Climate-Proofing Training Module For South & East Sikkim

Picture credit: Down to Earth

WRI INDIA

CANSA CLIMATE ACTION NETWORK South Asia

CANSA CLIMATE ACTION NETWORK South Asia

WORLD RESOURCES INSTITUTE

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION & TRAINING NEEDS ASSESSMENT

1.1 Purpose of the module

This **Training Module for Climate-Proofing District Development** will support the development of climate change-sensitive strategies and action plans at the district level by providing scientific, technical, and methodologically driven information and training in three states (Sikkim, Tamil Nadu, and Madhya Pradesh).

It aims *"to provide a guide manual and course framework for designing and delivering training programs for understanding, analyzing, designing and mainstreaming **Climate Change Adaptation (CCA)** concerns into district-level development planning for key vulnerable sectors."*

1.2 Objectives of the module

This module will be a reference document to:

a) Build capacity for key stakeholders from selected sectors and line departments to climate-proof district development plans.
b) Help them understand the linkages between CCA and sustainable development, and the associated impacts and challenges.
c) Equip them with knowledge and skills to understand and develop pathways to mainstream CCA concerns into development planning.
d) Build institutional capacity for climate vulnerability analysis, scientific data, and hands-on experience in using the NEX-GDDP[1] climate portal tool to design adaptation strategies for key sectors.
e) Help districts to successfully climate-proof their development plans and incorporate adaptation strategies into their planning processes.

This module is tailored for the state- and district-level policymakers and practitioners. It will also build the capacity of technical and sectoral experts and representatives in departments such as agriculture, horticulture, water, disaster management, and forests and biodiversity, by enabling them to frame solutions that build long-term resilience. The module is designed to enable officials to understand CCA and local-level disaster risk concerns, and to equip them with knowledge and skills to assess and draft strategies and deliver their roles with mitigating risk, preventing disaster, and implementing disaster-proof development schemes.

1.3 Target audience

The module is developed by looking at the performance gaps and training needs of these target participants:

- Senior- to mid-level officials at the state and district levels from selected sectors/departments, and appointed climate nodal officers from departments.
- Members/representatives of non-governmental and community organizations engaged in activities related to assessment, planning, implementation, or monitoring of any aspect of disaster management, environment and development, and climate change.

[1] *The NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP).* This portal highlights the trends expected in key climate indicators at the district level in the coming years. This would help to identify the vulnerabilities faced by the key sectors of a district.

- Faculty members/professionals from training, education, and research centers and other master trainers related to environment/ecology, disaster management, rural development, urban planning, health, forestry, land and water, agriculture, housing, etc.

1.4. Capacity-building needs for Sikkim

Sikkim's location in the Himalayas, the dependence of the majority of its population on agriculture, water scarcity, and the constant risk of disasters such as landslides, flash floods, and cloudbursts make Sikkim one of India's most vulnerable states. Climate change increases risks as it causes high variability in seasonal weather events and changing rainfall patterns.

Sikkim's climate is experiencing rapid change. Some key changes predicted due to this are:

- Changes in the timing of seasonal events
- Increased frequency of disasters such as landslides and GLOFs (glacial lake outburst floods)
- Increase in the incidence of forest fires
- Impact on livelihoods
- Impact on access to firewood from forests
- Increase in man-animal conflict
- Changes in forest vegetation type
- Changes in the geographical distribution of flora and fauna

Considering these impacts, Climate Action Network South Asia (CANSA) and World Resources Institute (WRI India) are collaborating to help the state effectively plan, implement and monitor interventions such as mobilization of expertise, capacity building of resource persons and institutions, facilitating the implementation of strategies, and knowledge-sharing with the Sikkim State Disaster Management Authority (SSDMA), following the areas highlighted in the Sikkim State Action Plan on Climate Change (SSAPCC). The aim is to create adaptation strategies for key sectors such as agriculture, biodiversity, forests, wildlife management, and ecotourism, urban and rural habitats, and urban transport.

1.5 Approach to training needs assessment

A preliminary study was needed to assess the technical and functional capacities of focus sectoral departments in Sikkim to plan and implement climate-resilient policies and schemes. The approach for conducting the study is as follows:

- An inception meeting was conducted with the government of Sikkim/SSDMA to outline the approach and methodology that would be followed for the study on March 3, 2020.
- A review of SSAPCC and other publicly available research material was carried out to identify the activities to be implemented for these focus sectors:
  - Water
  - Agriculture & allied (horticulture and livestock)
  - Forest resources
  - Disaster management
  - Urban habitation

Departments and institutions (see Table 1)[2] that coordinate and implement policies in the focus sectors as well as schemes that enhance climate change resilience were mapped, and relevant personnel were identified for interviews to understand the status of activities. The list of departments/institutions included:

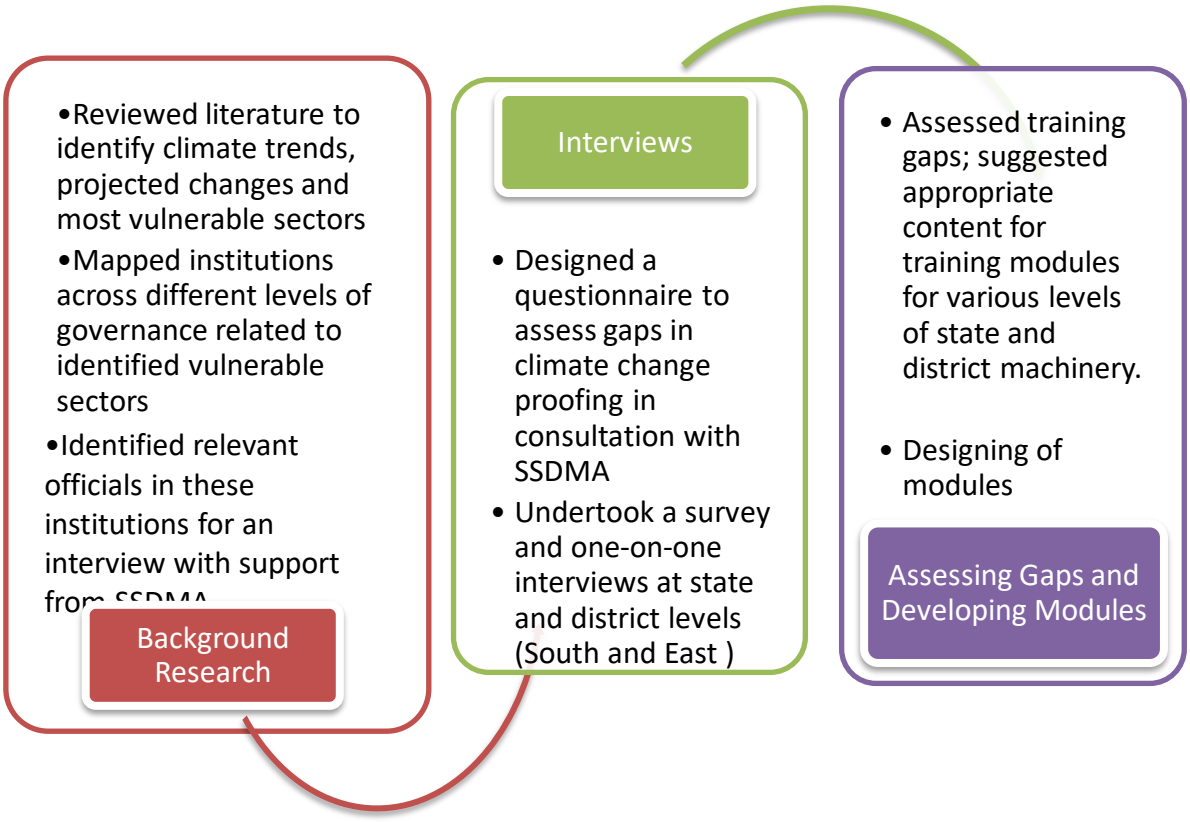
- Climate Change Cell, Department of Science & Technology (DST)

[2] Annex

- Forest and Environment Department
- Water Resource and River Development Department (WRRDD), formerly known as Irrigation and Flood Control Department
- Rural Management and Development Department (RMDD)
- Health and Family Welfare Department
- Sikkim State Disaster Management Authority, Land Revenue & Disaster Management Department
- Departments of agriculture, horticulture, and livestock
- Urban Development and Housing Department

- Existing mandates of state nodal institutions and focus departments/institutions were documented.
- Questionnaires were developed for each department/institution, and relevant personnel was interviewed to assess capacity gaps and training needs.
- Details received from the departments and institutions, such as manpower strength, technical qualifications, list of training programs conducted, etc., were collated and analyzed.

Based on the assessment of capacity gaps, training modules and a capacity building plan are being proposed for district-level officers in the state.



The secondary research and one-on-one consultation with various department officials revealed that every department has a training program at all levels of governance. Training programs are usually conducted at the service entry point. For capacity enhancement during service, courses are undertaken regularly as required for career growth and exposure to current issues and knowledge. The training is either imparted within departmental training cells or by the faculty of relevant specialized training institutions within the state or at the national or regional level.

In most departments, technical content remains the same across senior and middle levels of governance. However, for field-level workers, training content is more action-oriented. Various departments involved in natural resource management impart training to staff to enable a better understanding of the basics of their focus area. They need ongoing programs on existing, new, and emerging techniques, tools, and technologies of resource management.

A sincere effort to link frequent and extreme disasters with **Climate Change** as one of the drivers is long due. The current disaster response protocol focuses on **response and rescue** rather than **mitigating disasters** and enabling **long-term resilience**. Many adaptation strategies and measures need to be incorporated to ensure resilience against climate-induced disasters.

Sector-wise evaluation of ongoing schemes in Sikkim shows a lack of orientation towards addressing climate change in day-to-day work (Table 2)[3]. Similarly, meetings and discussions with various departments officials, which are documented in Table 3[4] (*Response from One on One Discussion with Stakeholders on Integrating Climate Change Adaption Training in Sikkim)*, highlight the need to impart climate-based training in various departments.

The state needs to include climate change as a strategic area of training in all departments of the government because:

- Although officials are aware of climate change, departments are yet to convert that awareness into the ability to handle its impact on resources and the people associated with those resources.
- Departmental training programs have not yet taken into account the likely impacts of climate change. They need capacity and knowledge support to make decisions based on climate data and develop strategies for adaptation and mitigation.

Disaster management training are still reactive. They do not take into account the projected impacts of climate change and need to move from ex-post to ex-ante. In other words, they need to focus more on what can be done before a disaster event, rather than just focusing on what can be done after it.

[3]Annex
[4] Annex

CHAPTER 2: CLIMATE CHANGE ADAPTATION IN SIKKIM

2.1 Difference between weather and climate

Climate is defined as the statistical description of the average and variability of things such as temperature, rainfall, snowfall, and wind over months or years[5]. A 30 - year historical average is used as the climate normal in this case.

Weather describes atmospheric conditions at a certain place and time, regarding temperature, pressure, humidity, wind, and other meteorological elements. It could also refer to the presence of clouds, precipitation (e.g. rain, snow, hail), and the occurrence of phenomena such as thunderstorms, dust storms, and tornados (IPCC, 2013).

2.2 What is climate change?

The United Nations Framework Convention on Climate Change (UNFCCC) 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 periods**.

The Intergovernmental Panel on Climate Change (IPCC) defines **climate change adaptation**[6] (CCA) as **the process of adjustment to actual or expected climate and its effects**. It means doing what we can to live with and minimize the destruction and suffering that comes from climate change. Adaptation involves reducing risk and vulnerability; seeking opportunities; and building the capacity of nations, regions, cities, the private sector, communities, individuals, and natural systems to cope with climate impacts, as well as mobilizing that capacity by implementing decisions and actions (Tompkins et al., 2010).

Examples of adaptation measures include: using scarce water resources more efficiently, adapting building codes to future climate conditions and extreme weather events, building flood defenses and raising the levels of dykes, developing drought-tolerant crops, choosing tree species and forestry practices less vulnerable to storms and fires, and setting aside land corridors to help species migrate.

IPCC defines **climate change mitigation**[7] as **actions or human intervention to reduce the sources or enhance the sinks of greenhouse gases**. A sink is something that reduces greenhouse gas emissions by storing carbon in some form – trees or oceans, for example. Mitigating[8] climate change involves reducing the release of greenhouse gases such as carbon dioxide, nitrous oxide, methane, and ozone, which are warming our planet.

Mitigation strategies include retrofitting buildings to make them more energy-efficient; adopting renewable energy sources like solar, wind, and small-scale hydropower; helping cities develop more sustainable transport such as bus rapid transit, electric vehicles, and biofuels; and promoting more sustainable uses of land and forests.

[5] As per the Intergovernmental Panel on Climate Change (IPCC 2013), the typical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.
[6] https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap14_FINAL.pdf
[7] https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf
[8] https://www.thegef.org/topics/climate-change-mitigation

2.3 Understanding long-term resilience: Relationship between climate change and development

Changes in climate and weather patterns have predicted increased exposure[9] and vulnerability[10] due to extreme events such as high-intensity floods, frequent droughts, and higher air temperature, etc. Increased exposure and vulnerability are generally outcomes of skewed development processes that lead to environmental degradation, rapid and unplanned urbanization in hazardous areas, failures of governance, and the scarcity of livelihood options for the poor.

Increasing global interconnectivity and the mutual interdependence of economic and ecological systems can sometimes have contrasting effects, reducing or amplifying vulnerability and disaster risk. Countries can more effectively manage disaster risk if they include considerations of disaster risk in national development and sector plans, and if they adopt climate change adaptation strategies, translating these plans and strategies and actions targeting vulnerable areas and groups. Hence, closer integration of CCA and disaster risk reduction (DRR) measures, and incorporating both into local, sub-national, national, and international development policies and practices, could help at all levels.

In a rapidly developing country like India — where socio-economic development parameters such as social welfare, quality of life, infrastructure development, livelihood, etc., are at stake due to the increasing number and intensity of disastrous events — there is a need to take proactive measures to sustain development efforts by incorporating a multi-hazard approach into planning and action for disasters in the short term, and adaptation to climate extremes in the long term.

Measures such as **early warning systems, risk communication, community participation, land use planning, ecosystem management, water and sanitation management, climate and disaster-resilient infrastructure development, adoption of diversified agriculture methods, enforcement of building codes, and better awareness and training, etc. should be adopted**. Strengthening institutional structures by integrating techno-legal frameworks and good governance will also help promote long-term, disaster-resilient development.

