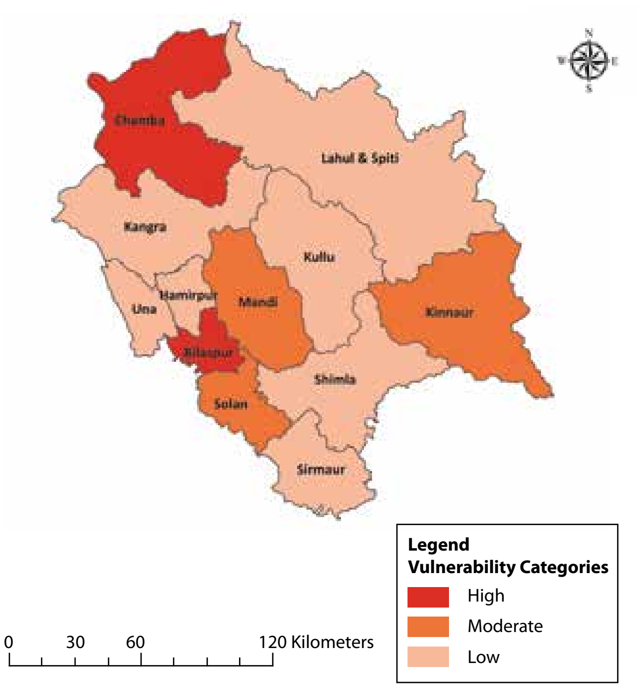
Assam, as a state, falls in the higher side of vulnerability index six major drivers of vulnerability are- least area under irrigation, least forest area available per 1,000 rural households, and least number of farmers taking loans as compared to other states. It also has the second lowest per capita income, low percentage area covered under crop insurance and low MGNREGA participation. In fact, other than population density, this state has relatively high vulnerability with respect to all sub-indicators under socio-economic, demographic and health indicator. Similarly, since Assam has more flat lands relative to other states, which suggests lower sensitivity to natural disaster, lack of access to information and infrastructure puts this state into a situation where it would be extremely difficult to cope with any climate variability.

Vulnerability category map of Assam



3. HIMACHAL PRADESH

Vulnerability category map of Himachal Pradesh



Himachal Pradesh takes its name from the mighty Himalayas. The state is situated in lower Himalayan region with numerous mountain ranges. **Spread over an area of** 55,673 sq. km, it neighbours Jammu and Kashmir in the North, Punjab in the West and South-West, Haryana in the South and Uttarakhand on South-East. While most of the territory is mountainous, certain belts bordering Punjab and Haryana have a sub-mountenous topography. The Geographical Location of Himachal Pradesh with respect to latitude is between 30 o 22' 40" North to 33o 12' 40" North and it falls between 75 o 45' 55" East to 79 o 04' 20" East in longitudinal axis.

Demographic Profile

The State is divided into 12 districts, 78 blocks and 3243 Gram Panchayats, comprising 59 cities & town and 20690 (17882 inhabited) villages.

As per 2011 census, the total population of Himachal Pradesh was 68.7 lakh. The population density of the State is low at 123 compared to all India figure of 382. The rural and SC/ ST population constitute 90% and 31% respectively of the total population of the State. The total work force estimated at 33.2 lakh accounting for 48% of the total population. The gender ratio of the State stands at 972 against the national figure of 940. The literacy rate in the State as per 2011 census, improved remarkably from 76% in 2001 to 83% in 2011. The State has also been able to considerably reduce its gender disparity in literacy rates. As per 2011 census, female literacy rate improved to 76% while male literacy to about 90% in the State. The poverty ratio in the State is low. As per GoI estimates, the population below poverty line in the State during 2011-12 was at 8% as compared to all India figure of 22%.

Climate Profile

Due to differences in the geophysical features, the state experiences variations in the temperature and rainfall. Climate of the state varies from moderate to extreme cold/ sub-zero temperature. Winter season spans from October to February, bringing enormous snow falls in the higher region while the duration of the summer season is from March/April to June. The average weather of various regions in the State varies as per altitude levels. The annual rainfall varies from 1500 mm to 1800 mm.

The State is divided into four climatic zones summarised in Table 1.1:

Himachal Pradesh State Strategy and Action Plan on Climate Change

The fundamental purpose and goal of the Himachal Pradesh State Strategy and Action Plan on Climate Change (HPSSAPCC) is to begin a state-wide, ongoing and committed process of adapting to the changing climate in the context of other changes in the environment, economy and society. To achieve this goal, the adaptation strategy pursues the following specific objectives:-

Table 1.1: Climatic Zone of Himachal Pradesh

Sr. No.	Agro climatic Zone	Districts
1	Shivalik Hill Zone – 350 mtr. to 650 mtr. above mean sea level	Kangra, Una, Hamirpur, Bilaspur, Solan
2	Mid Hill Zone – 651 mtr. to 1800 mtr. above mean sea level	Mandi, Sirmaur
3	High Hill Zone – 1801 mtr. to 2200 mtr. above mean sea level	Kullu, Shimla
4	Cold Dry Zone – 2201 mtr. and above	Chamba, Lahaul and Spiti, Kinnaur

Source: Department of Agriculture

1. Identification and synthesis of climate change risks
2. Developing the criteria for prioritizing identified adaptation strategies
3. Identification of sector-specific and cross-sectoral adaptation strategies to reduce vulnerabilities and build climate resilience
4. Evolving cross-cutting supportive strategies to identify government efforts such as policy-making or changes in regulation, procedural adjustments to enable development and implementation of identified adaptation strategies.

Himachal Pradesh State Knowledge Climate Change Centre

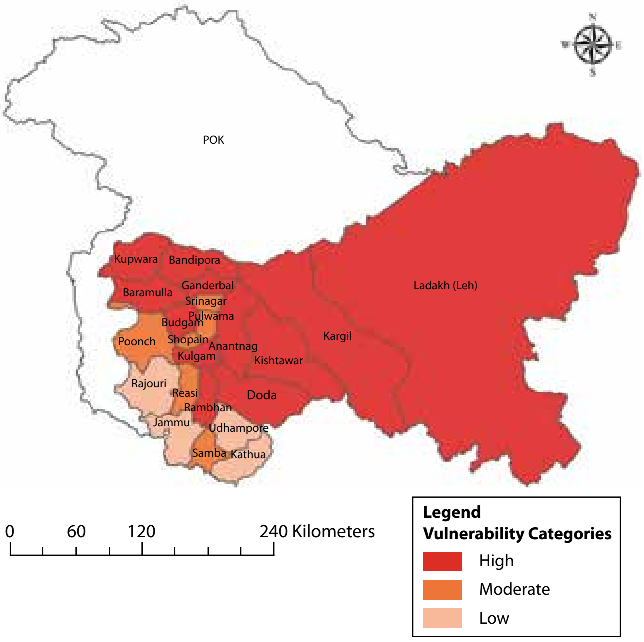
HP State Knowledge Cell on Climate Change (HPKCCC) under National Mission for Sustaining the Himalayan Ecosystem (NMSHE) has been setup in the Department of Environment, Science & Technology, Govt. of Himachal Pradesh after the approval of The Ministry of Science & Technology, Govt. of India. Through this cell the data base on climate change is generated and the knowledge gaps are being filled up. The setting up of a knowledge centre has built a vibrant and dynamic knowledge system in line with the objectives of National Missions with primary focus to collection, collation and dissemination of climate change knowledge in the State through building human and knowledge capacities, institutional capacities, evidence based policy implementation capacities, continuous learning and pro-active designing of development strategies capacities, regional network of knowledge institutions engaged in research on Himalayan Ecosystem.

State Vulnerability on Climate Change

The state is vulnerable in terms of creation of its adaptive capacity through access to information and infrastructure. With respect to socio-economic, demographic and health, the performance of the state has been consistently better with very low population density, availability of healthcare centres and very high participation of women in the labour force. Only low livestock to human ratio and the presence of marginal farmers are the two major drivers of vulnerability in the socio-economic sector.

4. JAMMU & KASHMIR

Vulnerability category map of Jammu and Kashmir



Jammu and Kashmir is situated on the northernmost part of India, between 32° 17′ N and 36° 58′ N latitudes and 73° 26′E and 80° 30′ E longitudes. Covering an area of 222,236 sq km, it is the 6th largest state of India occupying 6.76% of the country's geographical area. The state shares 221 km international boundary with Pakistan in Jammu region and 365 km with China in Ladakh. J&K is home to several valleys such as the Kashmir Valley, Tawi Valley, Chenab Valley, Poonch Valley, Sindh Valley and Lidder Valley. Jhelulm is the only major Himalayan River which flows through Kashmir Valley. The Indus, Tawi, Ravi and Chenab are other major rivers flowing through the state.

J&K is divided into 22 districts, 217 Tehsils, 86 towns and 6671 total villages as per Census, 2011. Administratively, the districts are divided into blocks for development purposes. There are 320 community development blocks in the state. This State capital changes according to the seasons, the Srinagar as the summer capital and Jammu as the winter capital. The state has three official languages- Urdu, Kashmiri, Dogri. Ladakhi is also a spoken language.

Demographic Profile

The state has a total population of 1.25 crores. It occupies 19th rank in population as per 2011 census. The state has three distinct regions, viz. the Kashmir, Jammu and Ladakh, comprising 22 districts. It is the only Indian state with a more prominent Muslim population. The population density of the state is 56 persons per square kilometre. The state has contained its population growth from 2001 to 2011 by around 6%. From 29.43% out in 2001, the population growth of Jammu & Kashmir has declined to 23.64% in 2011.

Climate Profile

The climate of the state varies from tropical in Jammu plains to semi-arctic cold in Ladakh with Kashmir and Jammu mountainous tracks having temperate climatic conditions. The annual rainfall also varies from region to region with 102 mm in Leh, 514.9 mm in Srinagar and 1338.60 mm in Jammu. A large part of the state forms part of the Himalayan Mountains. The state is geologically constituted of rocks varying from the oldest period of the earth's history to the youngest present-day river and lake deposits. 10.46% of the total geographical area of the state is under forests. The per capita forest area accounts for 0.15 hectares as against 0.06 hectares at the National level.

As per UNEP report some parts of the State are moderate to highly vulnerable. As per INCCA assessment, the number of rainy days in the Himalayan region in 2030s may increase by 5-10 days on an average, with an increase by more than 15 days in the eastern part of the Jammu and Kashmir region. The intensity of rain fall is likely to increase by 1-2 mm/day. This is likely to impact some of the horticultural crops. The rate of recession of glaciers is reportedly varying which is being attributed to winter precipitation, climate warming and anthropogenic elements. Temperature, precipitation and cold wave are most likely to significantly impact the agricultures sector.

Jammu and Kashmir State Action Plan on Climate Change

The main objective of Jammu and Kashmir State Action Plan on Climate Change (SAPCC J&K) is to strategic adaptation and mitigation initiative towards emission stabilization and enhancement of ecosystem resilience, climate proofing of the livelihood sector and diversification of dependency on the natural resources. Considering the issues related to the impacts of climate change on the ecologically sensitive as well as economically important sectors, ten missions specific to the state were identified along with corresponding ten working groups and sanctioned by the Government. These ten missions are:

- Energy - Solar Mission and Renewable Energy
- Enhanced Energy Efficiency
- Water
- Sustainable Habitat
- Sustainable Agriculture
- Tourism
- Sustainable Himalayan Ecosystem
- Health
- Disaster Management
- Strategic Knowledge Mission

J&K State Climate Change Cell

The Department of Ecology Environment and Remote Sensing has been given the responsibility to coordinate the implementation of NMSHE in J&K. The Ministry of Science and Technology, Government of India, has sanctioned J&KSCCC under NMSHE for implementation of the programme. The J&KSCCC has been established with an aim to address the need to better understand how to assess and address climate change related risks in state. This Climate Change Centre is mandated with the responsibility of research, data collection, and public awareness in the field of Climate Change. The Climate Change Centre act as a nodal agency to coordinate with line departments on eight national and eleven state missions. The Centre aims to strengthen its capacity as a single window repository of climate change. The Centre is expected from this programme to build human capacity, generate additional resources for the state and facilitate interfacing with national and international agencies to reduce vulnerability of the state, preserving the ecosystem and enhancing resilience.

State Vulnerability on Climate Change

Several drivers of vulnerability are evident for the state of J&K. These include, in the order of significance, least road density, no area under crop insurance, low area under forests per 1,000 rural households, high percentage of marginal farmers, low percentage area under horticulture crops, low livestock to human ratio and low percentage of women in the overall workforce. This implies that four out of six sub-indicators under the socio-economic indicator, one out of three under the agricultural sensitivity indicator, one out of two forest-related sub-indicators and all access-related sub-indicators barring the average slope exhibit high degree of sensitivity and lack of adaptive capacity of the state. In fact, this state is in the most difficult situation with respect to two important factors that increase the adaptive capacity - road density and crop insurance. Similar to Assam, one may observe that the states ranking higher in the order with respect to vulnerability are generally lagging in terms of most of the sub-indicators considered. Vulnerability in J&K is rather composite in nature and not explicitly sector specific.

5. MANIPUR

Manipur is one of the smaller States in the North-Eastern corner of India having a total geographical area of 22,327 sq.km, which is 0.70 % of the total land surface of India. The State has two distinct topographical zones namely hills and valley. Hills cover nearly 90% (20,089 sq. km) of the total geographical area, while the central valley portion consisting of 2238 sq. km accounts for only one-tenth of the geographical area. The State has 352 kms long international border with Myanmar (Burma) to the South- East and 502 kms long border with the adjacent states of Nagaland and Assam on the West and Mizoram on the South and the South-West). The state has 09 districts – 04 in the Valley and 05 in the hills, 66 Sub-divisions and 2515 inhabited villages. Further, there are 33 different tribes of different ethnic groups.

Demographic Profile

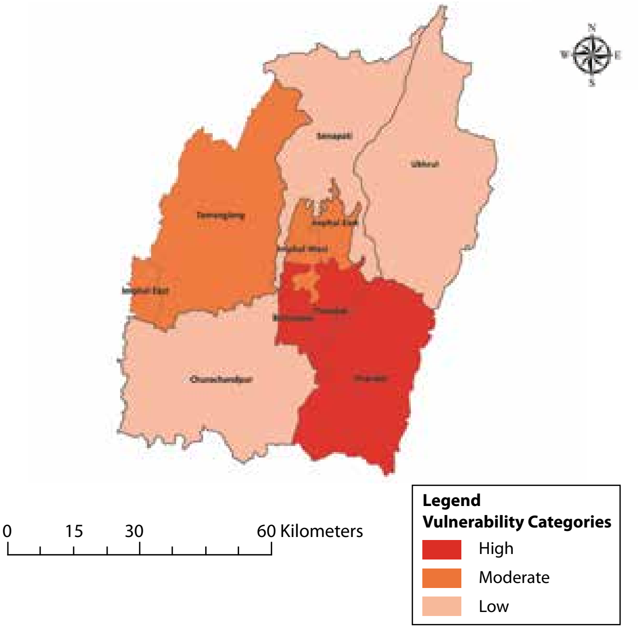
The population of Manipur forms 0.24 percent of India in 2011. There are 33 different Scheduled Tribes of different ethnic groups presenting a hue of socio-economic phenomena. The total numbers of households in the State stand at 6,09,964, of which, 3,97,837 are rural households and 2,12,127 are urban households.

Total population	28.56 Lakhs (Census 2011)
Male population	14.43 lakh
Female population	14.17 lakh
Population density	128 persons per sq. km
Sex ratio	985 females per 1000 male (Census 2011)
Literacy rate	76.94 percent (Census 2011)

Climate Profile

Manipur falls under Eastern Himalayan agro climatic zone with two broad topographic divisions, viz., plains and hills. The zone covers Sub Tropical, Temperate & Mild tropical hill zone. Manipur's climate is classified as tropical. The monsoon climate is confined within four summer months from June to September. Hence, when compared to winter, summer receives much more rainfall. The southwest monsoon is the main source of rain, and June is the rainiest month. The average rainfall

Vulnerability category map of Manipur



received is 1467.5 mm annually. The rain fall distribution varies from region to region in Manipur. While Imphal receives 933 mm of rain, Tamenglong receives 2593 mm. The weather in the state is highly influenced by the winds blowing from the Bay of Bengal with heavy rains during the rainy season.

The rainfall is projected to increase by 20%. Similarly, average annual temperatures varies between 12.2° and 15.8 °C. An increase in temperature above 1.7°C is projected (Manipur State Action Plan on Climate Change, 2013).

Manipur State Action Plan on Climate Change

The Directorate of Environment, Government of Manipur, as the Nodal Agency, in collaboration with 20 line government departments / agencies of Manipur Government, has prepared the Manipur State Action Plan on Climate Change (SAPCC), with the objective to deal with the future challenges of climate change and taking action to reduce associated risks and vulnerabilities. The SAPCC-Manipur addresses the urgent and critical concerns of the state through a directional approach including the enhancement of the existing and planned programmes with technical assessment and approach as laid down by the NAPCC. The SAPCC –Manipur, targets to achieve coherence between the strategies and actions on climate change policy. Address the adaptation challenges by improving the adaptability of the public through developing suitable infrastructures and preserving its eco-systems.