2.4 India's response to climate change: Status of National Action Plan and State Action Plan on Climate Change

2.4.1 National Action Plan on Climate Change (NAPCC)

Recognizing the challenges of climate change, the Government of India launched the National Action Plan on Climate Change (NAPCC) in 2008, with various ministries implementing eight missions: solar energy, enhanced energy efficiency, sustainable habitats, water, sustaining the Himalayan ecosystem, green India, sustainable agriculture, and strategic knowledge for climate change.

The NAPCC states that for appropriate implementation of these missions, it is necessary to create capacity at different levels of governance. At the state level, several agencies would need to redefine goals and areas of operation. At the local level, capacity and the involvement of communities in actions to adapt to climate change would be crucial. Public awareness of climate change would have to be spearheaded by the government at all levels[11] .

[9] Exposure means the presence of people, livelihoods, species or ecosystems, environmental services and resources, infrastructure, or economic, social, or cultural assets in places that could be adversely affected.

[10] Vulnerability means the characteristics of a person, group of persons (community) or their resources (property, infrastructure, environment or ecosystems) and the concerned situation that influences their capacity to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard.

[11] http://www.nicra-icar.in/nicrarevised/images/Mission%20Documents/National-Action-Plan-on-Climate-Change.pdf

2.4.2 Why state-level planning is important: Role and origin of SAPCCs

The State Action Plans on Climate Change (SAPCC) were the first sub-national exercise in climate change planning and served as the primary policy document at this level.

The NAPCC recognized the crucial role of state and local governments in implementing the action plan. Therefore, the process to prepare SAPCCs was initiated. Around 32 states and union territories submitted SAPCCs to the MOEF&CC. For Sikkim, the final revised Sikkim SAPCC[12] was approved by Sikkim High-Level Coordination Committee in March 2011, and it was endorsed by MOEFCC's National Steering Committee in July 2012. Currently, the state is in the process of updating and revising its SAPCC.

2.4.3 At the global level: Paris Agreement

In 2015, around 190 countries committed to creating an international climate agreement at the UNFCCC summit in Paris. This is the landmark Paris Agreement to combat climate change, which seeks to accelerate and intensify actions for a sustainable low-carbon future. The Paris Agreement requires countries to outline and communicate their post-2020 climate actions, known as Nationally Determined Contributions (NDCs), and to strengthen these efforts in the future (UNFCCC, 2018).

The NDC outlines eight targets for 2021-30, which include:

(i) to reduce emission intensity of Gross Domestic Product (GDP) by 33-35 percent, compared to the 2005 level.

(ii) to achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources.

(iii) to create an additional carbon sink of 2.5 to 3 billion tons of CO_2 equivalent through additional forest and tree cover.

Apart from these quantitative targets, the NDC emphasizes building capacities at the domestic level (target No. 8[13]) and enhancing investment into climate change adaption in the most vulnerable sectors, such as agriculture, water resources, Himalayan region, coastal regions, health, and disaster management (target No. 6[14]). The other targets focus on sustainable lifestyles, climate-friendly growth paths, climate change finance, and capacity building and technology[15].

Under the Paris Agreement, countries have committed to taking measures to ensure that the global rise in temperature does not go beyond 1.5 degrees Celsius compared to preindustrial times. India submitted its Intended Nationally Determined Contribution (INDC) to the UNFCCC in 2015. This became NDC in 2016 after Parliament ratified the Paris Agreement. India's NDC identifies capacity-building as a priority, especially at the sub-national and state levels, for actions related to climate change adaptation.

2.5 Linking SDGs with Climate Change Adaptation

In Sikkim, linking CCA and DRR with the 17 sustainable development goals (SDGs) is essential to strengthening the resilience state agenda as there are several benefits. Sikkim has been self-sufficient in maize and millet production but has not fared well in other food crops essential for nutritional security. It has been lagging in

[12] http://www.nicra-icar.in/nicrarevised/images/State%20Action%20Plan/Sikkim-SAPCC.pdf

[13] Target 8: To build capacities, create domestic framework and international architecture for quick diffusion of cutting-edge climate technology in India and for joint collaborative R&D for such future technologies

[14] NDC Target 6: To better adapt to climate change by enhancing investments in development programs in sectors vulnerable to climate change, particularly agriculture, water resources, Himalayan region, coastal regions, health and disaster management

[15] https://pib.gov.in/newsite/PrintRelease.aspx?relid=176985

irrigation, despite constructing multiple dams – only 11 percent of agricultural land is under irrigation, compared to the Indian average of 35 percent.

In all, 80 percent of Sikkim's rural population depends on springs for water, which are in decline partly because of climate change. Integrating climate adaptation, SDGs, and measures against slow-onset disasters in developmental planning and budgeting will help the state address these issues. The state would also need to focus on the following SDGs:

1) SGD 6: Clean Water and Sanitation
2) SDG 7: Affordable ad Clean Energy
3) SDG 12: Responsible Consumption and Production
4) SDG 13: Climate Action
5) SDG 14: Life Below Water
6) SDG 15: Life on Land

In summary, these goals address environmental protection and climate action

2.6 Addressing climate change through local action: Role of districts

Climate change is a major issue for all levels of government. However, district responses to it have so far been unaccounted for. There is scientific consensus that local-level planning plays a critical anticipatory role in promoting robust adaptation. While the issue of climate change is gaining recognition about shifting rainfall patterns and high-intensity rains leading to flooding risks or landslides, the wider implications (for instance, for biodiversity and water resources) are not yet integrated into plans. This is because the planning profession does not engage enough with climate change networks.

2.7 Why the local level matters for adaptation

Decisions about livelihood strategies and investments that represent real-life demonstrations of adaptation are best observed and understood at the local level. A local-level perspective helps us understand the actual impact of development decisions taken at higher levels, whether they are policies, programs, or projects. Engaging with local actors rveals whether individuals and households can strengthen their livelihoods, improve the quality of their lives and reduce vulnerability to shocks and stresses.

In terms of climate change adaptation, the local level is important for three main reasons:

• **First, climate change impacts are experienced locally**. While climate change is broadly understood as an increase in global mean temperature, leading to changes in regional climate patterns, it appears locally as hotter days, more intense storms, less rainfall, or changes in the onset and length of crop-growing seasons. These changes affect livelihood activities, health risks, etc.

• **Second, vulnerability and adaptive capacity are realized locally**. This is because they are context-specific. They result from interactions between factors such as income level, settlement patterns, infrastructure, ecosystem and human health, gender, political participation, and individual behavior. These factors shape how people can reduce their exposure to, cope with, and recover from the negative impacts of climate change. They also determine how people can take advantage of opportunities created by climate change. Regional and national vulnerability indices often mask dramatic variations in vulnerability at local levels.

• **Third, adaptation action is best observed at the local level**. The anticipated or actual experience of the impact of climate change shapes adaptation decision-making and action. Such action is the translation of knowledge and capacity into behavior. Individual and household decisions about livelihood strategies and investments (for example, crop selection, equipment purchase, skill training, and contingency planning) can be real-life demonstrations of adaptation. These demonstrations are important to policy makers and practitioners since they help in monitoring and evaluating how policies, programs, and projects support adaptation and provide a basis for scaling up, revising, and learning.

Adaptation is best served if accessed, implemented, and monitored locally. However, it is not easy to generalize the process for it – the more localized the scale of analysis and action, the more difficult it is to develop broadly applicable guidance on promoting successful adaptation.

In any country, different administrative levels have different roles in development policy planning and implementation, often depending on prevailing governance structures and approaches (including the type and extent of decentralization). In India, functional responsibilities are demarcated between the Union and states in Schedule VII of the Constitution, through the Union, state, and concurrent lists**.** There is a three-tier local governance structure at the sub-state level as well. **Therefore, it is necessary to identify and highlight the most localized and ideal unit for adaptive action.**

2.8 Role and comparative advantage of district collector's office

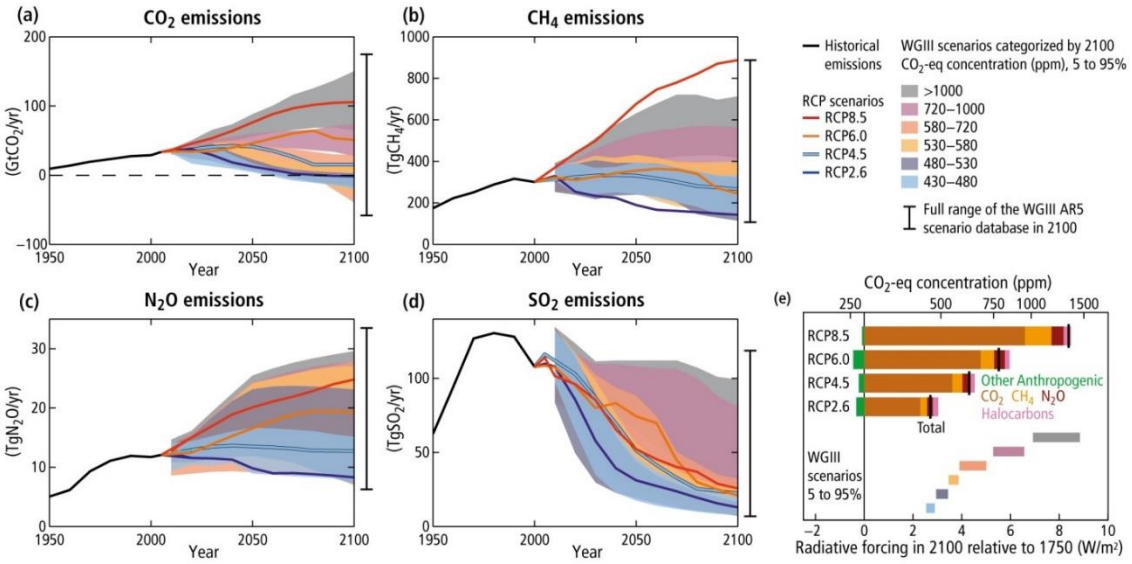
The local government refers to the level of formal state governance closest to the people. It can consist of locally elected representatives, central government-appointed representatives, and publicly accountable decision-making and service-delivery organizations (Tyler, 2006). The district is the most important unit of administration in India. Considering the roles and functions of a district collector, it is not hard to conclude that the district collector's office is a node for all-important development and welfare schemes. It is the focal point for the on-ground assessment of adaptation needs and challenges, and action through development programs.

CHAPTER 3: INTERPRETING CLIMATE DATA AND VULNERABILITY FOR SIKKIM

3.1 Causes of climate change

The delicate balance between incoming shortwave (ultraviolet) radiation and outgoing longwave (infrared) radiation maintains the Earth's surface temperature at a level that supports life on the planet. Greenhouse gases (GHGs), present in the atmosphere in trace amounts, trap the outgoing radiation, raising the temperature. This phenomenon is known as the greenhouse effect. However, human activities such as the burning of fossil fuels, urbanization, agriculture, and deforestation raise the level of GHGs[16] and cause climate change.

Figure 3.1 Greenhouse Gas Emission Trajectory from 1950 to 2000 and Emission Forecast till 2100[17]



Source[18]

In the last 150 years, the world has become approximately 0.9 degrees Celsius warmer. Figure 1 above illustrates the factual growth of the most potent greenhouse warming gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and sulphur dioxide (SO_2) from the 1950s until 2000, and projected growth based on various IPCC emission scenarios. In nearly 200 years since the beginning of the industrial revolution in the early to mid-eighteenth century, the concentration of carbon dioxide (CO_2) has risen from 278 ppm (parts per million) to 417 ppm[19] in the atmosphere. Figure 2[20] illustrates the change in global surface temperature from the pre-industrial

[16] Greenhouse gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6)) 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 by clouds. This property causes the greenhouse effect https://www.ipcc.ch/sr15/chapter/glossary/

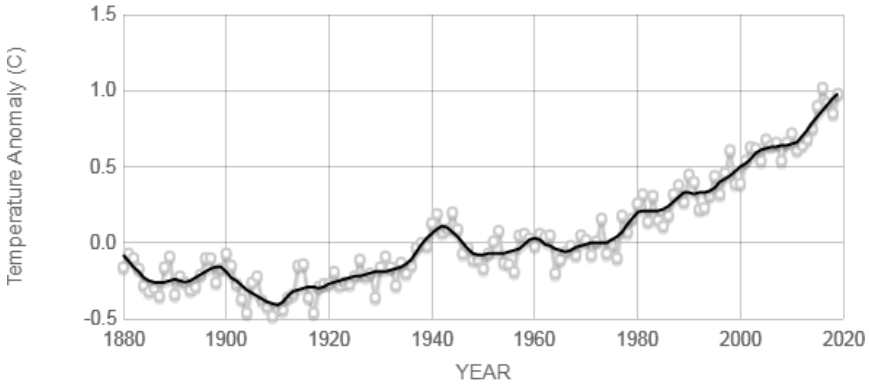
[17] https://www.ipcc.ch/report/ar5/syr/

[18] https://www.ipcc.ch/report/ar5/syr/

[19] https://www.co2.earth/

[20] https://climate.nasa.gov/vital-signs/global-temperature/

Figure 3.2: Rise in Global Mean Temperature from Pre-Industrial Times to date



Source: climate.nasa.gov

era to date. Nineteen of the 20 warmest years have occurred since 2001, except 1998. The year 2016 is the warmest on record. The IPCC Special Report 15[21] released in 2018 noted that to limit global warming, we would need to limit the total cumulative global anthropogenic (human activity-related) emissions of CO_2 from the preindustrial period. Staying within a total **Carbon Budget**[22], if the target is to limit global warming below the 1.5 degrees Celsius limit, the world is only left with another 420 gigatons of CO_2 into the atmosphere. In this case, there is a 67 percent chance that we will keep the temperature increase under 1.5 degrees. If we release 580 gigatons of CO_2, that chance is only 50 percent.

3.2 Climate change trends and impacts in South Asia and India

3.2.1 Key messages from IPCC Fifth Assessment Report

The Fifth Assessment Report of the IPCC has found beyond reasonable doubt that the Earth's climate is warming. Since the 1950s, the rate of global warming has been unprecedented compared to previous decades and millennia. Since the mid-19th century, the average temperature increase of the Earth's surface has been 0.85 degrees Celsius. Globally, sea levels have risen faster than at any time during the previous two millennia.

The effects of climate change are being felt acutely in South Asia. **Changing patterns of rainfall or melting snow and ice are altering freshwater systems, affecting the quantity and quality of water available[23]. Climatic risks threaten lives, food security, health, and well-being**.

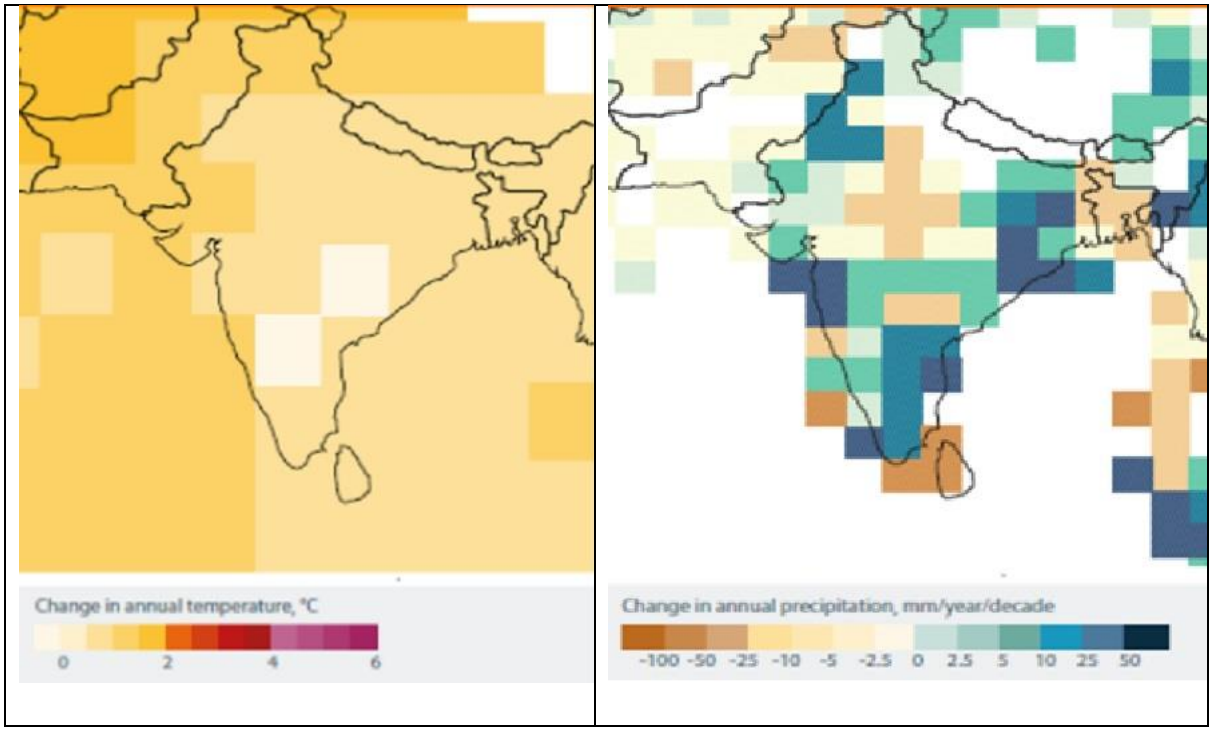
South Asia is urbanizing rapidly. **Districts with poor infrastructure and rapid population growth are the most vulnerable areas. Extreme events are expected to be more catastrophic for the people living in such districts**. Despite the urbanization, South Asia remains predominantly agrarian. Climate-sensitive sectors such as agriculture and fisheries are affected by rising temperatures, rising sea levels, and changing rainfall patterns.

[21] https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf

[22] The carbon budget refers to how much carbon dioxide countries can release into the atmosphere before the world is guaranteed to warm at least 1.5 degrees Celsius compared to pre-industrial levels — the maximum increase set by the goals of the Paris climate agreement

[23] The IPCC accords a degree of certainty to each of its key findings, based on the type, amount, quality and consistency of evidence (e.g. data, theory, models, expert judgment), and the degree of agreement among scientists. The terms to describe evidence are: limited, medium or robust; and to describe agreement: low, medium or high. The *Fifth Assessment Report's* 'confidence' in a finding represents a synthesis of how much evidence there is, and how much scientific agreement exists. The levels of confidence used are: very low, low, medium, high and very high.

Figure 3.3: Image 1 depicts Change in Annual Average Temperature from 1901 to 2012, and Image 2 depicts Change in Annual Average Precipitation from 1951 to 2012 in South Asia



Source: The IPCC's Fifth Assessment Report, What's in it for South Asia

Fifth Assessment Report identifies a set of key climate-related risks for Asia including **flood damage to infrastructure, livelihoods and settlements, food and water shortages, and heat-related mortality**

3.2.2 Predicted climate trends

Table 3.1

Indices	Predicted trends for S. Asia	Predicted trends for India
Temperature	Average annual temperatures could rise by more than 2°C in South Asia by the mid-21st century and exceed 3°C by the late 21st century in a high-emissions scenario.	The annual averaged mean, maximum and minimum temperatures as a whole show a significant warming trend of 0.15°C, 0.15°C, and 0.13°C per decade, respectively, since 1986. By the end of the 21st century, the frequency of warm days and warm nights is projected to increase by 55% and 70%, respectively, compared to 1976-2005[24].
Rainfall	More frequent and heavy rainfall days are projected over parts of S.	There has been a shift toward more frequent dry spells (27%

[24] https://reliefweb.int/report/india/assessment-climate-change-over-indian-region-report-ministry-earth-sciences-moes

	Asia. Extreme rainfall events are likely *to* occur where tropical cyclones make landfall.	higher during 1981–2011 than during 1951–1980) and more intense wet spells during the summer and monsoon. Increased rainfall is likely at higher latitudes by the mid-21st century in a high-emissions scenario. In a lower emissions scenario, more rainfall at higher latitudes will be likely by mid-century but changes in rainfall are not likely at low latitudes.
Sea level rise	The global mean sea level is likely to rise by 26-55 cm in the last two decades of the 21st century, as compared to sea levels in 1986–2005, in a low-emissions scenario. In a high-emissions scenario, that figure is likely to be 45–82 cm and could go up to 98 cm by 2100. This magnitude of sea-level rise by the century's end implies significantly increased risks for coastal settlements. The sea level in the North Indian Ocean (NIO) rose at the rate of 1.06–1.75 mm per year during 1874–2004 and accelerated to 3.3 mm per year during 1993–2017. At the end of the 21st century, the NIO sea level is projected to rise by approximately 300 mm relative to the average during 1986–2005[25].	

3.2.3 Climate change challenges to growth and development in South Asia

The IPCC identifies three key risk areas related to climate change for the South Asia region. They are **widespread damage to infrastructure, livelihoods, and settlements from risks such as flooding, increase in heat-related mortality, and drought-related water and food shortage leading to malnutrition.**

Flood damage to infrastructure, livelihoods, and settlements: Riverine, coastal and urban floods linked to extreme rainfall events, rising sea levels, and cyclones could cause widespread damage to infrastructure, livelihoods, and settlements. In the near term (2030–2040), the risk of flood damage is medium but could be reduced through adaptation measures. In the long term (2080–2100), this risk could be very high, and could be reduced to high by adaptation under 4 degrees Celsius warming, and high but could be reduced to the medium by adaptation under 2°C warming. The risk of floods – and loss of life and property due to floods – is highest in India and Bangladesh.
Food and water shortages: Key risks identified for Asia include water and food shortages linked to rising temperatures, extreme temperatures, and drying trends. More erratic rainfall in parts of Asia could lower rice yields and lead to higher food prices and living costs, malnutrition, and worsened rural poverty.

[25] https://reliefweb.int/report/india/assessment-climate-change-over-indian-region-report-ministry-earth-sciences-moes

Heat-related mortality: Another key risk for Asia is increased mortality due to rising temperatures and extreme temperatures This will become a major public health concern across Asia.

Table 3.2

Table 24-1 | Key risks from climate change and the potential for risk reduction through mitigation and adaptation in Asia. Key risks are identified based on assessment of the literature and expert judgments, with supporting evaluation of evidence and agreement in the referenced chapter sections. Each key risk is characterized as very low, low, medium, high, or very high. Risk levels are presented for the near-term era of committed climate change (here, for 2030–2040), in which projected levels of global mean temperature increase do not diverge substantially across emissions scenarios. Risk levels are also presented for the longer term era of climate options (here, for 2080–2100), for global mean temperature increase of 2°C and 4°C above pre-industrial levels. For each time frame, risk levels are estimated for the current state of adaptation and for a hypothetical highly adapted state. As the assessment considers potential impacts on different physical, biological, and human systems, risk levels should not necessarily be used to evaluate relative risk across key risks. Relevant climate variables are indicated by symbols.

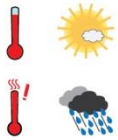
Climate-related drivers of impacts: Warming trend; Extreme temperature; Extreme precipitation; Drying trend; Damaging cyclone; Sea level; Ocean acidification

Level of risk & potential for adaptation: Potential for additional adaptation to reduce risk; Risk level with **high** adaptation; Risk level with **current** adaptation

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation (Very low – Medium – Very high)
Increased risk of crop failure and lower crop production could lead to food insecurity in Asia (*medium confidence*) [24.4.4]	Autonomous adaptation of farmers on-going in many parts of Asia.		Present; Near term (2030-2040); Long term (2080–2100) 2°C, 4°C	
Water shortage in arid areas of Asia (*medium confidence*) [24.4.1.3, 24.4.1.4]	Limited capacity for water resource adaptation; options include developing water saving technology, changing drought-resilient crops, building more water reservoirs.		Present; Near term (2030–2040); Long term (2080–2100) 2°C, 4°C	
Increased riverine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (*medium confidence*) [24.4]	• Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation • Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, biomass, mobility, local ecosystems, telecommunications) • Construction of monitoring and early warning systems; Measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods • Economic diversification		Present; Near term (2030–2040); Long-term (2080–2100) 2°C, 4°C	
Increased risk of flood-related deaths, injuries, infectious diseases and mental disorders (*medium confidence*) [24.4.6.2, 24.4.6.3, 24.4.6.5]	Disaster preparedness including early-warning systems and local coping strategies.		Present; Near term (2030–2040); Long term (2080–2100) 2°C, 4°C	
Increased risk of heat-related mortality (*high confidence*) [24.4]	• Heat health warning systems • Urban planning to reduce heat islands; Improvement of the built environment; Development of sustainable cities • New work practices to avoid heat stress among outdoor workers		Present; Near term (2030–2040); Long term (2080–2100) 2°C, 4°C	
Increased risk of drought-related water and food shortage causing malnutrition (*high confidence*) [24.4]	• Disaster preparedness including early-warning systems and local coping strategies • Adaptive/integrated water resource management • Water infrastructure and reservoir development • Diversification of water sources including water re-use • More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)		Present; Near term (2030–2040); Long term (2080–2100) 2°C, 4°C	
Increased risk of water and vector-borne diseases (*medium confidence*) [24.4.6.2, 24.4.6.3, 24.4.6.5]	Early-warning systems, vector control programs, water management and sanitation programs.		Present; Near term (2030–2040); Long term (2080–2100) 2°C, 4°C	

Continued next page →

Table 24-1 (continued)

Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Exacerbated poverty, inequalities and new vulnerabilities (*high confidence*) [24.4.5, 24.4.6]	Insufficient emphasis and limited understanding on urban poverty, interaction between livelihoods, poverty and climate change.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low · Medium · Very high
Coral reef decline in Asia (*high confidence*) [24.4.3.3, 24.4.3.5, CC-CR, CC-OA]	The limited adaptation options include minimizing additional stresses in marine protected areas sited where sea surface temperatures are expected to change least and reef resilience is expected to be highest.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low · Medium · Very high
Mountain-top extinctions in Asia (*high confidence*) [24.4.2.4, 24.4.2.5]	Adaptation options are limited. Reducing non-climate impacts and maximizing habitat connectivity will reduce risks to some extent, while assisted migration may be practical for some species.		Present Near term (2030–2040) Long term (2080–2100) 2°C 4°C	Very low · Medium · Very high

Source: WG II-AR5 Table 24-1

3.3 Introducing vulnerability and risk assessment

What is vulnerability? It is the propensity or predisposition to be adversely affected (IPCC, 2014). Predisposition indicates that the system cannot deal with the adverse impact of a hazard. The vulnerability of a natural or socio-economic system is assessed as a function of its sensitivity to a hazard and its lack of adaptive capacity to overcome it (IHCAP, 2017).

What is risk? Climate risk is the 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, the 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). Hazard, exposure and vulnerability are affected by changes in the climate system as well as socio-economic processes.

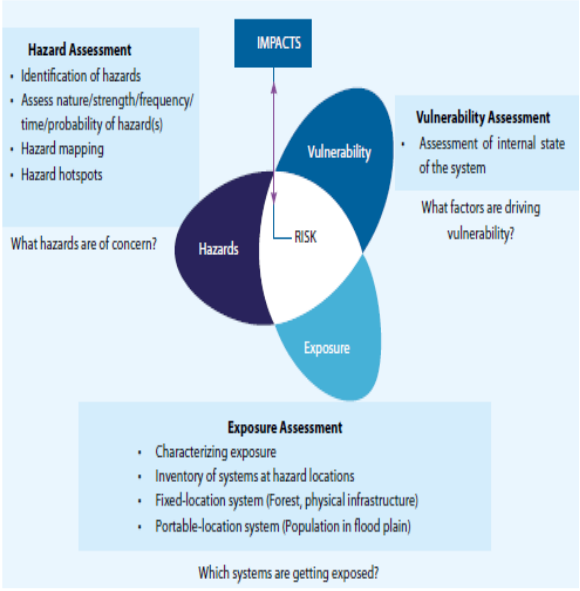
3.3.1 Risk assessment

Risk is assessed for a vulnerable system of interest for a climate hazard when the system is located where that hazard is likely to occur.

Hazard is defined as the potential occurrence of a natural or human-induced physical event/trend or physical impact that may cause death, injury, or other health impacts, and damage to or loss of property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (IPCC, 2014). Hazard includes 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 fast-onset events (e.g. floods, including glacial lake outburst floods, heatwaves, and landslides).

Exposure refers to the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, and economic, social, and cultural assets in settings that could be adversely affected (IPCC, 2014).
Risk assessment thus involves the assessment of vulnerability, hazards, and exposure. The conceptual framework to assess risk, outlining the steps to assess each of the factors, is shown in the figure below.