Manipur State Climate Change Cell

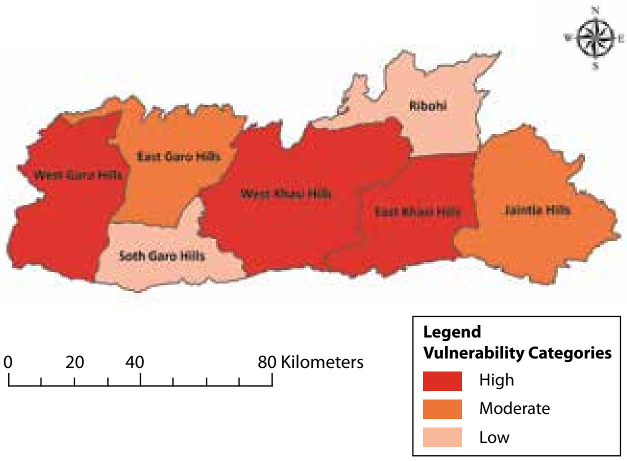
Manipur SCCC was established to address the existing as well as future challenges of climate change and takes actions to reduce the associated risks and vulnerabilities. The SCCC also act as the Nodal Agency, in collaboration with 20 line government departments / agencies of Manipur Government for preparing the Manipur SAPCC. The SCCC exist to work out certain strategy and activities in consonance with the NAPCC. It focuses on the protection of the poor and vulnerable sections of society through an inclusive & sustainable development strategy, sensitive to climate change. The SCCC stands to adapt & combat the climate change issues in the state.

State Vulnerability on Climate Change

Manipur has three major drivers of vulnerability - lowest per capita income, low percentage of farmers taking loans and low area under forests per 1,000 households. Interestingly, other than income, and the availability of healthcare facilities to some extent, the performance of this state with respect to other socio-economic, demographic and health indicators is relatively better than the other states. However, the high vulnerability of the state arises from other indicators as well.

6. MEGHALAYA

Vulnerability category map of Meghalaya



Meghalaya, situated in the north eastern region of India, is a narrow stretch of land, running between Bangladesh on the South and West and Assam on the North and East. The state shares an international boundary of about 443 Km with Bangladesh. The State's area of 22,429 sq.km is spread across the predominantly three hill regions of Garo Hills, Jaintia Hills and Khasi Hills, accounting for 0.68% of the geographical area of India with a population of 29.67 lakh (2011 census) accounting for 0.25 % of the population of India. It is spread over an area of 22423 sq Km and lies between 20.1° N and 26.5° N latitude and 85.49° E and 92.52° E longitude. The state has the highest length of rivers and canals with stretch of 5600 Km (26.83%) followed by Assam 4820 Km (23.09%) out of total resources under rivers and canal of North eastern states.

The State is divided into 11 Districts, 8 Civil Sub-divisions and 45 Community & Rural Development (C&RD) Blocks and has a varied topography - high mountains, plateaus, hills and plains.

Demographic Profile

The population of Meghalaya forms 0.25% of India. A total of 20.07% people live in the urban belts while 79.93% live in the rural areas. The urban population in the last 10 years has increased by 20.07 percent Sex Ratio in urban regions of Meghalaya is 1001 females per 1000 males.

Total population	29.67 Lakhs (Census 2011)
Male Population	14.91 lakh
Female Population	14.75 lakh
Literacy rate	72.89 % (census 2011)

Climate Profile

The climate of Meghalaya varies with the altitude. The climate of Khasi and Jaintia Hills is uniquely pleasant and bracing. It is neither too warm in summer nor too cold in winter, but over the plains of Garo Hills, the climate is warm and humid, except in winter. True to its name, the Meghalaya sky seldom remains free of clouds. The four seasons of Meghalaya are: Spring (March, April and May) summer (June, July and August) autumn (September, October and November) and winter (December, January and February). The state receives abundant average annual rainfall of 4,000 -9,000 mm making it the wettest state in the country. The state is characterised by diverse range of soil types including red loamy and laterite and five

Agro climatic zones which support a variety of crops, plantation & horticulture products. However, the State's agrarian population is highly vulnerable to the changing weather patterns, unpredictable floods and dry spells as well as soil and water contamination from acid mine drainage in mining areas.

Meghalaya State Climate Change Action Plan

The Meghalaya SAPCC was developed in the state to identify key priorities in each sector. This will also include creating awareness and building the capacity of line department staff and the vulnerable community towards implementation of the adaptation activities proposed under SAPCC. The main aim of SAPPC is to create scientific understanding of climate change phenomenon in the State and creation of knowledge at an adequate scale and resolution and assess its impact on different sectors.

Meghalaya State Climate Change Cell

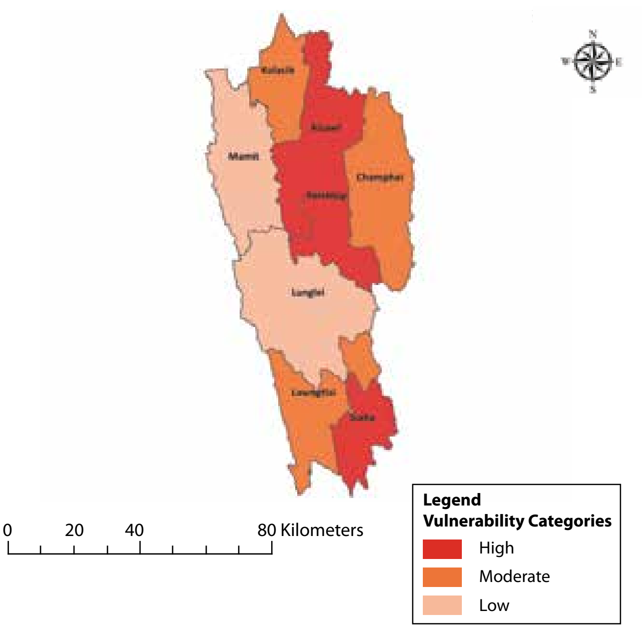
Understanding the importance and urgency of climate change issues and its impact on growth, development and poverty reduction, the State of Meghalaya has established a Climate change Cell in the year 2015 led by Meghalaya Basin Development Authority, Planning Department (Govt of Meghalaya) to address issues and activities for combating the effects of climate change. Meghalaya SCCC is responsible to forge partnership with private sector, academic institutions and civil society to facilitate the implementation of various proposed actions in the state.

State Vulnerability of Climate Change

The vulnerability of this state arises from the socio-economic indicators and lack of access to information and infrastructure. The state has four major drivers of vulnerability - very low area under crop insurance, low per capita income, low area under forests per 1,000 households and low percentage of farmers taking loans.

7. MIZORAM

Vulnerability ranking map of Mizoram



Mizoram is one of the seven states of North East Region (NER) of India, with Aizawl as its capital. The State is a mountainous region, a land of rolling hills, rivers and lakes. The hills are extremely rugged and steep with some plains scattered occasionally here and there. In the northeast, it is the southernmost landlocked State sharing borders with three States, namely, Tripura, Assam and Manipur. The State also shares a 722 kms long border with the neighbouring countries viz., Bangladesh and Myanmar. The National Highway No. 54, which runs through Assam and Meghalaya, connects it with the rest of the India. The State is divided into 8 districts, 23 sub-divisions and 26 R.D. Blocks for administrative purpose. Three Autonomous District Councils (Lai, Chakma and Mara) are functioning in the southern districts of Lawngtlai and Siaha. As per 2011 census, there are 23 towns and 704 inhabited villages in the State.

Demographic Profile

The population of Manipur forms 0.24% of India in 2011.Out of total population of Manipur, 29.21% people live in urban regions and 70.79% live in the villages of rural areas. The urban population in the last 10 years has increased by 29.21%.

Total population	28.56 Lakhs (Census 2011)
Male Population	1,438,586
Female Population	1,417,208
Population Growth (2001-2011)	24.50 percent

Climate Profile

Mizoram has a moderate climate; relatively cool in summer 20 to 29 °C (68 to 84 °F) and winter temperatures range from 7 to 22 °C (45 to 72 °F).The state is influenced by monsoon, raining heavily from May to September with lesser rain in the dry season. The climate pattern is moist tropical to moist sub-tropical.

Due to its geo-climatic condition, the state is one of the most hazard prone states in the country. The state is annually swept by cyclonic storms, cloudbursts, hailstorms and landslides. To make matters worse, the State falls under Seismic Zone V, and thus is liable to be hit by strong earthquakes. Small tremors are felt every now and then in and around the state. Although the State enjoys abundant rainfall during monsoon period, the dry spell during non-monsoon period hits people's lives. Due to the steepness of the hillsides, underground water retention is minimal, causing perennial water sources to dry up during this period. This has been further aggravated by the traditional custom of jhum cultivation, commonly known as slash and burn. The habit of felling trees and foliage of forests and burning them badly affects natural vegetation, thus causing ecological imbalances. Moreover, this usually leads to unwanted spread of fire in forests.