3.3 Figure Risk Management and Assessment Framework



Source: Manual on Adaptation to Climate Change in Indian Himalayan Region

RISK ASSESSMENT PROCESS

Step 1: Define the objective of risk assessment. The involvement stakeholders enhances the utility of the assessment.
Step 2: Identify the hazard causing the risk and the system under risk. Decide the resolution. Provide the scale and time frame for the assessment.
Step3: Identify the sector, community, region and scale of assessment for outcomes of vulnerability of systems for the anticipated hazard.
Step 4: Assess vulnerability, exposure and hazard.. Mark hazard hotspots for hazard assessment and prioritize vulnerable systems.
Step 5: Assess the probability of occurrence of the hazard at the system location. Combine the spatial distribution maps of hazard hotspots.
Step 6: Take up assessment at local levels to identify site-specific factors that determine vulnerability to identified hazards.
Step 7: Identify vulnerability adaptation and reduction measures in consultation with stakeholders to manage risks. This helps in dealing with current risk and prepares against future risk.

3.4 Climate change and its impact in Sikkim

The impact of climate change is a major concern in Sikkim. The state is unique among Himalayan states, not only in terms of topography but also the geographical challenges and vulnerability that its inhabitants face.

It is necessary to understand, highlight and prioritize not only rural vulnerability but also sectoral vulnerability, and the various reasons (institutional, financial, and coordination gaps) that aggravate the situation on the ground.

Climate change has contributed to erratic rainfall, the drying up of springs and streams, migration of species to higher elevations, shifts in the sowing and harvesting periods of crops, the emergence of invasive species, and the incidence of diseases and pests in crops and fodder species.

Changing temperature and rainfall trends: The projected mean annual rainfall varies from a minimum of 940-149 mm to 1330-174.5 mm. The increase from 1970s is from 0.3 percent to 3 percent. The North East region has shown a considerable decline in winter months with respect to the 1970s, with no additional rain between March to May and October to December. In the 2030s, the rainfall for June, July, and August is likely to be 5 mm higher than in the comparable period in the 1970s. In addition, the India Meteorological Department (IMD) records reveal changes in the climate of Gangtok between 1958 and 2005. The maximum temperature has been falling by 0.3 degrees C per decade, and the minimum temperature has been rising by 0.2 degrees C per decade. These have been discussed further in section 3.4.1.

Community vulnerability to climate change: Rural communities are more vulnerable to climate change due to lesser adaptive capacity. In Sikkim, a 2012 study by Tambe et al. found that the South district was the most vulnerable, followed by the West. The East and North districts were found to be relatively resilient to climate-

related changes. However, areas such as Karzi-Mangnam and Sakyong-Pentong villages, which were not highly exposed, were however found to be highly vulnerable due to their high sensitivity[26] and low adaptive capacity[27].

Melting of glaciers: Recent studies by the Centre for Development of Advanced Computing (C-DAC), Pune, conducted jointly with the Sikkim State Council of Science and Technology, Gangtok, have shown that many glacial lakes in the Sikkim Himalayan region have expanded over the years. Statistics indicate that the cold desert of North Sikkim is highly sensitive to climatic variation.

Field observations prove that glacial lakes have been growing in size and volume since 1965. New glacial lakes have also formed. Glacial lakes develop due to glacier retreat and melting. Glacial Lake Outburst Floods (GLOFs) have been seen in Sebu Chu Valley in North Sikkim. Glacier thinning and retreat in the Sikkim Himalayas has resulted in new glacial lakes and the enlargement of existing ones, due to the accumulation of meltwater behind loosely consolidated end moraine dams[28]. Such lakes are inherently unstable. They pose danger to people and property in the valleys below them (ICIMOD 2011). Settled and nomadic communities in the region depend on the lakes for their livelihood (SAC 2011).

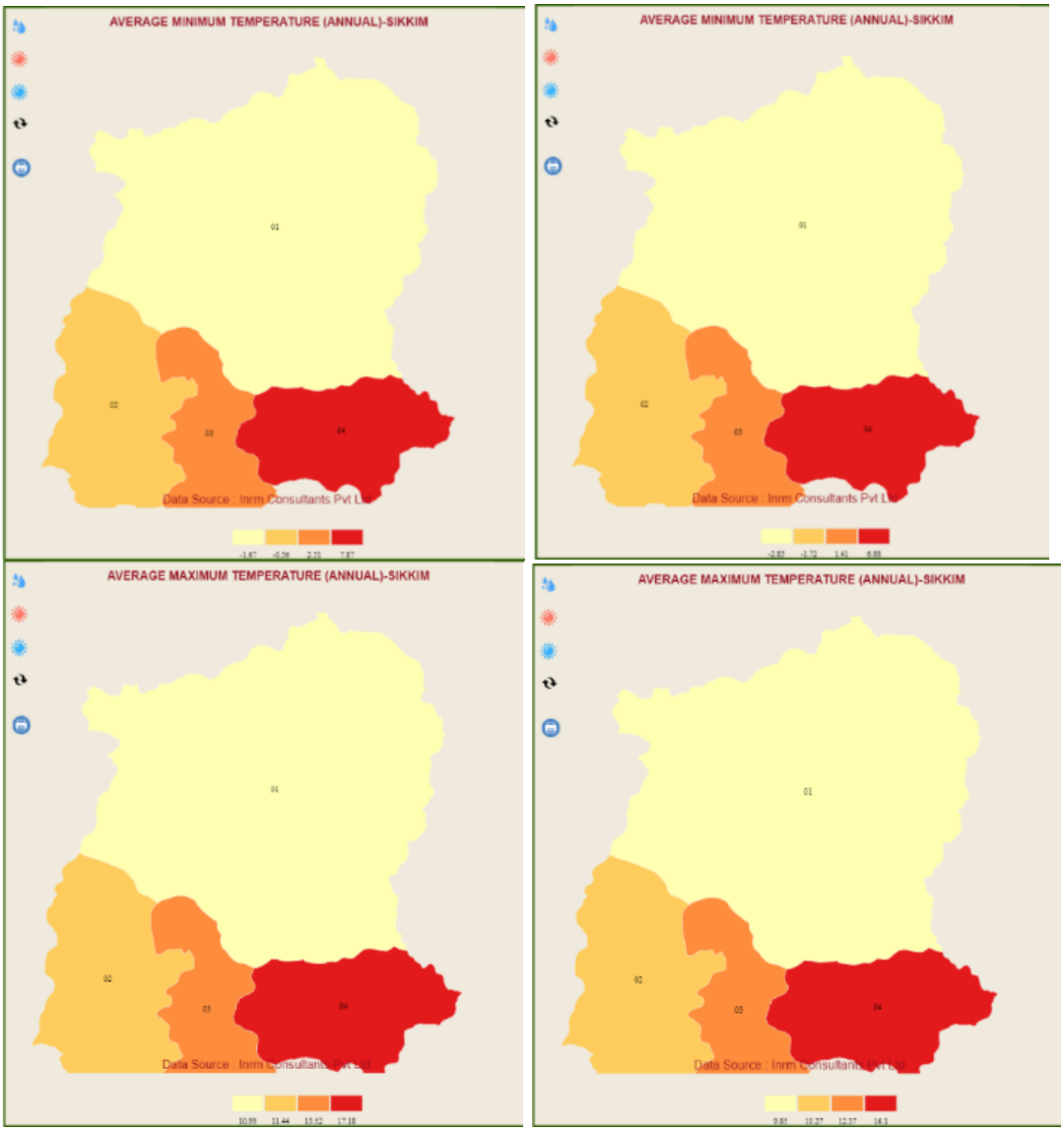
[26] **From IPCC Glossary Annex 2:** The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damage caused by an increase in the frequency of coastal flooding due to sea level rise) https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf

[27] **From IPCC Glossary Annex 2:** The ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf

[28] From AntarticGlaciers.com: Moraines are distinct ridges or mounds of debris that are laid down directly by a glacier or pushed up by it. The term *moraine* is used to describe a wide variety of landforms created by the dumping, pushing, and squeezing of loose rock material, as well as the melting of glacial ice. http://www.antarcticglaciers.org/glacial-geology/glacial-landforms/glacial-depositional-landforms/moraine-types/

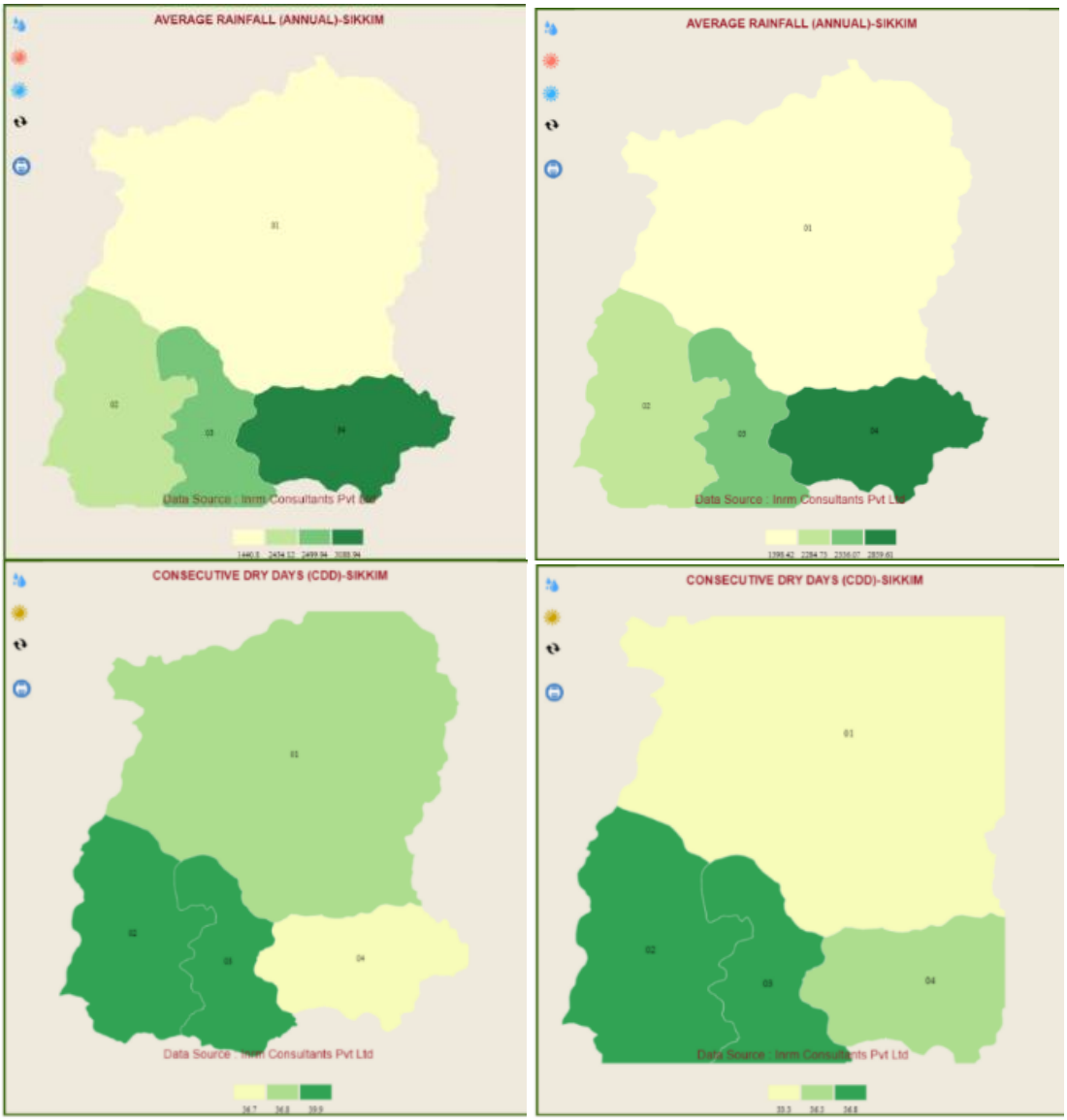
3.4.1 Climate projections for South and East Sikkim

Figure 3.4 Average temperature projected to increase



	Baseline (1981 -2011)	Near term (2011-2040)	Baseline (1981- 2011)	Near term (2011-2040)
South:	1.4°C	2.5 °C	12.4°C	13.5 °C
East:	6.9°C	7.9°C	16.1 °C	17.2 °C

Figure 3.5: Annual precipitation projected to decrease



Baseline (1981 -2011) Near term (2011-2040) Baseline (1981- 2011)

Near term (2011 – 2040)

South: 2,499 mm 2,336 mm

East: 3,088.9 mm 2,859.6 mm

Analysis of climate extremes in South Sikkim

- The daytime temperature range is projected to remain unchanged in the near term.
- Extremely wet days and maximum one-day precipitation are both set to increase. This means that although rainfall is expected to decrease, it will be uneven and there will be some days with extremely heavy rainfall, potentially leading to floods.
- Cold spells are set to decrease, and warm spells to increase. The south district is expected to become warmer with more hot days and fewer cold days in the future.

Analysis of climate extremes in East Sikkim

- Maximum five-day precipitation is projected to decrease in the near term from 310 mm to 254 mm. However, one-day maximum precipitation remains almost the same.
- Consecutive dry days are projected to decrease slightly in the near term.
- Cold spells are projected to decrease drastically from 3.3 to 0.6 degrees Celsius, and warm spells are projected to increase exponentially from 6.6 to 23.9 degrees Celsius.

Forest fires

Forest fires are common along the Himalayan foothills and in other deciduous forests. However, due to the increase in the frequency and duration of droughts and the over-exploitation of forest lands, there has been an increase in the number and size of wildfires. The impact on the environment has been proportionately negative (Sharma et al. 2012).

In Sikkim, forest fires are common in the winter months in the subtropical sal forests. Due to winters becoming increasingly warm and dry, the forest fires, which were previously thwarted by winter precipitation in these areas, now burn longer. The fires are usually of two types: ground fires and canopy fires. Ground fires are more frequent and mostly stick to the lower reaches of the vegetation, whereas canopy fires can be long-lasting and result in the entire trees being burnt. Most forest fires are due to anthropogenic factors or natural ones, such as lightning (Sharma et al. 2012).

About 317 km^2 of the forest area has become degraded within the last three decades of the 20th century. This has mostly affected temperate oak forests and can be attributed to open grazing, forest fires and selective felling of commercially profitable trees (Tambe, Arrawatia, and Sharma 2011). There also seems to be unsupervised use of forests for firewood in the state, with the estimated figures at around 6-8 tons per household per year. The dry biomass that gets accumulated in the dry period from November to March and leads to an increase in forest fires is a key observation in many studies (Banerjee 2020). While low-intensity fires can help forest growth by removing deadwood and releasing the nutrients in the soil biomass, high-intensity fires can be catastrophic and can lead to soil erosion, the decline in biodiversity and forest cover, etc.