Mizoram State Action Plan on Climate Change

Climate Change Council of Mizoram has develop a Mizoram State Action Plan for assessment, adaptation and mitigation of climate change with an objective to monitor the targets, objectives and achievements of the national missions specified by the National Action Plan on Climate Change (NAPCC). Analysing the key priorities, Mizoram Action Plan on Climate Change will also facilitate the conservation of biodiversity including restoration and rehabilitation which will help vulnerable people, mostly the tribal communities and economically most backward strata, to cope with climate change. SAPCC also synergize sustainable development and adaptation to climate change, a list of programmes and policies (as perceived by the State) have been identified in the following areas:

- Agriculture
- Sustainable Himalayan Mission
- Green Mission
- Sustainable Habitat
- Health
- Solar Mission and Renewable Energy Sector
- Energy Efficiency
- Water
- Strategic Knowledge Mission

Mizoram State Climate Change Cell

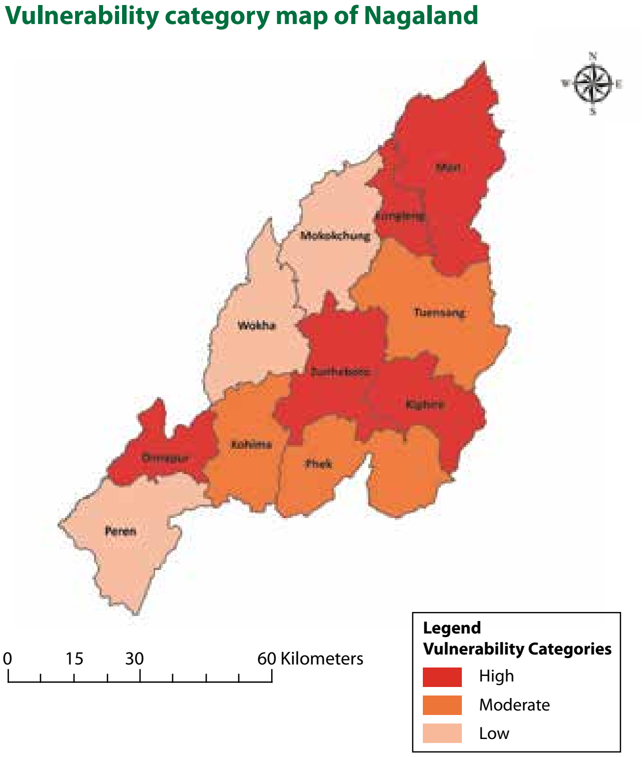
The Mizoram CCC was established in 2015 under the Mizoram Science, Technology and Innovation Council (MISTIC), Directorate of Science and Technology, Government of Mizoram. The Cell was established to coordinate all the activities of the SAPCC and responsible to work on the NMSHE and Strategic Knowledge Mission (SKM) of the SAPCC. The key priorities of SCCC are mainly related to strategize adaptation and mitigation initiative towards emission stabilization and enhance the resilience of the ecosystem in the state to reduce the vulnerability.

State Vulnerability on Climate Change

The state has seven major drivers of vulnerability - highest yield variability, no area under crop insurance, largest area under open forests, and largest area under slope >30% as compared to other states. It also has the second lowest percentage area under irrigation and the third lowest road density among the 12 states. A glance at the normalized values of the sub-indicators show that agricultural sensitivity and lack of access are two major drivers leading to lack of adaptive capacity of the state.

8. NAGALAND

Vulnerability category map of Nagaland



Nagaland, with an area of 16,579 sq. km. emerged as a State, out of the Naga Hills district of Assam and NEFA province, in 1963 and accounts for 0.16% of the country's population as per Census 2011 data with its total population of 19.79 lakh. The State has common boundaries with Myanmar in the East, state of Assam in the West; Arunachal Pradesh and a part of Assam in the North with Manipur in the south. It is mostly mountainous though the regions bordering the Assam valley are plains. The Naga Hills are a part of the Arakan Mountain Range and Mt. Saramati is the highest peak of Nagaland with an altitude of 12,552 feet. There are four main rivers flowing through Nagaland, which are Dhansiri, Doyang, Dikhu and Jhanji.

The State is divided into 11 districts and 74 Community & Rural Development blocks. It has been provided with a special constitutional protection under Article 371(A) of the Indian Constitution to safeguard the culture, traditions and way of life of the Nagas such that no Act of Parliament in respect of the Naga Customary Law, the religious/social practices of Nagas, administration of civil and criminal justice as per Naga Customary Law and ownership & transfer of land and its resources, shall apply to Nagaland unless so decided by the State Legislative Assembly by a resolution.

Demographic Profile

As per Census 2011, Nagaland is the only state in the country which registered a negative decadal growth rate of -0.58%. There are 16 major tribes, each with its distinct language, customs and culture. The population density is 119 per square km which is lower than national average of 382 per square km. The total literacy rate of Nagaland is 79.55% which is greater than average literacy rate 72.98% of India. 28.86% people live in urban areas while 71.14% are in rural areas. The workforce participation rate is 49.24% with approximately 9.74 lakh workers.

Climate Profile

The climate of Nagaland in general is controlled by its terrain features. It is hot to warm subtropical in areas with elevations of 1000 to 1200 m. The climatic environment is warm sub temperate in areas with elevations of 1200 m and above. The climate as such is typical of a tropical country with heavy rainfall. Most of the heavy rainfall occurs during four months i.e. June to September. The rain during April to May is low. The temperature varies from 0°C in winter to about 40°C in summer depending on elevation. The average annual temperature ranges from 18°C to 20°C and 23°C to 25°C in the higher and lower elevations, respectively.

Nagaland State Action Plan on Climate Change

The Government of Nagaland has put in place the State Action Plan for integrating climate concerns in its developmental plans into the future and achieve a low carbon inclusive growth, while ensuring complementarity with the national agenda on climate change. The key elements in the climate response strategy of the state include accelerating inclusive economic growth, promoting sustainable development, securing and diversifying livelihoods and safeguarding ecosystem services to be integrated into the regular developmental planning process.

Some of the key sectors identified in the State Action Plan of Nagaland are as follows:

- Integrated Agriculture
- Forests and Biodiversity
- Water Resources
- Energy
- Livelihoods

Nagaland State Climate Change Cell

Nagaland SCCC was established in April 2017 under NMHSE. In line with its objectives, the Centre focuses on issues underlined and prioritised in the Nagaland State Action Plan on Climate Change (NSAPCC). The Centre has also been ardently involved in revising NSAPCC.

Realising the need for Climate Change Sensitization, the Centre has been taking initiatives to build capacity in understanding and tackling Climate Change in the State. CCAPS- Climate Change Awareness Programme for Students is one of the pilot programmes introduced by the NSCCC aimed at fulfilling this objective. Besides, the NSCCC is keenly working towards establishing a network for research in the field of Climate Change.

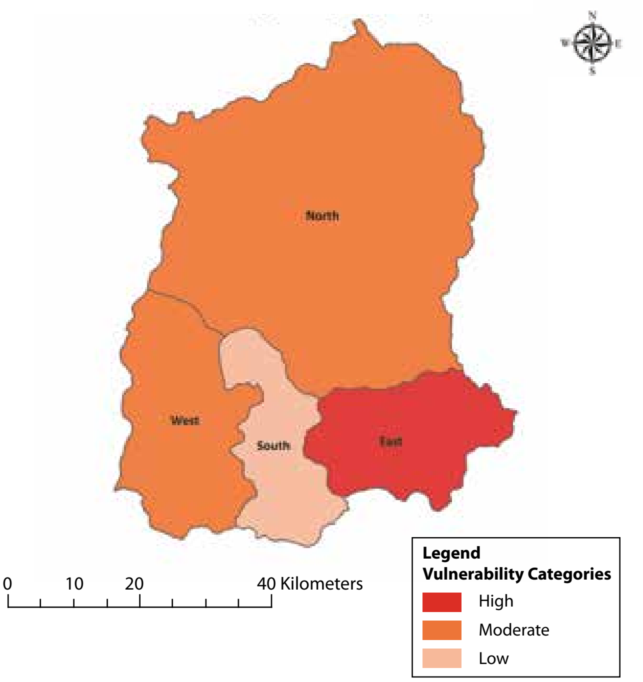
NSCCC is in the process of launching a climate change knowledge repository which will address the issues of Data Deficiency and lack of knowledge dissemination on Climate Change in the State.

State Vulnerability on Climate Change

No area under crop insurance, low percentage of farmers taking loans and low area under forests per 1,000 rural households are the three major drivers of vulnerability in the state. However, this state has high per capita income, low population density, lowest prevalence of marginal farmers and highest women participation in the labour force that make the state relatively resilient.

9. SIKKIM

Vulnerability category map of Sikkim



Nestling in the Himalayan Mountains, the State of Sikkim is characterised by mountainous terrain. The State is located at the foothills of Eastern Himalayas between27° 5′ N to 20° 9′ N latitudes and 87° 59′ E to 88° 56′ E longitudes. Sikkim, the 22nd state of India came into existence with effect from 16th May, 1975. Sikkim, being a very small state extends approximately 115 Kms from north to south and 65 Kms from east to west and is surrounded by vast stretches of Tibetan Plateau in the North, the kingdom of Bhutan in the east, Darjeeling district of West Bengal in the south and the kingdom of Nepal in the west. The state having alpine zones and snow bound land, carries elevations ranging from 300 to 8586 mtrs above mean sea level. Mt. Kanchendzonga, the world's third highest peak, is the state's highest point, situated on the border between Sikkim and Nepal. Ethnically Sikkim has mainly three groups of people viz. Nepalis, Bhutias, Lepchas. English is the official language.

The total geographical area of the state is 7,096 sq.km, divided into four districts – East Sikkim, West Sikkim, North Sikkim and South Sikkim with the headquarters at Gangtok, Gyalshing, Mangan and Namchi respectively.