Mitigation of forest fires

A wide range of topographical and meteorological features have been used to understand forest fire dynamics and to predict them. These include altitude, aspect, slope, Topographic Wetness Index (TWI), precipitation, temperature, humidity, wind speed, lightning, etc. Scientists aim to understand their influence on the direction and speed of fires, as well as the triggering mechanisms and conditions that cause the fires. Human-induced factors such as proximity to road networks, ground factors such as soil moisture and texture, and vegetational features like vegetation type and Normalized Difference Vegetation Index (NDVI) through the aid of satellite imagery have also provided insights into predicting forest fires. Machine learning methods are gaining popularity in this type of research (Banerjee 2020).

The maximum entropy machine learning method analyzes remote sensing imagery and has indicated that anthropogenic features such as road networks, tree cover fraction, and meteorological features, were accountable for most forest fire incidents. The majority of these incidents were observed in the southern part of Sikkim, where logging activities are greater in number.

Another change detection study using satellite imagery revealed that there is an urgent need to protect small, fragmented forests which are comprised of subtropical trees and are predominantly converted for agricultural or residential use (Tambe, Arrawatia, and Sharma 2011). The main cause of degradation and fragmentation of temperate oak forests is heavy dependence on firewood and timber, heavy grazing, and their naturally slow-growing nature. Incidents of forest fires in temperate forests have increased lately, and there is a pressing need to implement appropriate adaptation and education

Current management practices in Sikkim

Community-based joint forest management practices in Sikkim have the potential to protect biodiversity, strengthen local systems and create opportunities for community participation. Local needs for fuel, fodder, minor timber, non-timber forest produce, and grazing depend greatly on the forests and community-based forest management aims to meet these needs.

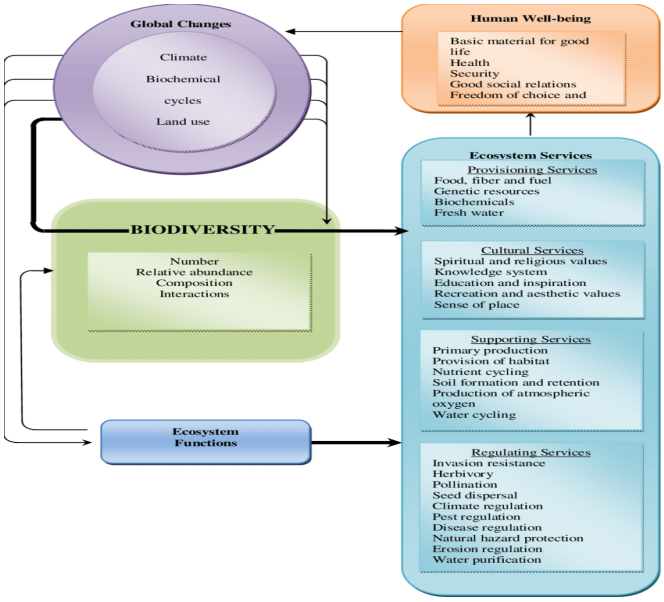
There is usually a two-pronged strategy for fire management. One part is early detection and management, which covers higher altitudes and includes community participation in management. The other part is the planting of tree species in forests immediately after the area is burnt. For this, it is necessary to set up nurseries for sal, oak, and conifer trees, with adequate saplings available for future requirements, and research to identify forest tree species that would adapt at different altitudes (Government of Sikkim 2014).
The lack of awareness about forest fire management practices among forest communities remains a contributing factor in curbing the effect of forest fires and efficient forest management (Satendra and Dev 2014). The current forest management practices of the Sikkim government address the following sectors (Department of Forest and Environment - Government of Sikkim 2019):

- Strengthening the territorial sector: This sector is characterized by effective forest management and protection, and is supported by motivated field staff, sound legal enactment, efficient and effective transport and communication, accommodation and facilities, and vital amendments to laws to make offences such as illegal tree-felling non-bailable. Overall surveillance has been intensified through patrolling at regular intervals, effective forest check posts, checks on illegal extraction, and timely reporting of all forest-related offences.
- Forest fire management: A forest fire management policy has been developed in the state to enable the government to focus on fire prevention and to coordinate the efforts of various agencies. It integrates modern firefighting approaches with community-based strategies and aims to preserve biodiversity by prioritizing forest cover based on its vulnerability and intrinsic value.
- Grazing control: Grazing in a reserved forest, plantation, and water source areas is banned to encourage the regeneration of forest resources.
- Joint forest management committees: Decentralizing participation in forest management to the grassroots level is encouraged through joint forest management committees, which include villagers involved in management functions of their nearby forests. There are 155 such committees across the state, which at the district level have formed what is known as the Forest Development Agency. They are responsible for the afforestation and maintenance of forest cover in their respective areas.
- Infrastructure development: The government is currently developing infrastructure for forest and wildlife management staff, further developing wireless communication, and installing computer facilities in offices for all divisions.
- Survey transport: The government plans to initiate a new survey and demarcation of forests. This was last done in the mid-20th century, and since then, some forest cover has vanished due to the increasing population, encroachment for grazing, etc. Currently, major territorial divisions have patrolling vehicles with wireless facilities, but there is a need for similar facilities in other sensitive regions as well.

3.4.2 Vulnerability assessment of Sikkim

Climate affects humans directly through experienced weather (physically and psychologically) and its impacts on daily living conditions, and indirectly through its impacts on economic, social, and natural environments. Climate change and its impacts continue to affect mountain ecosystems, sometimes beneficially, but frequently with adverse effects on the structure and functioning of ecosystems, leading to the vulnerability of human well-being. Fortunately, the functioning of many ecosystems can be restored if appropriate action is taken in time. The linkage between climate and human well-being is complex and dynamic, as shown in the figure below.

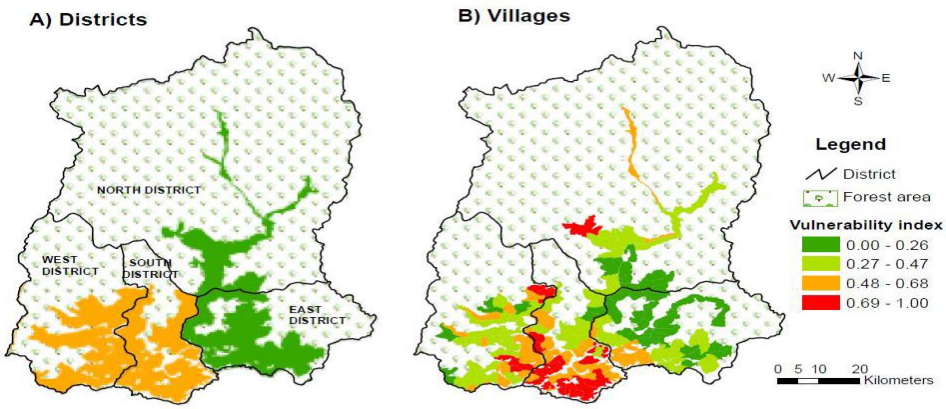
Figure 3.6 *Biodiversity, Ecosystem and Human Well-being Relationship*



Source: Adapted from MEA, 2005: 28.

The Sikkim State Action Plan on Climate Change (SSAPCC) assesses the vulnerability of the state's rural population in terms of the interplay of risk of exposure to climate change, the sensitivity of the system, and the adaptive capacity of the communities (see Figure 5):

Figure 3.7 Vulnerability of Rural Communities in Sikkim



- Communities that practiced the most climate-sensitive livelihoods had least adaptive capacity and also faced high exposure.
- Communities practicing sensitive livelihoods of rainfed farming have the least adaptive capacity (poverty, education, and infrastructure) and also faced high exposure of climate-related change (drought, pests).
- Diverse development interventions are needed at the village level to counter the exacerbated impacts of climate change, as **significant variation in vulnerability was found within a district itself**.

South Sikkim vis-à-vis East Sikkim

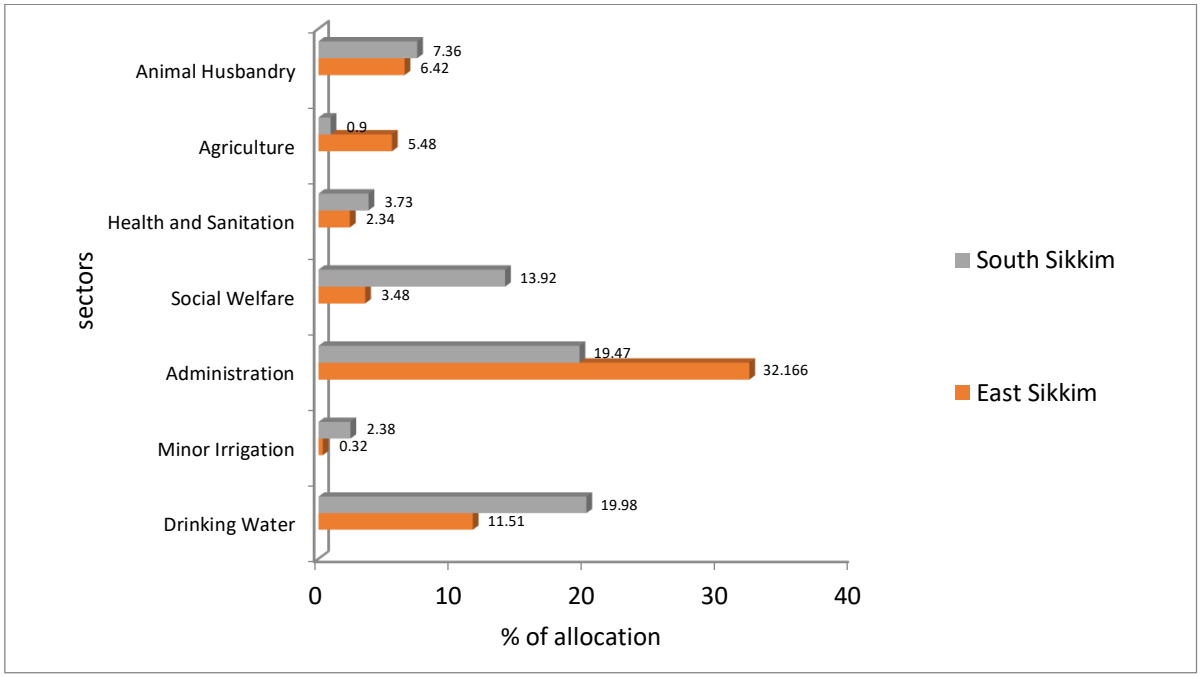
- Table 1 below factually compares of Vulnerability and coping capacity of South and East Sikkim based on various social-economic factors, availability and access to necessary services, and local weather conditions.
- Graph 1 gives a factual allocation of Budget in South & East Sikkim to various sectors in percentage

Table 3.3: Sensitivity and Vulnerability Comparison between South & East Sikkim

Component	Sector	Proxy Indicator	East Sikkim	South Sikkim
Exposure	Temperature	*Annual mean temperature (max. and min.)*[29]	26.7 C 16.5 C	26.7 C 16.5 C
	Rainfall	*Mean annual rainfall*[30]	3,245 mm	2,753 mm
Sensitivity	Water resources	*% rain-fed farming*[31]	10.5 thousand hectares	15.44 thousand hectares
	Livelihoods	*% farming population*[32]	30.76	56.17
		Elevation	610m	400 – 2,000m
	Human health	*Family size*	4.5	4.5
Adaptive capacity	Economic capacity	*Poverty rate*	7	8
	Human capacity	*% of Class 10 educated population*	88.90	88.45
	Environmental capacity	*Population density*	295	196
	Physical connectivity	*Rural connectivity*	Data not available	Data not available

[29] http://climatevulnerability.in/historical/#
[30] http://climatevulnerability.in/historical/#
[31] http://www.crida.in/CP-2012/statewiseplans/Sikkim/SKM1-East%20Sikkim-30.10.12.pdf
[32] 2011 State Census

Figure 3.7 Budgetary allocation to various sectors in percentage for South & East Sikkim



Source 1 *Department of Revenue (Govt of Sikkim)*

Findings: South Sikkim vis-à-vis East Sikkim

1. **Climate:** The annual average minimum and maximum temperature patterns in both districts are the same. However, South Sikkim receives 492 mm less rainfall than East Sikkim annually.
2. **Irrigation:** Despite being a rain-shadow district, South Sikkim depends more heavily on rain-fed agriculture than East Sikkim.
3. **Socioeconomic comparison:** There is no stark difference in poverty and family size. However, the population density is greater in East Sikkim, which is more urbanized due to Gangtok.
4. **Agriculture:** More than half of South Sikkim's population (56.7 percent) depends directly on agriculture (as cultivators or laborers), which is above the state average of 38 percent. In East Sikkim, 30.5 percent of the population depends on agriculture.
5. **Labor**: In East Sikkim, 8.5 percent of the labor force is engaged in farm work, in keeping with the state's average. However, the corresponding figure for South Sikkim is 5 percent, which underlines the challenges that this district faces due to low farm productivity and the absence of labor-intensive farming, primarily due to the scarcity of water.
6. **Budgetary allocation:** A comparison of key sectoral allocations in South Sikkim and East Sikkim reveals the following:
    - **Water:** South Sikkim's allocations for drinking water and minor irrigation schemes are higher than East Sikkim's. This highlights both the challenge and priority of the South district's administration regarding water security.
    - **Agriculture:** Despite more than half of South Sikkim's population depending directly on agriculture, the allocation is a mere 0.9 percent compared with East Sikkim's 5.5 percent.
    - **Animal husbandry:** South Sikkim spends around 7 percent and East Sikkim spends around 6 percent to promote animal husbandry.
    - **Social security, and health and sanitation**: South Sikkim spends around 13.5 percent and 3.7 percent of its budget, respectively, on these sectors. East Sikkim allocates around 3.48 percent

and 2.38 percent, respectively. The lower spending on social security in Gangtok shows that inhabitants in East Sikkim are better off economically, and have multiple avenues for livelihood from sectors such as tourism and industry.