There are 31 Administrative Blocks and 176 Gram Panchayat Units (GPUs) administering 989 Gram Panchayat Wards (villages).

Demographic Profile

Sikkim is the second smallest state in the country . The rural population constitutes 74.85% (4,56,999) and urban population constitutes 25.15% (1,53,578). The density of population is 86 persons per sq.km, one of the least densely populated in the country. . Schedule caste and schedule tribe population is 4.63 % (28,275) and 33.80% (2,06,360) respectively. Broadly, the population can be divided into tribal and non-tribal groups. East district is the most populated whereas North district is least populated.

Total Population	6.11 lakh (as per 2011 census)
Decennial population growth from 2001 to 2011	12.89%
Sex ratio	890 female per 1000 male population
Literacy rate	81.4%

Climate Profile

The geographical location of Sikkim, coupled with its altitudinal variation allows it to have tropical, temperate and alpine climatic conditions within its small area of 7,096 kms. Temperature conditions vary from sub-tropical in the southern lower parts to cold deserts in the snowy north. It is also the most humid region in the whole range of the Himalayas due to its proximity to the Bay of Bengal and direct exposure to Southern monsoon. The temperature distribution like the mean daily maximum temperature in the sub-basin varies from about 26.8^0 C in September to 20.7^0 C in the month of January. Mean daily minimum temperatures are around 7.5^0 C in January, 10.7^0 C in April, 14.5^0 C in July and 13.3^0 C in October. Rainfall is heavy and well distributed during the months from May to early October. July is the wettest month in most of the places. The intensity of rainfall during South-West monsoon season decreases from south to North, while the distribution of winter rainfall is in the opposite order.

Sikkim State Action Plan on Climate Change

Sikkim State was in need for decentralization of the National Action Plan on Climate Change. Hence, the State Action Plan on Climate Change Sikkim has come to the fore. The Government of Sikkim has taken a very systematic and proactive approach for formulation of the State Action Plan on Climate Change. Sikkim Action Plan on Climate Change identified five key concerns for devising strategies to address the said concerns in the short, medium and long term future. State Action Plan on Climate Change would strengthen the policies and programmes of the Sikkim Government that have been undertaken in the past two decades to protect the ecology and environment of the Himalayan State for its sustainable and inclusive development. The key areas of concern for Sikkim that were identified in the workshop were:

- Agriculture, horticulture and livestock
- Forests, wildlife, and eco-tourism
- Promotion of energy efficiency
- Urban and rural habitats and communities

Sikkim State Climate Change Cell

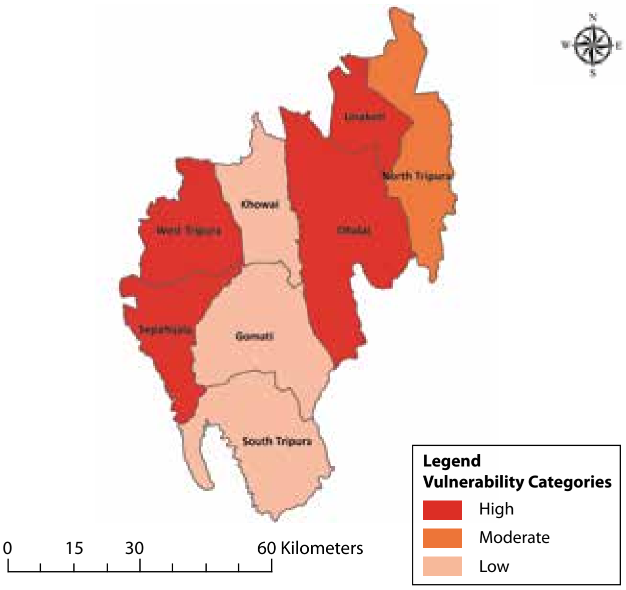
Sikkim SCCC is established in October 2014 under Sikkim State Council of Science and Technology, an autonomous organisation of Department of Science and Technology, Government of Sikkim. The Cell is established under NMSHE, one of the missions under National Action Plan on Climate Change, supported by DST, Government of India. The SCCC has undertaken two kinds of initiatives as according to the guidelines of NMSHE, 1) programme focused on conservation of natural ecosystem and study of impact of climate change on Himalayan ecosystem, 2) another programme focused on human lives and livelihood that will help the people in the state directly and indirectly to tackle the impact of climate change.

State Vulnerability on Climate Change

Although Sikkim has three major drivers of vulnerability - low area under forests per 1,000 households, low percentage area covered by insurance and low percentage of farmers taking loans, it has the highest per capita income and the lowest area under open forests, which relatively lowers vulnerability of the state when compared to other states in the IHR.

10. TRIPURA

Vulnerability category map of Tripura



Tripura is the third smallest State in the Country located in terms of area. The state is situated between the geographical coordinates of 22º 56′ north and 24º 32′ north latitude and 91º and 92º 22′ east longitude. It shares its borders with the country of Bangladesh (84%) and the states of Mizoram (10.8%) and Assam (5.2%). The state of Tripura is marked by distinct geographical features. The prominent hill ranges of the State are Jampui, Sakhantang, Longtharai, Atharamura, Baramura, Deotamura, Belkum and Kalajhari. Betling Shib (939 meters), situated in the Jampui Range, is the highest peak of Tripura. It has an area of 10,491.69 sq. km. The State is located in the bio-geographic zone of 9B-North-East hills and possesses an extremely rich bio-diversity.

At present, there are 8 districts (Dhalai, Gomati, Khowai, North Tripura, Sepahijala, South Tripura, Unakoti and West Tripura), 23 Sub-Divisions, 58 Blocks, one Tripura Tribal Areas Autonomous District Council (TTAADC) {created under the Sixth Schedule of the Constitution}, 595 Panchayats, 874 revenue villages and 527 TTAADC villages.

Demographic Profile

Tripura ranks 18th at all India level in terms of density of population. Among the north-eastern states, Tripura remained the second highest populous State after Assam. The population density of Tripura in 2011 is 350 persons per sq. km., as against the all India population density of 324. The population of Tripura is characterized by social diversity. As per 2011 Census, the ST population (11,66,813) constitutes 31.75% and SC population (6,54,918) constitutes 17.8% of the total population of the State. The state's literacy rate improved by more 14% in 2011 from 2001. The state achieved a high level of literacy and ranked third at all India level after Kerala and Mizoram in 2011.

Total population	36.74 Lakhs (1,874,376 males and 1,799,541 females) (Census 2011)
Sex ratio	961 (per 1000 males) (Census 2011)
Literacy Rate	87.22 % (Census 2011)

Climate Profile

The climate of Tripura exhibits a strong seasonal rhythm. The State is characterised by a warm and humid sub-tropical climate with five distinct seasons, relatively high temperature, occasional thunderstorms and wind velocities characterise the summer season, which extends from March end to mid-May. The average maximum temperature is 34ºC and average minimum temperature is 15ºC.

The state is a high rainfall zone with the incidence of very high concentration of rainfall (up to 450 mm per day) in the monsoon season, which lasts from June to September. The average annual rainfall in the state is 2024.4 mm (50 years average). Maximum rainfall is generally received in the months of July to September. Intermittent rainfall is received round the year, but the pattern of rainfall throughout the year is not homogenous.

Tripura State Action Plan on Climate Change

The Government of Tripura has formulated a state action plan on climate change that integrates the mitigation and adaptation agenda with the plans underway for the purpose of poverty alleviation and sustainable development of the state. The SAPCC focuses on key areas in the state to augment the strategies of climate change adaptation.

- Solar Mission, Energy Efficiency and Sustainable Habitat

- Water Mission
- Himalayan Ecosystem, Green Tripura and Sustainable Agriculture
- Strategic Knowledge for Climate Change

Tripura State Climate Change Cell

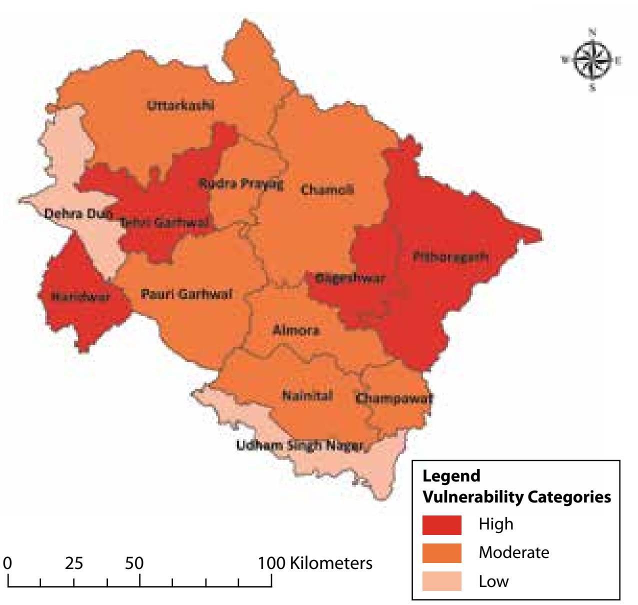
The Department of Science, Technology and Environment has been notified as the Nodal Department in the month of June, 2008 to handle all issues regarding Climate change and Clean development mechanism (CDM) in the state. An Inter-Departmental Committee on Climate Change was constituted with members from Planning, Power, Agriculture, Forest, P.W.D, Urban development and Science, Technology & Environment Department to draw out a road map on Climate Change issues. The Tripura Climate Change Cell has a more focused approach to adaptation and mitigation of climate change.

State Vulnerability on Climate Change

The issues of vulnerability of the state of Tripura to climate change are intimately related to its location and indigenous population. The people of Tripura depend primarily on forests and other natural resources for their livelihoods. Although Tripura has the highest percentage under marginal farmers, low per capita income, low percentage area under forests and crop insurance, it has the highest road density, lowest area under slope >30%, highest MGNREGA participation and lowest yield variability in comparison to other states.

11. UTTARAKHAND

Vulnerability category map of Uttarakhand



The Himalayan State of Uttarakhand is located on the southern slope of the Western Himalayan ranges and has a total geographical area of 53483 sq km. The state is divided into two regions, the Western Region called as Garhwal Mandal and the Eastern Region known as the Kumaon Mandal. Uttarakhand is bordered by Nepal to the east, Uttar Pradesh to the south, Haryana to the west and Himachal Pradesh to the North West. The state comprises 13 districts with 95 blocks and 15745 inhabited villages (Total villages – 16793).

Demographic Profile

The State comprises of 13 districts – 6 located in the Kumaon region and 7 in the Garhwal region, 95 blocks and 15745 inhabited villages (Total villages 16793). Out of total population, 30.23% people live in urban regions and 69.77 percent live in the villages of rural areas. Census 2011 reveals that hill districts like Pauri Garhwal and Almora show negative population growth rates of 1.41 & 1.28 respectively, even though the population of the State increased during the decade. The migration rate in Uttarakhand is one of the highest, in the country.

Total Population	100.86 lakh, (51.38 lakh male and 49.48 lakh female population)
Urban Population Growth	30.23 percent (2011)
Literacy rate	79.6% 88.3% (Male literacy rate) 70.7% (Female Literacy Rate)

Climate Profile

The state has two distinct climatic regions: the predominant hilly terrain and the small plain region. The climatic conditions of Uttarakhand vary greatly due to variations in altitude and proximity towards Himalayan ranges. The climatic conditions of the plains are very similar to those in the Gangetic plain, i.e. tropical conditions. Summers are relatively hot and winters are chilly, with temperatures going below 0°C. The lowest temperature recorded is –3.0°C at Mukteshwar and the highest is 43.2°C at Pantnagar. The extremes can further intensify, depending upon the coverage of meteorological observatories. About 45% area of the State is under forest cover. The average rainfall in the state varies from 92 cm, in Srinagar, to 250 cm in Nainital. However, spatial distribution of the rainfall varies, depending upon the geographical location and slope and aspect of the place. The amount of rainfall is generally high in low mountainous regions such as Nainital and Dehradun and it gradually decreases with increasing height. About three-fourths of the total rainfall is confined to the monsoon season and remaining one-fourth occurs in other seasons due to the western disturbances and local orographic effects. The monsoonal activities generally start in the later part of June and pick up in July/August.

Uttarakhand having different and almost all types of agro climatic conditions, is one of the best suited States for doing commercial horticulture and vegetable cultivation. The climate is congenial for different horticulture crops and production can be done round the year.

Uttarakhand is most vulnerable to climate-mediated risks. Mountainous regions are vulnerable to climate change and have shown "above average warming" in the 20th century. Some of the reported climate change induced changes in the Uttarakhand Himalayas include: receding glaciers and upwardly moving snowline, depleting natural resources, erratic rainfall (leading to flash floods as seen in June 2013 disaster), irregular winter rains, advancing cropping seasons, fluctuations in the flowering behaviour of plants (e.g. Renwartia spp), shifting of cultivation zones of apple (the zone has moved by 1000 m to 2000 m), reduction in snow in winter, rise in temperature, increasing intensity and frequency of flash floods, drying up of perennial streams, etc. One of the major drivers of vulnerability for the state of Uttarakhand is low area under forests per 1,000 households.

State Action Plan on Climate Change

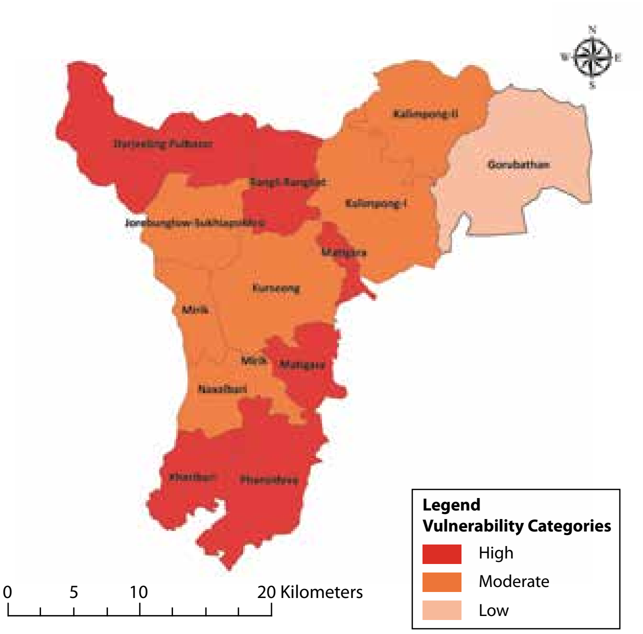
The Uttarakhand Action Plan on Climate Change (UAPCC) has been formulated in accordance with the principles and guidelines of the National Action Plan on Climate Change (NAPCC). The UAPCC integrates the action plan of Uttarakhand with the ongoing and proposed developmental programmes in the state, and in tandem with the eight national missions along with the principles and guidelines listed out in the NAPCC. UAPCC is committed to the overall development and inclusive growth of the State at a rapid pace. The state has adopted this as the underlying principle in the formulation of the Uttarakhand Action Plan for Climate Change (UAPCC) and aims to become a green and carbon neutral state by 2020.

Uttarakhand State climate change Cell

Uttarakhand SCCC has been established to formulate climate actions with support from United Nations Development Programme (UNDP) and other partners. The SCCC envisages to integrate Climate Actions, SAPCC - Uttarakhand, Vulnerability and Risk Assessment (VRA), SDGs and Intended Nationally Determined Contributions (INDCs). The institution of SCCC has been supplemented with supporting institutions such as, Climate Action Group (CAG), Sectoral Working Groups on Climate Change (SWGCC), Knowledge Management Group (KMG).

12. WEST BENGAL

Vulnerability category map of West Bengal



West Bengal is strategically located in the eastern part of India. It stretches from the Himalayas in the north to the Bay of Bengal in the south. Lying between 21°20′ and 27°32′N latitude and 85°50′ and 89°52′E longitude with a coastline of 150 kms, it serves as a gateway to the North-Eastern States, Nepal, Bhutan and South-East Asian Countries.

The total area of the state is 88,752 sq km which is 2.7% of the total area in the country. The state has two distinct natural divisions - the Northern Himalayan region and the Southern Alluvial plains. In the north three main rivers, namely, Teesta, Torsa, and Jaldhak flow which are tributaries of Bramhaputra's. The other two important rivers passing through the state are Ganga and Hooghly. The Ganga drains into the Bay of Bengal forming the famous delta of Indian Sundarbans. On a physiographic basis the state can be divided into four physiographic divisions, namely, the Himalayan Region; Eastern fringe of Chotanagpur Plateau; the Deltaic Zone and the Alluvial Plains Remaining areas of the State. In the north of West Bengal: Darjeeling, Jalpaiguri, Alipurduar and Cooch Bihar are the constituent districts of the hilly and terai region of the Himalaya.

Demographic Profile

With a density figure of 1,028 people per sq km, West Bengal is one of the most populous states. The population of West Bengal forms 7.54 percent of India in 2011.

The rural population of the state is around 68% and they are directly/indirectly dependent on / related to agriculture and allied activities.

Population	9.13 Crores (Census 2011)
Total Population Growth	13.84 percent (2011) 17.84 percent (2001)
Sex Ratio (Urban Regions)	944 females per 1000 males
Child (0-6) sex ratio (urban region)	947 girls per 1000 boys
Literacy Rate	81.69% (male) 70.54% (female)

Climate Profile

The climate of the State is tropical and humid except in the northern hilly region which is close to the Himalayas. Rainfall is the main source of water in West Bengal. The average rainfall in the State is about 1750 mm with considerable variation among the districts ranging between 1234 mm in Birbhum to 4136 mm in Jalpaiguri. Around 76% of the rainfall is received in the monsoon months and the rest in the non-monsoon period.