CHAPTER 4: BUILDING RESILIENCE IN KEY VULNERABLE SECTORS

4.1 Agriculture

Background: More than 64 percent of Sikkim's population depends on agriculture for their livelihood, cultivating 109,963 hectares, which is only 15 percent of the state's total land area. Some hill slopes have been converted into terraced farmland. Cardamom is the main cash crop, grown on 19 percent of the cropped area. Other crops such as rice (13 percent of the cropped area), millet, corn, etc., are also grown in limited quantities. Cabbage and potato are produced in large quantities in Lachung Valley and are exported out of the state. Radish, too, is exported from this area. Other vegetables such as peas and cauliflower are grown all over the state. Apple is grown in large quantities in the Lachung Valley. Other fruits, such as peach, guava, orange, and plum, are also grown.
Maintaining farm productivity is important to ensure food and economic security. However, cultivation in Sikkim faces several problems. Dryland and wasteland constitute 58 percent and 10 percent of the total area, respectively. Cultivable land is beset with variable agro-climatic conditions, difficult terrain, steep slopes, acidic soil, and prolonged dry spells. Farming is almost entirely rain-fed, and the majority of cultivable land provides a single summer crop.

Animal husbandry plays an important role in Sikkim's rural economy. Livestock such as cows, buffaloes, pigs, sheep, goats, and yaks are reared in Sikkim. Yaks are reared in the northeastern ranges bordering Tibet and Bhutan, and the western region bordering Nepal.

4.1.1 What does adaptation in agriculture mean?

Adaptation to climate change in agriculture aims to minimize people's vulnerability by improving their ability to cope with the impacts of climate change. This is also known as **adaptive capacity.** Adaptive capacity is often limited, particularly in poor rural areas where people live on subsistence agriculture. People need to be provided with climate change-related information and given access to social, economic, institutional, and technical resources. New adaptation strategies and measures must be integrated into existing capacities, assets, and resources. An analysis of the existing adaptive capacity and assets of a given target group is, therefore, a crucial starting point.

Historically, small-scale farmers in drought-prone areas have autonomously adapted to changes in the climate. They have used drought-resilient crops and adjusted production practices, spreading risk, for example, by staggering sowing, weeding fields promising the highest yield, or using hand-dug wells to irrigate their fields in case of low rainfall.

However, farmers are often not aware of the overall scale of climate change, and of the fact that their adaptation practices may not be enough to cope with current climate change impacts, which would threaten their family's livelihood. Initially, social networks might provide a safety net, but a sustained dry spell could exhaust the farmers' adaptive capacity. With the help of an extension service designed to improve understanding, farmers' adaptation strategies could be more effective.

Agricultural extension services can help farmers become aware of the scope of adaptation to climate change, and to receive information on the availability of technical, water, and nutrient management alternatives (e.g. floodplain cultivation with flood irrigation and groundwater recharge, or drip irrigation). These services can also help them to access credit and insurance.

With awareness of climate change at all levels, farmers could, for example, be connected to a publicly planned and financed broad-scale irrigation infrastructure. This could connect small-scale farmers' irrigation schemes to the water supply needed during droughts, and make them less dependent on their individual water sources (New Agriculturist 2007).

4.1.2 Impact of climate change on agriculture in Sikkim

Climate change is likely to have serious consequences for Sikkim's agriculture. Recent changes in climate indicating a warmer and drier winter have resulted in a decline in the production of winter crops and an increased incidence of forest fires. Due to increased runoff and dry winters, springs have started drying up, and their lean-season discharge is reducing drastically. Annual mean rainfall showed high variation depending on geography, with the rain shadow areas in the lower part of South and West Sikkim districts receiving only half the rainfall compared to East Sikkim. Over 98 percent of Sikkim's water is used for irrigation: according to the state irrigation department, out of the 2,176 cusecs used in 2010 for irrigation, urban and rural drinking water, and industry, 2,135 cusecs were used for irrigation alone. Higher temperatures increased evapotranspiration, and decreased winter precipitation may bring about more droughts in Sikkim. In addition, the Teesta and Rangit rivers may face highly variable flows with climate change.

Some key concerns of agriculture due to climate change:

- Crop yield instability. Loss of production and quality due to variable rainfall, temperature, etc.
- Decreased water availability for crop production. Increased risk of extinction of already threatened crop species, notably traditional crop varieties. According to the Agricultural Handbook of the Indian Council of Agricultural Research (ICAR) published in 2016, the number of rainfall events and the number of rainy days has declined by 52 percent and 34 percent, respectively, during the last 10 years in the Himalayas. The incidence of high-intensity rainfall and drought has increased.
- Loss of soil fertility due to erosion of topsoil and runoff. Loss of fields due to flash floods, landslides, and rill and gully formations. Soil nutrient loss through seepage.
- Loss of flower and fruit crop yield due to hailstorms. Deteriorated produce quality (fruits and vegetables) by untimely incessant heavy rains and hailstorms. An impact assessment study by Bharatiya Agro Industries Foundation (BAIF) in 2012 on climatic components on rice-wheat cropping systems showed that higher mean, maximum and minimum temperatures during winter have resulted in poor wheat yield.
- Delayed sowing due to late rainfall. Crop damage due to sudden early frost (paddy) and late spring frost (potato).
- Pest and disease outbreaks in fields and storage where they were previously unknown.
- Damage to road infrastructure, risking food security.
- According to Indian Network for Climate Change Assessment (INCCA) report in 2010, with increasing temperature, the shifting of agriculture to higher altitudes may result in the loss of permanent pastures and grassland (bugyals) to arable cultivation.

Table 4.1 Agricultural crops and indicators of changing climate[33]

S.No.	Crops	Indicators of Change
1.	Cereals and pulses	Several traditional varieties of rice have disappeared, such as *Punaro, Kanchi Attey, Kagey Tulasi, Thulo Attey, Ghaiyya Dhan, Sanu Tulashi, Seto Tulashi, Thulo Marshi, Tauli Dhan, BagheyTulashi*. The roots are infected by termites when the rice is in the fruiting stage.
2.	Large cardamom	The spread of fungal diseases, and viral diseases commonly called *chirkey* and *furkey,* have reduced production by 60 percent, and plantation area by almost 50 percent, since the early 1980s.

[33] *Climate Change and Sustainability of Agrodiversity in Traditional Farming of the Sikkim Himalaya* by Ghanshyam Sharma and Lalit Kumar Rai

3.	Ginger	The biggest challenge for ginger cultivation has been to control soil-borne diseases, soft rot, dry rot, bacterial wilt, etc. Other challenges include the production of sufficient manure, manpower for cultivation and marketing when prices are favorable.
4.	Chayote	Shrinking leaves, blight, etc., have been observed in the last five years.
5.	Broom grass	Broom grass is a multipurpose agroforestry species in the mountain farming system along the Himalayas. In the last 10 years, it has struggled with the yellowing of leaves and leaf blight. During winter, especially after October, bushes develop leaf blight and dry up, making fodder unpalatable to farm animals.
6.	Oranges	Recently, productivity has declined due to diseased trees whose potential fruit-bearing potency is lost. Besides, old plantations have lost vigor, and the majority of them are affected by viral and other diseases.
7.	Fodder species	In recent years, farmers have seen significant declines in tree fodder production. One reason is that pests eat the leaves before they mature for harvesting, especially during the lean season. Some of these trees are *Artocarpus lakoocha* (Badar), *Ficus cunia* (Khasreto), *Ficus benghalensis* (Pate Bar), *Ficus roxburghi* (Nibaro), *Ficus lacor* (Kabro), *Ficus semicordata* (Drooping fig)
8.	Common grass and fodder declining	With colonization by invasive species, common fodder species such as *Digitaria sanguinalis* (Ghogey Banso), *Paspalum conjugatum* (Chitre Banso), *Panicum repens* (Phurkey), *Thysanolaena agrostis* (Amliso) are declining.
9.	Emergence of weeds in cultivated farms	Common weeds that affect maize include *Eleusine indica* and *Setaria glauca*. Paddy is affected by weeds such as *Cyperus eragrotis*, *Hydrocotyle nepalensis*, *Paspalum pasploides*, *Echinocloa crusgalli*, *Echinocloa colonum*, *Cyperus rotundus*, *Cynodon dactylon*, *Ageratum conyziodes,* etc. Weeds that affect wheat include *Chenopodium album*, *Amaranthus spinosus, Cynodon dactylon*, *Polygonum capitata,* etc. The most common weeds are *Echinocloa crusgalli*, *Echinocloa colonum*, *Cyperus rotandus*, *Cynodon dactylon*, *Ageratum conyzioides* etc. Potato and mustard, both common winter crops, are mostly infested by weeds such as *Polygonum capitata*, *Cyperus rotandus*, *Cyperus iria*, *Cynodon dactylon*, *Drymaria cordata*, *Spilanthus paniculata*, *Sida rhombifolia*, *Gnaphalium officinale,* etc.

4.1.3 Adaptation options in agriculture

Selection criteria for adaptation options should help decision-makers identify adaptation strategies or measures to implement, and when to implement them. This is particularly important, given the uncertain environment of climate projections and continuous change. Often there is no definitive answer to questions such as:

- How is the local climate likely to change, and how fast?
- How sensitively will certain agricultural systems respond to this change?
- Will potential adaptation options perform well, and will they pay off financially in the long run?

For subsistence farmers in rural areas, who have low adaptive capacity, many choices will require putting in an enormous effort. The wrong choice could be costly, even deadly (Leary et al. 2007).

According to Leary, the criteria for the selection of adaptation measures might be:

- economic and social benefits

- consistency with development objectives
- environmental impacts and spillover effects
- cultural acceptance and social feasibility.

Prioritizing adaptation measures implies defining and applying criteria that help decide when to implement an appropriate adaptation option. Consequently, anticipatory or planned adaptation would be particularly favorable in cases where future impacts are potentially catastrophic or irreversible. Conversely, it might make sense to defer adaptation in cases where it would be very costly. In any case, the adaptation measure that yields the greatest benefit should always be chosen (Rosegrant et al. 2008). Benefits are generally related to farmers' income through increased yields.

In any event, **no-regret options** that are beneficial even without climate change should be prioritized (Kumar 2008**).** One such option is the **introduction of adapted crop varieties and species** (e.g. water-efficient crops)**.** The decision should be well-matched with the **farmer's capacities**, e.g. financial resources available**.** Integrating no-regret options that provide a good balance between costs and benefits into an anticipatory strategy is the most promising way forward. Not only do they help cope with climate change but they also contribute to sustainable development (Rosegrant et al. 2008).

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

Adaptation measures implemented in Sikkim include installing sprinklers, using micro-irrigation techniques, and introducing 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 popularize entrepreneurship initiatives among youth
- Developing policies and framework to enhance the capacity of farmers to add value to various types of produce by processing, marketing, branding, and transportation
- Supporting areas such as rural finance, entrepreneurship development, crop diversification, and participative community farming, to create livelihood opportunities.

Agro-ecological zone mapping should be employed 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 altitude. Indicative lists are available for different altitudes that may be modified to suit expected climate change impacts. On technology development, there are continuing efforts to develop genotypes of varieties/species for environments beyond their native range. Advances in growing crops in shelters such as polyhouses are also making it possible to grow crops in new locations or during the off-season (BAIF, 2011).

Conservation and management of soil and water resources should be a priority in the mid-hill areas that hold a high production potential. While retaining runoff water in ponds is a potential adaptation option for terraces higher up the slope, fields in lower areas can use drip or gravity-based irrigation. The emphasis should be on maximizing the efficiency of resource use in terms of farm productivity per unit of land or water consumed. In this regard, the scope for growing high-value crops and aquaculture needs to be explored.

Post-harvest activities in fruit production play an important role in enhancing shelf life with assured quality, especially given increased temperatures due to climate change. For example, in Uttarakhand, shrink-wrapping is used to keep maltas, a citrus species, fresh for about five months. Zero-energy cool chambers are another way to store fruits for longer durations. Losses due to transportation delays can be minimized by using such post-harvest processing and value-addition techniques (BAIF, 2012).

Agroforestry is another practice that has high potential in hilly areas. It is an extension of cropping systems but combines perennials with annual crops. This can help in climate change adaptation as it can play a crucial role in sustaining many ecosystem services. Agricultural wasteland can 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)[34]:

• Sustainably increase agricultural productivity to support equitable increases in farm incomes, food security, and development
• Adapt and build the resilience of agricultural and food security systems to climate change at multiple levels
• Reduce greenhouse gas emissions from agriculture, including crops, livestock, and fisheries. CSA can be useful in increasing the resilience of mountain farming to climate change.

.

Example: ***Integrated organic farming system: An approach to improve livelihood security of farmers in Sikkim***

East Sikkim resident Nim Tshering Lepcha's only means of livelihood is farming on his two hectares of land. As assured irrigation is not available, farmers in the region practise rain-fed farming that integrates agriculture, horticulture, and animal husbandry. Sikkim's rich biodiversity, with abundant plant species, makes the soil rich in organic matter. However, the fragile ecosystem demands sustainable farming systems without depletion of natural resources.

During 2013 and 2016, Krishi Vigyan Kendra (KVK) in collaboration with the ICAR Research Complex for the North Eastern Hill (NEH) region initiated development interventions for capacity-building of farmers, field demonstrations, and one-on-one support. Organic manure, bio-fertilizers, and organic fungicides were encouraged under the National Initiative on Climate Resilient Agriculture (NICRA). The aim was to introduce farmers like Lepcha to the integrated organic farming system (IOFS) as means to enhance their income.

A slew of other measures was also introduced, including:

- Agri-polythene sheets (250 gm) to make jalkunds
- Low-cost plastic tunnels (transparent UV stabilized sheet of 45 gsm) for sequential vegetable cultivation
- Garden pea (TSX 10) variety for rotation with rice fallow cultivation under zero tillage
- Cultivation of improved maize line
- Backyard poultry production with the Vanaraja variety of fowl

These interventions encouraged Lepcha to opt for diversification of integrated organic farming with institutional intervention and his competence. The result was a threefold increase in his income and a considerably low investment in labor costs.

4.1.4 Adaptation interventions for crops in Sikkim, including horticulture

To ensure the livelihood security of poor farmers, the focus should be on optimizing productivity with maximum profits. Research and development will play a vital role in identifying new cultivars resilient to higher temperatures, water stress, and high concentration of carbon dioxide. Some possible strategies for ensuring food security could be:

i. Introduce high-yielding rice varieties best suited to the Eastern Himalayan foothills, which can withstand the low light intensity and water stress.

Example: Farmers were told about the various rice trials undertaken at KVK, and given a demonstration of the rice variety RCPL-412. Its yield is 5,440 kg/ha. The variety is suitable for both upland and irrigated conditions of

[34] https://www.youtube.com/watch?time_continue=106&v=q7JnJ0oBa94&feature=emb_logo

Sikkim for timely sowing conditions up to an altitude of 1,300 meters above sea level[35]. The genesis of this research lies in the systematic identification of temperature-tolerant rice and maize varieties for the northeastern hill ecosystem, where the evaluation of major food crops for tolerance to climatic stresses and genetic enhancement of tolerance is done[36].