West Bengal State Action Plan on Climate Change

The Government of West Bengal, through a consensus, has identified the key sectors and regions that are likely to be most vulnerable and require additional efforts over and above its existing programmes and policies. The sectors identified are - Water resources, Agriculture, Biodiversity and Forests, Human Health, Habitats and Energy. Additionally, two regions have been identified as most vulnerable, namely, the Darjeeling Himalayan region in its northern boundary and the Sundarbans at its coastal southern end. The adaptation strategies for each sector and the two vulnerable regions have been identified through the following steps:

i. A review of each sector in West Bengal (and the regions of Darjeeling Himalayas and Sundarbans) was undertaken.
ii. The current concerns of each sector and the regions were identified along with the institutions and the

government programmes, projects and activities that are supporting development and, hence, addressing these concerns.

iii. An assessment of the current climate trends and the climate projection scenarios for the Mid Century (2021-2050) were made.

iv. The likely climate change concerns and the corresponding adaptation and mitigation strategies that would ameliorate the climate change concerns were identified.

West Bengal State Climate Change Cell

The Department of Environment is the nodal department for all climate change related activities. A Climate Change Cell has been set up in the Department of Environment. The Climate Change Cell is co-ordinating the Climate Change related activities among different line departments, facilitating upcoming programmes under various missions and maintaining liaison with the nodal persons from respective departments, which are identified as nodal agencies for execution of various projects under different mission. Department of Science & Technology GoWB (DST) is the nodal agency for carrying out vulnerability assessment under NMSHE and the Climate Change Cell of DoE, GOWB has been closely working with state DST for this vulnerability study.

State Vulnerability on Climate Change

This state has the highest population density, least number of primary healthcare centres per 100,000 households, least percentage of women in the overall workforce, second lowest area under forests, high percentage of marginal farmers and low MGNREGA participation as compared to other states. Given the highest/close to highest normalized values of almost all socio-economic, demographic and health indicators, one would actually expect the state to have higher vulnerability ranking than it has been found to be. However, extremely resilient agricultural sector with maximum irrigation facilities and horticulture, along with access to information services and infrastructure helped the state to have relatively higher adaptive capacity.

Annexure 5

Glossary

(Source: IPCC, 2014)

Adaptation

The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

- **Incremental adaptation:** Adaptation actions where the central aim is to maintain the essence and integrity of a system or process at a given scale.
- **Transformational adaptation:** Adaptation that changes the fundamental attributes of a system in response to climate and its effects.

Adaptation needs

The circumstances requiring action to ensure safety of populations and security of assets in response to climate impacts.

Adaptation options

The array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be categorized as structural, institutional, or social.

Adaptive capacity

The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Adaptive management

A process of iteratively planning, implementing, and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect and changes in the system brought on by resulting feedback effects and other variables.

Biodiversity

The variability among living organisms from terrestrial, marine, and other ecosystems. Biodiversity includes variability at the genetic, species, and ecosystem levels.

Biomass

The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass. Biomass burning is the burning of living and dead vegetation.

Capacity building

The practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society, or organization to respond to change.

Carbon dioxide (CO_2)

A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, such as oil, gas, and coal, of burning biomass, of land use changes, and of industrial processes (e.g., cement production). It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1.

Clean Development Mechanism (CDM)

A mechanism defined under Article 12 of the Kyoto Protocol through which investors (governments or companies) from developed (Annex B) countries may finance greenhouse gas emission reduction or removal projects in developing (Non-Annex B) countries, and receive Certified Emission Reduction Units for doing so, which can be credited towards the commitments of the respective developed countries. The CDM is intended to facilitate the two objectives of promoting sustainable development in developing countries and of helping industrialized countries to reach their emissions commitments in a cost-effective way.

Climate

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate change

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes.

Climate model (spectrum or hierarchy)

A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions, and feedback processes, and accounting for some of its known properties. The climate system can be represented by models of varying complexity; that is, for any one component or combination of components, a spectrum or hierarchy of models can be identified, differing in such aspects as the number of spatial dimensions, the extent to which physical, chemical, or biological processes are explicitly represented, or the level at which empirical parameterizations are involved. Coupled Atmosphere-Ocean General Circulation Models (AOGCMs) provide a representation of the climate system that is near or at the most comprehensive end of the spectrum currently available. There is an evolution towards more complex models with interactive chemistry and biology. Climate models are applied as a research tool to study and simulate the climate, and for operational purposes, including monthly, seasonal, and inter-annual climate predictions.

Climate prediction

A climate prediction or climate forecast is the result of an attempt to produce (starting from a particular state of the climate system) an estimate of the actual evolution of the climate in the future, for example, at seasonal, inter-annual, or decadal time scales. Because the future evolution of the climate system may be highly sensitive to initial conditions, such predictions are usually probabilistic in nature. See also Climate projection and Climate scenario.

Climate projection

A climate projection is the simulated response of the climate system to a scenario of future emission or concentration of greenhouse gases and aerosols, generally derived using climate models. Climate projections are distinguished from climate predictions by their dependence on the emission/concentration/radiative-forcing scenario used, which is in turn based on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized. See also Climate scenario.

Climate scenario

A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional information such as the observed current climate. See also Emission scenario and Scenario.

Climate system

The climate system is the highly complex system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere, and the biosphere, and the interactions among them. The climate system evolves in time under the influence of its own internal dynamics and because of external forcings such as volcanic eruptions, solar variations, and anthropogenic forcings such as the changing composition of the atmosphere and land use change.

Climate variability

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability). See also Climate change.

Co-benefits

The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits.

Community-based adaptation
Local, community-driven adaptation. Community-based adaptation focuses attention on empowering and promoting the adaptive capacity of communities. It is an approach that takes context, culture, knowledge, agency, and preferences of communities as strengths.

Coping
The use of available skills, resources, and opportunities to address, manage, and overcome adverse conditions, with the aim of achieving basic functioning of people, institutions, organizations, and systems in the short to medium term.

Deforestation
Conversion of forest to non-forest.

Ecosystem
A functional unit consisting of living organisms, their non-living environment, and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems, and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms, or are influenced by the effects of human activities in their environment.

Ecosystem services
Ecological processes or functions having monetary or non-monetary value to individuals or society at large. These are frequently classified as

(1) supporting services such as productivity or biodiversity maintenance, (2) provisioning services such as food, fiber, or fish, (3) regulating services such as climate regulation or carbon sequestration, and (4) cultural services such as tourism or spiritual and aesthetic appreciation.

Emission scenario
A plausible representation of the future development of emissions of substances that are potentially radioactively active (e.g., greenhouse gases, aerosols) based on a coherent and internally consistent set of assumptions about driving forces (such as demographic and socioeconomic development, technological change) and their key relationships. Concentration scenarios, derived from emission scenarios, are used as input to a climate model to compute climate projections.

Eutrophication
Over-enrichment of water by nutrients such as nitrogen and phosphorus. It is one of the leading causes of water quality impairment. The two most acute symptoms of eutrophication are hypoxia (or oxygen depletion) and harmful algal blooms.

Exposure
The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

External forcing
External forcing refers to a forcing agent outside the climate system causing a change in the climate system. Volcanic eruptions, solar variations, and anthropogenic changes in the composition of the atmosphere and land use change are external forcing. Orbital forcing is also an external forcing as the insolation changes with orbital parameters eccentricity, tilt, and precession of the equinox.

Extreme weather event
An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season).

Flood
The overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.

Forecast
See Climate prediction and Climate projection.

Food security
A state that prevails when people have secure access to sufficient amounts of safe and nutritious food for normal growth, development, and an active and healthy life.

Global change
A generic term to describe global scale changes in systems, including the climate system, ecosystems, and social-ecological systems.

Greenhouse gas (GHG)
Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O, and CH_4, the Kyoto Protocol deals with the greenhouse gases sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Groundwater recharge
The process by which external water is added to the zone of saturation of an aquifer, either directly into a geologic formation that traps the water or indirectly by way of another formation.

Hazard
The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.

Human system
Any system in which human organizations and institutions play a major role. Often, but not always, the term is synonymous with society or social system. Systems such as agricultural systems, political systems, technological systems, and economic systems are all human systems in the sense applied in this report.

Impact assessment (climate change)
The practice of identifying and evaluating, in monetary and/or nonmonetary terms, the effects of climate change on natural and human systems.

Impacts (Consequences, Outcomes)
Effects on natural and human systems. In this report, the term impacts is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts, and sea level rise, are a subset of impacts called physical impacts.

Income
The maximum amount that a household, or other unit, can consume without reducing its real net worth. Total income is the broadest measure of income and refers to regular receipts such as wages and salaries, income from self-employment, interest and dividends from invested funds, pensions or other benefits from social insurance, and other current transfers receivable.

Indigenous Communities
Indigenous Communities and nations are those that, having a historical continuity with pre-invasion and pre-colonial societies that developed on their territories, consider themselves distinct from other sectors of the societies now prevailing on those territories, or parts of them. They form at present principally non-dominant sectors of society and are often determined to preserve, develop, and transmit to future generations their ancestral territories, and their ethnic identity, as the basis of their continued existence as peoples, in accordance with their own cultural patterns, social institutions, and common law system.