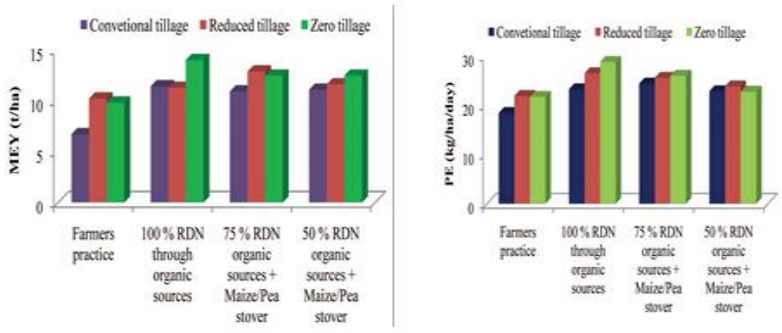
ii. Introduce a system of rice intensification (SRI), which helps to grow paddy in minimum water.

Example: KVK conducted 60 front-line demonstrations of SRI in farmers' fields in different villages of East Sikkim district, over three Kharif seasons from 2009-10 to 2011-12. They showed an increasing trend in yield performance, with 25.44 percent more yield than the traditional random planting (TRP) method. The pooled grain yield of rice recorded under SRI was 21.45 quintals per hectare as compared to 17.10 q ha-1 for TRP.[37]

iii. Encourage the cultivation of value-added maize cultivars such as popcorn, baby corn, and sweet corn, suitable for different ecological zones, as rising temperatures are beneficial to maize.[38] Initiate crop diversification by popularizing indigenous varieties such as buckwheat, maize, paddy, soybean, rajma, rice bean, and urd, which are climate-resilient. Cultivation practices need to be improvised through the introduction of newer technologies and setting up fixed packages and practices of these landraces[39] for their crop production.

iv. Undertake a large cardamom rejuvenation program through the control of disease and pests. Involve ICAR, Spices Board, etc., with a special focus on identifying emerging diseases and production of quality plant material including tissue culture.[40]

Figure 4.1



Graph System productivity (MEY) and production efficiency (PE) of maize-pea cropping systems under different tillage practices and organic N sources

v. Continue the ginger disease management program to control pests and diseases through biological and organic interventions.

[35] https://krishijagran.com/news/need-to-adopt-high-yielding-varieties-of-rice-suitable-for-organic-conditions-to-raise-productivity/ accessed on May 8, 2020

[36] http://www.icarneh.ernet.in/nicra/Achievements%201/Achievements_under_NICRA.pdf

[37] https://www.researchgate.net/publication/265211706_Enhancing_Rice_Oryza_sativa_Productivity_through_Demonstrations_of_SRI_Method_of_Cultivation_in_Mid-Altitude_Region_of_Indo-Himalayan_Belt_of_Sikkim

[38] https://www.researchgate.net/publication/325035576_Crop_Diversification_and_Intensification_for_Enhancing_Livelihood_Security_in_Sikkim/link/5af28badaca272bf4259de96/download accessed on May 6, 2020

[39] A landrace is a domesticated, locally adapted, traditional variety of a species of animal or plant that has developed over time, through adaptation to its natural and cultural environment of agriculture

[40] http://www.indiaenvironmentportal.org.in/files/file/Large%20Cardamom%20Farming%20in%20Changing%20climatic%20and%20socioeconomic%20conditions.pdf

Example: Ginger, cultivated widely in Sikkim, is one of the most important cash crops, especially for marginal and small farmers. Rhizome rot is a major problem in its cultivation, causing severe losses to farmers. Farmers in Phongla village, South Sikkim, who once were prominent ginger growers, gradually switched to other crops. Ginger almost vanished from their cropping system. After the establishment of KVK South Sikkim in 2007 at Namthang, farmers' clubs were formed in many villages, to disseminate modern organic technologies and revive highly remunerative crops, including ginger, in the area. The Phongla Farmers' Club was supported with 12 quintals of ginger seeds, worth INR 39,000, in May 2009 to ensure proper monitoring and timely treatment. The farmers were advised to undertake cluster cultivation in 0.3 hectares of land.

Technologies applied in the field were the treatment of quality seeds with Bordeaux mixture (1:1:10)[41], seed solarization (covering seeds with plastic sheets and keeping them in direct sunlight for five to six hours to kill seed-borne diseases), and the application of Effective Microorganisms Fermented Plant Extract (EMFPE)[42]. This treatment not only successfully controlled all types of rot but also eradicated disease inoculum from the fields.

A field day – a day of crop-cutting experiments – proved highly beneficial to farmers. With proper management, 0.3 hectares of land yielded 96 quintals of organic ginger valued at INR 144,000, a gain of approximately INR 140,000 excluding labor costs.

NABARD recognized the novel efforts of Phongla Farmers' Club by naming it the second-best Farmers' Club in Sikkim and nominating it for a national award. In the following season, 96 quintals of ginger rhizome were replanted in April 2010. The entire cultivation management was overseen by the Phongla Farmers' Club and monitored by KVK South Sikkim. The Club assured the supply of 400 quintals of disease-free ginger seeds to the Horticulture and Cash Crops Development Department for the next season. The efforts of Phongla Farmers' Club and the direction provided by KVK South Sikkim paved the way for the reintroduction of ginger as a cash crop in Phongla village after a hiatus of over a decade.[43]

Figure 4.2

vi. Intensify the Sikkim mandarin orange rejuvenation program by providing technological and input support, which can include budded plants for early fruiting, drip irrigation, mulching, etc.

Example: The Sikkim mandarin (Citrus reticulata Blanco) is one of the choicest table fruits. It is cultivated in an area of 6,300 hectares, with an estimated production of 17,190 metric tons and productivity of 1,664 kilograms per hectare. South Sikkim has 925 hectares under mandarin cultivation, with the production of 1,740 quintals and productivity of 1,881 kilograms per hectare. Despite South Sikkim's congenial climate for mandarin cultivation, most orchards are declining due to poor nutrient management, and improper disease and pest management.

[41] **Bordeaux mixture** is prepared by **mixing** 1 kg of copper sulphate and 1 kg of lime in 10 liters of water.

[42] EMFPE of garlic + onion leaves + cannabis sp. leaves + wild poisonous plant leaves in mixture of cow urine + EM solution + extract after washing polished rice + alcohol + water in a ratio of 1:1:1:1:1:15.

[43] https://www.sikkimorganicmission.gov.in/success-stories/ accessed on May 10, 2020

To revive these orchards, packages of organic technologies were demonstrated by KVK South Sikkim in a 15-hectare area of Turuk village in South Sikkim. Methods for pruning unproductive plants, on-farm production of compost and vermicompost, preparing cow pat pits for pasting the tree trunks, and using pheromone traps for fruit flies were demonstrated. Critical inputs such as pruning saw pheromone traps for controlling fruit flies and light traps for white grubs were provided for the farmers.

The demonstration and practice of the technologies in the field have been fruitful. The trees have shown increased growth, production, and quality of fruits, and a drastic reduction in fruit drop due to fruit flies. The total cost of rejuvenation for the 15-hectare orchard was INR 427,000, including all inputs and labor. The net return from the orchard was calculated at INR 2,000,000, which meant there was a significant increase in yield and the cost-benefit ratio was 1:4. This program encouraged other farmers to adopt integrated organic management to improve the productivity and profitability of organic plantations.[44]

vii. Study the impact of climate change on orchids, and introduce appropriate adaptation strategies, viz. ascertain new production centers and encourage the growing[45] of other flowers of high value by taking advantage of the changing climate.

Figure 4.3

viii. Achieve self-reliance in the production of quality organic seeds, which are also moisture stress-resistant, by developing infrastructure for storage and seed testing in every district, and training farmers to produce quality seeds that can be certified to minimize dependence on outside sources.

Example: Indigenous knowledge plays a major role in helping farmers save a large quantity of stored grains and seeds, and avoid around 10 to 20 percent loss every year from insect and pest damage. Traditional storage structures were scientifically based, and are still being used by the Lepcha and Limboo tribes. Since these ITKs

[44] https://www.sikkimorganicmission.gov.in/success-stories/

[45] https://icar.org.in/content/blooming-orchid-cultivation-integrated-hill-farming-system-sikkim accessed on May 9, 2020

(Indigenous Traditional Knowledge) are eco-friendly and location-specific, proper documentation, scientific validation, and refinement with modern technical knowledge is essential to conserve them and use them effectively for sustainable crop cultivation. ITKs are cheap, easy to adopt, locally available, and can reduce the input of chemical pesticides in the food chain and environment.

Figure 4.4

Source Indigenous methods of grain storage followed by the Lepcha and Limbo tribes in Himalayan Tribes of Sikkim

Most storage structures in Sikkim are made of bamboo in combination with mud, wood, wheat straw, cow dung, etc. The preference for bamboo over modern materials may be due to its abundant availability and low cost. The materials and techniques used for storage are in line with the concepts of organic farming and do not involve the use of chemicals.[46]

ix. Make crop insurance mandatory through Kisan Credit Card and encourage the taking of crop loans to insure crops.

The Government of India launched the Pradhan Mantri Fasal Bima Yojna (PMFBY) to cover all farmers in the country, including those who grow commercial and horticultural crops. The scheme is being implemented on an area approach basis. It envisages defined areas for each notified crop, with the assumption that all insured farmers in a unit of insurance face similar risk exposure, incur a more or less identical cost of production per hectare, earn comparable farm income per hectare, and experience similar extents of crop loss.

Example:

Protecting livelihoods against climate risks through index-based insurance: Index-based insurance mechanisms are an innovative way to address climate impacts on poverty, notably in rural contexts, and increase the

[46] Indigenous methods of grain storage followed by the Lepcha and Limboo tribes in the Himalayan tract of Sikkim https://www.researchgate.net/publication/336369065_Indigenous_methods_of_grain_storage_followed_by_the_Lepcha_and_Limbo_tribes_in_the_Himalayan_tract_of_Sikkim/link/5d9dfa7ba6fdcc04fac5d74a/download

resilience in agricultural systems. They have the potential to help protect livelihoods against climate risks, for example, when small-scale farmers suffer losses from climate shocks. In addition, they can help lift people out of poverty traps.

A key example of an index-based financial risk transfer product is weather index insurance. It is linked to the occurrence of a weather event (e.g. rainfall, streamflow, or temperature), rather than to the actual consequences of weather, such as crop failure.

This subtle distinction resolves a number of fundamental problems that make traditional insurance unworkable in rural parts of developing countries. A key advantage is that transaction costs are low. As insurance is not based on actual losses but paid out if the rainfall amount is below an earlier agreed threshold, the insurance company does not need to visit fields to determine premiums or assess the damage. Index-based insurance is being tested for poverty reduction and climate change adaptation in countries such as Bangladesh, China, Ethiopia, India, Malawi, Morocco, Mexico, Peru, and Tanzania.

4.2 Livestock

Background: Livestock is an important component of mixed farming in Sikkim, and dependence on this alternative source of income is significant. The consumption of meat is relatively high in this region, and that of milk and milk products is low.

During the past several decades, the contribution of agriculture and allied sectors to the country's GDP has declined. On the other hand, the contribution of livestock to farm GDP has been increasing. It increased from 24 percent in 1992-93 to 28 percent in 2002-03. Sikkim reflects the trend, with the share of livestock increasing from 15.5 percent to 17.5 percent during this period (see table below).

Table 4.2 Contribution of livestock to agriculture

State	1992-93			2002-2003		
	Share of agriculture in SDP (%)	**Share of livestock in agriculture VOP %**	**Per capita income (Rs)**	**Share of agriculture in SDP (%)**	**Share of livestock in agriculture VOP %**	**Per capita income (Rs)**
Sikkim	32	15.4	8,500	20.4	17.3	12,374
India	29.2	24.1	8,222	21.4	27.6	11,977

Source: National Accounts Statistics, CSO, GOI

The dependency of Sikkim on livestock, either as an additional source of income or for personal use, can be understood by the percentage availability of livestock in large, medium, small, and marginal families – above the national average in all sections (see table below). Only the landless section of Sikkim's population falls below the national average in terms of access to livelihood assets.

Table 4.3 Percentage of households with access to livestock assets in Sikkim

States	Landless	Marginal	Small	Medium	Large	All
Sikkim	6.2 %	64.4 %	95.3 %	97.7 %	100 %	61.6 %
India	23.5 %	54.5 %	83.3 %	89.3 %	92.5 %	56.0 %

Source: Unit level data of NSS, 54th Round 1998

Livestock production in Sikkim is predominantly the endeavor of small producers. Small and marginal farmers own nearly 85 percent of livestock and poultry, even though they own or operate less than 55 percent of farmland and practice mixed crop-livestock farming. Poultry holding (backyard poultry) by marginal and small farmers is 90 percent, with 3-14 birds per household. Some 80 percent of the state's sheep population is in North and West Sikkim. Sheep are kept for meat and wool, and goats for meat. Pigs are kept mostly by tribals, and their meat is favored by the local population.

In terms of the adoption of crossbreed varieties, Sikkim has shown the highest growth among northeastern states. The proportion of cattle and pig crossbreeds has increased from 22.7 percent and 18.2 percent to 51 percent and 50.44 percent, respectively, between 1992 and 2003.

4.2.1 Impact of climate change on the livestock sector in Sikkim

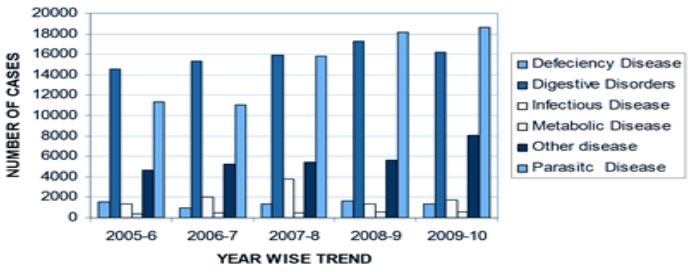
Warmer and wetter weather (particularly warmer winters) will increase the risk and occurrence of animal diseases, because certain species which serve as disease vectors, such as biting flies and ticks, are more likely to survive year-round. Some existing parasitic diseases may become more prevalent, or their geographical range may spread if rainfall increases. This may contribute to an increase in disease spread, including zoonotic diseases.