Developed/developing countries
There are a diversity of approaches for categorizing countries on the basis of their level of development, and for defining terms such as industrialized, developed, or developing. Several categorizations are used in this report. In the United Nations system, there is no established convention for the designation of developed and developing countries or areas. The United Nations Statistics Division specifies developed and developing

regions based on common practice. In addition, specific countries are designated as least developed countries, landlocked developing countries, small island developing states, and transition economies. Many countries appear in more than one of these categories. The World Bank uses income as the main criterion for classifying countries as low, lower middle, upper middle, and high income. The UNDP aggregates indicators for life expectancy, educational attainment, and income into a single composite human development index (HDI) to classify countries as low, medium, high, or very high human development.

Informal settlement

A term given to settlements or residential areas that by at least one criterion fall outside official rules and regulations. Most informal settlements have poor housing (with widespread use of temporary materials) and are developed on land that is occupied illegally with high levels of overcrowding. In most such settlements, provision for safe water, sanitation, drainage, paved roads, and basic services is inadequate or lacking. The term slum is often used for informal settlements, although it is misleading as many informal settlements develop into good quality residential areas, especially where governments support such development.

Institutions

Institutions are rules and norms held in common by social actors that guide, constrain, and shape human interaction. Institutions can be formal, such as laws and policies, or informal, such as norms and conventions. Organizations—such as parliaments, regulatory agencies, private firms, and community bodies—develop and act in response to institutional frameworks and the incentives they frame. Institutions can guide, constrain, and shape human interaction through direct control, through incentives, and through processes of socialization.

Key vulnerability, Key risk, Key impact

A vulnerability, risk, or impact relevant to the definition and elaboration of "dangerous anthropogenic interference (DAI) with the climate system," in the terminology of United Nations Framework Convention on Climate Change (UNFCCC) Article 2, meriting particular attention by policy makers in that context.

Key risks are potentially severe adverse consequences for humans and social-ecological systems resulting from the interaction of climate related hazards with vulnerabilities of societies and systems exposed. Risks are considered "key" due to high hazard or high vulnerability of societies and systems exposed, or both.

Vulnerabilities are considered "key" if they have the potential to combine with hazardous events or trends to result in key risks. Vulnerabilities that have little influence on climate-related risk, for instance, due to lack of exposure to hazards, would not be considered key.

Key impacts are severe consequences for humans and social-ecological systems.

Likelihood

The chance of a specific outcome occurring, where this might be estimated probabilistically.

Livelihood

The resources used and the activities undertaken in order to live. Livelihoods are usually determined by the entitlements and assets to which people have access. Such assets can be categorized as human, social, natural, physical, or financial.

Non-linearity

A process is called non-linear when there is no simple proportional relation between cause and effect. The climate system contains many such non-linear processes, resulting in a system with potentially very complex behavior. Such complexity may lead to abrupt climate change.

Outcome vulnerability (End-point vulnerability)

Vulnerability as the end point of a sequence of analyses beginning with projections of future emission trends, moving on to the development of climate scenarios, and concluding with biophysical impact studies and the identification of adaptive options. Any residual consequences that remain after adaptation has taken place define the levels of vulnerability (Kelly and Adger, 2000; O'Brien et al., 2007).

Projection

A projection is a potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Unlike predictions, projections are conditional on assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized. See also Climate prediction and Climate projection.

Proxy

A proxy climate indicator is a record that is interpreted, using physical and biophysical principles, to represent some combination of climate related variations back in time. Climate-related data derived in this way are referred to as proxy data. Examples of proxies include pollen analysis, tree ring records, speleothems, characteristics of corals, and various data derived from marine sediments and ice cores. Proxy data can be calibrated to provide quantitative climate information.

Representative Concentration Pathways (RCPs)

Scenarios that include time series of emissions and concentrations of the full suite of greenhouse gases and aerosols and chemically active gases, as well as land use/ land cover (Moss et al., 2008). The word representative signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term pathway emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome. (Moss et al., 2010).

RCPs usually refer to the portion of the concentration pathway extending up to 2100, for which Integrated Assessment Models produced corresponding emission scenarios. Extended Concentration Pathways (ECPs) describe extensions of the RCPs from 2100 to 2500 that were calculated using simple rules generated by stakeholder consultations, and do not represent fully consistent scenarios.

Four RCPs produced from Integrated Assessment Models were selected from the published literature and are used in the present IPCC Assessment as a basis for the climate predictions and projections presented in Chapters 11 to 14:

RCP2.6 One pathway where radiative forcing peaks at approximately 3 W m–2 before 2100 and then declines (the corresponding ECP assuming constant emissions after 2100)

RCP4.5 and RCP6.0 Two intermediate stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W m–2 and 6.0 W m–2 after 2100 (the corresponding ECPs assuming constant concentrations after 2150) RCP8.5 One high pathway for which radiative forcing reaches greater than 8.5 W m–2 by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250)

Reforestation

Planting of forests on lands that have previously contained forests but that have been converted to some other use.

Resilience

The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.

Risk

The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term risk is used primarily to refer to the risks of climate-change impacts.

Risk assessment

The qualitative and/or quantitative scientific estimation of risks.

Risk management

Plans, actions, or policies to reduce the likelihood and/ or consequences of risks or to respond to consequences.

Risk transfer

The practice of formally or informally shifting the risk of financial consequences for particular negative events from one party to another.

Runoff

That part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water.

Scenario

A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g., rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts, but are useful to provide a view of the implications of developments and actions. See also Climate scenario and Emission scenario.

Sensitivity

The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).

Sink
Any process, activity, or mechanism that removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas or aerosol from the atmosphere.

Socioeconomic scenario
A scenario that describes a possible future in terms of population, gross domestic product, and other socioeconomic factors relevant to understanding the implications of climate change.

Subsistence agriculture
Farming and associated activities that together form a livelihood strategy in which most output is consumed directly but some may be sold at market. Subsistence agriculture can be one of several livelihood activities.

Sustainability
A dynamic process that guarantees the persistence of natural and human systems in an equitable manner.

Sustainable development
Development that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987).

Traditional knowledge
The knowledge, innovations, and practices of both indigenous and local communities around the world that are deeply grounded in history and experience. Traditional knowledge is dynamic and adapts to cultural and environmental change, and also incorporates other forms of knowledge and viewpoints. Traditional knowledge is generally transmitted orally from generation to generation. It is often used as a synonym for indigenous knowledge, local knowledge, or traditional ecological knowledge.

Tsunami
A wave, or train of waves, produced by a disturbance such as a submarine earthquake displacing the sea floor, a landslide, a volcanic eruption, or an asteroid impact.

Uncertainty
A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements (e.g., reflecting the judgment of a team of experts) (see Moss and Schneider, 2000; Manning et al., 2004; Mastrandrea et al., 2010). See also Likelihood.

United Nations Framework Convention on Climate Change (UNFCCC)
The Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." It contains commitments for all Parties. Under the Convention, Parties included in Annex I (all OECD countries and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention entered in force in March 1994. In 1997, the UNFCCC adopted the Kyoto Protocol.

Uptake
The addition of a substance of concern to a reservoir. The uptake of carbon containing substances, in particular carbon dioxide, is often called (carbon) sequestration.

Urban heat island
The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, effects on heat retention, and changes in surface albedo.

Vulnerability
The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. See also Outcome vulnerability.

Vulnerability index
A metric characterizing the vulnerability of a system. A climate vulnerability index is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability.

Water-use efficiency
Carbon gain by photosynthesis per unit of water lost by evapotranspiration. It can be expressed on a short-term basis as the ratio of photosynthetic carbon gain per unit transpirational water loss, or on a seasonal basis as the ratio of net primary production or agricultural yield to the amount of water used.

About DST NMSHE

The Department of Science and Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organising, coordinating and promoting S&T activities in the country.

The National Mission for Sustaining the Himalayan Ecosystem (NMSHE) coordinated by the Department of Science and Technology, is one of the eight missions under India's National Action Plan on Climate Change. The broad objectives of NMSHE include - understanding of the complex processes affecting the Himalayan Ecosystem and evolve suitable management and policy measures for sustaining and safeguarding the Himalayan ecosystem, creating and building capacities in different domains, networking of knowledge institutions engaged in research and development of a coherent data base on Himalayan ecosystem, detecting and decoupling natural and anthropogenic induced signals of global environmental changes in mountain ecosystems, studying traditional knowledge systems for community participation in adaptation, mitigation and coping mechanisms inclusive of farming and traditional health care systems and developing regional cooperation with neighbouring countries, to generate a strong data base through monitoring and analysis, to eventually create a knowledge base for policy interventions.

About SDC IHCAP

The Swiss Agency for Development and Cooperation (SDC) has been a partner of India for more than sixty years. Since 2011, SDC's programme focuses specifically on the issue of climate change and environment.

The Indian Himalayas Climate Adaptation Programme (IHCAP) is a project under the Global Programme Climate Change and Environment (GPCCE) of SDC, and is being implemented in partnership with the Department of Science and Technology (DST), Government of India. IHCAP is supporting the implementation of the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) as a knowledge and technical partner. The overall goal of IHCAP is to strengthen the resilience of vulnerable communities in the Himalayas and to enhance and connect the knowledge and capacities of research institutions, communities and decision-makers.

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