The disease investigation cell has observed a rise in reproductive disorders such as retention of placenta and greater infertility, parasitic diseases and vector borne diseases. Infertility cases are mainly due to mineral deficiency. Animal diseases constitute a major constraint in livestock production and the safe utilization of animal products. For the poor, the impact of livestock disease on livelihoods is particularly severe: an outbreak can mean the difference between sufficient food stocks and food insecurity, and between having a secure income to the loss of key household assets.

4.2.2 Adaption strategies for the livestock sector in Sikkim

Figure 4.5

Considering the dependence of small and marginal farmers on ruminants, concrete strategies must be put in place to climate-proof livestock health, dairy products, and other livestock products. Some strategies suggested are as follows:



Graph; Disease profile of Livestock in Sikkim. Source: AH,LFVS Annual Report 2009

a) Strengthen the disease investigation system through the study of causes of prevalent diseases that are escalating and also emerging diseases, and devise methods to arrest them.

b) Undertake preventive health measures to control and contain existing epidemic diseases. The department needs to prepare a long-term strategy to ensure that the entire livestock population is regularly vaccinated. Animal health camps need to be set up periodically to make people aware of different control measures.

Example:

There are five veterinary Hospitals, 14 dispensaries, one veterinary polyclinic, and 60 artificial insemination centers in Sikkim. However, more such facilities need to be developed, with special emphasis on the eradication of the most prevalent diseases in the state.

c) Improve cattle sheds and feed management practices at the farmer's level to improve hygiene, protect animals from exposure to heat, and curb methane emissions.

Example:
The demand for goat meat in East Sikkim is around 3,650 metric tons per year, but production is around 600 metric tons. The gap is met by importing meat from West Bengal. The government promotes stall-fed conditions, as goat grazing causes massive ecological damage.

d) Conserve threatened indigenous livestock species by undertaking appropriate programs, and create the infrastructure for establishing embryo transfer technology for these breeds.

Example:
The Sikkim livestock board and the state implementing agency under the national project for cattle and buffalo breeding aim to upgrade indigenous animals up to 50 to 62.5 percent exotic blood level using the jersey breed. However, when it comes to traditional practices of rearing dairy animals, out of 46,000 animals in south Sikkim, 49 percent are indigenous cows.

e) Encourage the production of leguminous fodder crops, which require less management and are produced through the mixed crop system.

f) Establish farmer-centered fodder banks to combat winter shortages. Undertake mineral mapping in different regions to assess the mineral status and supply specific mineral mixtures to farmers.

g) Improve the quality of milk by establishing milk cooling facilities at strategic locations. Improve facilities at Jorethang and Gangtok dairy plants for conducting bacteriological tests.

h) To sustain farmers' incomes through the mixed farming system, encourage sustainable poultry and pig farming.

Example: In East Sikkim, under the centrally sponsored scheme of the Entrepreneurship Development and Employment Generation (EDEG) component of the National Livestock Mission for 2018-19, a subsidy of 50 percent of the eligible total financial outlay (TFO) is available for SC/ST and BPL beneficiaries, and a subsidy of 35 percent is available for APL beneficiaries for taking up poultry activity. There are three poultry breeding farms and one hatchery unit in East Sikkim.

Example:
The ICAR Research Complex for the NEH Region, Sikkim Centre, Tadong, intervened by introducing Vanaraja dual-purpose improved backyard poultry birds through the Poultry Seed Project of the Directorate of Poultry Research, Hyderabad, under the Tribal Sub Plan. The performance of the improved poultry birds was significantly better than that of the local variety in respect of average body weight of males at three months (2.4 kg), the average body weight of females at three months (1.7 kg), the average age at first laying (150-155 days), average egg production (150-170 per annum) and the benefit-to-cost ratio (1.93).

i) Capacities within the department should be developed to gain knowledge on climate change and advise farmers on adaptation practices. Training centers need to be strengthened with all the facilities needed to train farmers and field staff.

Example:
Akash Subba, son of Purna Subba, is a resident of the 9th mile under Marchak Gram Panchayat Unit, East Sikkim. Encouraged by the availability of training, subsidy on day-old chicks, and organized marketing through the Denzong Cooperative Society, he started with 1,000 units of broiler birds in his premises in January 2010. He has since expanded his farm capacity to 5,000 birds. With his capability and departmental intervention, he has made remarkable progress in a short period. Subba has been producing 1,000 to 1,500 broiler birds per batch and

averages four batches a month. He consistently supplies broiler meat to the Denzong Co-operative Society, for consumption by military personnel. His net profit is around INR 15,000 to INR 20,000 per batch, averaging INR 60,000 to INR 80,000 per month.

4.3 Water

Background: Sikkim depends on springs and streams to meet its water demand. Himalayan mountain springs such as Mohaan, Kuaan, and Dhara are the main sources of water for 80 percent of the rural population, for drinking and irrigation. Due to the terrain, piped water cannot be transported to remote villages, nor can canals be dug for water to reach every farming plot.

A wealth of traditional knowledge exists regarding water conservation and management. Water sources were preserved traditionally as Devisthan and protected from biotic interferences. However, mountainous regions, ridge-top locations, rain-shadow areas, and places with little or no forest cover in upper catchments are vulnerable areas that face drinking water scarcity during the lean season.

Research shows that 10 of the state's 26 blocks are drought-prone. They fall fully in the rain shadow of the Darjeeling Himalayas, located in the gorge of the Teesta and Rangit rivers, and having steep and rocky terrain with little or no forest cover in the upper catchments.

These drought-prone areas lie in the lower belt of East, South, and West districts. They include Duga, Rhenock, and Khamdong in East Sikkim, Namthang, Melli, Jorethang, and Namchi in the South, Soreng and Kaluk in the West, and a few parts of the North district comprised of sal and middle hill forests. Availability of water may be highly variable, with water available in the monsoon, and none in the winter months. Water becomes available through extreme precipitation. Appropriate planning is needed to address this concern, and ways must be found to trap some of the water flow when it rains**.**

Table 4.4 Water deficiency comparison between South and East Sikkim

East Sikkim	South Sikkim
Total geographical area: 96,000 hectares	Total geographical area: 75,000 hectares
Cultivable area: 31,900 hectares (33.2 %)	Cultivable area: 38,581 hectares (51.44 %)
Gross irrigated area: 5,245 hectares	Gross irrigated area: N/A
Net irrigated area: 2,105 hectares	Net irrigated area: 2,532 hectares
Rain-fed area: 15.5 hectares (0.73%)	**Rain-fed area: 10.5 hectares (0.41%)**

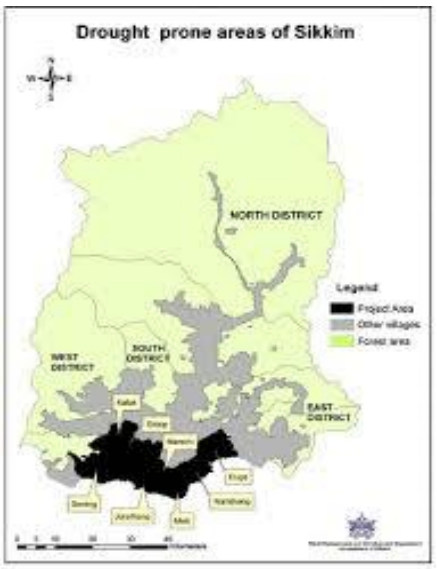
As per NABARD's Potentially Linked Plans (PLPs) for South and North Sikkim for 2019-20, there is huge scope for the promotion of efficient water utilization in farming through building water harvesting structures and drip/sprinkler irrigation. Public and private intervention in promoting these techniques should be accelerated.

4.3.1 What does adaptation mean for Sikkim's water sector?

To ensure water security and adapt to climate change, water resources management must incorporate climate change considerations for future risks and uncertainties. Extreme weather events such as droughts and floods, and higher rainfall variability, will exacerbate the vulnerability of livelihoods. Therefore, incorporating adaptation measures into water resource management is vital, particularly in semi-arid to arid areas such as South Sikkim.

Proven and established measures should be adjusted to changing conditions. At the same time, new approaches need to be developed. Climate data and models have been instrumental in highlighting general changes in the water cycle that are triggered by climate change. Uncertainty makes it difficult to translate trends, such as higher rainfall variability, into quantitative terms that could serve as a basis to develop concrete water management strategies and measures.

Figure 4.6



Therefore, mapping vulnerability and assessing its underlying factors are crucial steps to identify the policies and measures needed to reduce vulnerability, increase adaptive capacity, and highlight options for adaptation. Key priorities for initial action in the water sector include:

- Addressing current and expected water scarcity problems
- Dealing with floods and other extreme events
- Expanding the knowledge base on water resources
- Dealing with exposure to climate change and impacts
- Strengthening the national capacity for integrated water resources management and planning.

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

Adaptation by increasing water supply and ecosystem services

a) Expansion of **rainwater harvesting to improve rain-fed cultivation and aquifer recharge**, *archiving and disseminating traditional water management practices, focus on the role of forests in rainwater recharge, artificial recharge to revive springs by harvesting rainwater, reviving dried hilltop lakes, increasing base flow of critical streams by rainwater harvesting.*

b) Increased **storage capacity** by building reservoirs *(Increasing water storage capacity by building household, community, and village level reservoirs)*

Adaptation by decreasing water demand and increasing water use efficiency

a) Improvement of water use efficiency by water recycling, *exploring the opportunity of harnessing stream water for household and irrigation needs, reutilizing wastewater from industries*

b) Improved management of irrigated agriculture, e.g. changing the cropping calendar, crop mix, irrigation method and repair and maintenance of irrigation infrastructure, developing an a*ccelerated irrigation benefit program*

c) Expanded use of economic incentives to encourage water conservation

d) Improvement of urban water and sanitation infrastructure, d*evelopment of water regulation policies while mainstreaming climate change strategies*

Adaptation by improving flood protection

a) Construction of flood protection infrastructure

b) Restoration and maintenance of wetlands and lakes

c) Improved dynamic flood forecasting, floodplain mapping, establishing an early warning system, enhancing the understanding of hydrology pattern

4.3.2 Approaches to water management

1) **Integrated water resource management (IWRM):** This 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- and demand-side water resource processes and actions and incorporates stakeholder participation in decision-making.

The IWRM framework encompasses analysis of the costs and benefits of demand- and supply-side management options. It also promotes an open and participatory decision-making process, the development of water resource alternatives that recognize community values and environmental issues which may be impacted by the ultimate decision, and recognition of the institutions concerned with water resources and competing policy goals among them (UNFCCC).

2) **Adaptive water management (AWM):** This is a systematic process for improving policies and practices by learning from the outcomes of implemented strategies. Water management regimes are still shaped by the tradition of a command-and-control approach focusing on technical solutions. The implementation of innovative 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 that 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 behavior, to management interventions. It is important to note that while identifying adaptation options for the water sector, it is crucial to consider the socioeconomic factors that drive the supply and demand of water in a region.

4.3.4 Initiatives for water security in Sikkim

During the lean season, it is natural for local water sources to start drying up since they follow an annual cycle and mirror rainfall patterns. However, local water users say that over the last decade, the lean period discharge of water sources has been declining at an alarming rate. In 42 percent of water sources, it has declined by more than 50 percent over the last decade (see table below). Water sources near the ridgeline are declining faster. Therefore, an integrated, landscape-level approach was adopted by mapping these water resources and reviving dried hill-top lakes, critical streams, and springs. Some experiments taken up over the last few years involve are described below.

Table 4.5 Perception of water users on the percentage decline in the lean season discharge of water resources in drought-prone regions of Sikkim (500-2,000 m)

Elevation	0-25%	26-50%	51-75%	76-100%	Don't know	Total
501 -1000 m	8	23	15	11	2	**59**
1001-1500 m	2	44	17	6	4	**73**
1501-2000 m	0	7	10	1	1	**19**
Total	**10**	**74**	**42**	**18**	**7**	**151**

Understanding springs and preparing the Village Spring Atlas: Resource mapping of the springs on a GIS platform, **Village Spring Atlas,** has been done to better understand this valuable resource. The data has been made accessible online at www.sikkimsprings.org. This database provides information on the location, GPS coordinates, land tenure, catchment status, dependency, discharge (supply/demand) of nearly 700 springs and is also linked to the Google Earth platform.

Analysis of this data by Tambe et al (2012) indicates that the rural landscape is dotted with micro-springs occurring largely in farmers' fields, with an average dependency of 27 households per spring. The spring discharge generally shows an annual periodic rhythm, suggesting a strong response to rainfall. **The mean discharge of the springs was found to peak at 51 liters/minute during the post-monsoon months (September–November) and diminish to 8 liters/minute in the spring (March-May). The lean period (March-May) discharge is perceived to have declined by nearly 50 percent in drought-prone areas, and by 35 percent in other areas over the last decade**.

The spring-shed development program to revive dying springs: The spring-shed development (*Dhara Vikas*) approach further refines the spring sanctuary approach in using geohydrology to identify the recharge area. An incentive mechanism for farmers facilitates the use of private lands and their conservation. The results of the program have been encouraging[34]. **This approach also differs significantly from watershed development (which adopts the catchment approach) in terms of scale, costs, duration, treatment methods, and success indicators. Based on these successful pilots, springs-shed development was added to the list of permissible works of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) national flagship program in 2012.**

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

Background: Dhara Vikas (spring-shed development) is a government-supported program in Sikkim, implemented in partnership with NGOs and other institutions. It aims to increase the discharge of springs in rural Sikkim by protecting the catchment areas that protect and recharge aquifers. The project was conceptualized in 2008-09, was used in capacity building, and implemented in 2010. The Dhara Vikas program is a unique example of decentralized management of natural resources that required community participation.

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

Creating trenches in barren lands and drains in cultivated land gives rainwater more time to percolate. Drains in cultivable land also provide additional water to crops and help catch the soil and the nutrients that have run off from other terraced fields. Decisions related to the digging of trenches and recharge points were based on principles of geohydrology. All work-related decisions were taken up in the panchayat and sorted through village-level discussion.

With an investment of over INR 25 million during 2010-14, Dhara Vikas has resulted in around 900 million liters of annual growth recharge. The program has led to the revival of 50 lakes, and reforestation in and around seven hilltops in Sikkim.

Enhancing the hydrological contribution of hilltop forests: Sloping forest lands above villages are ideal locations to take up groundwater recharge structures such as staggered contour trenches, ponds and check dams in appropriate locations. Locating these trenches and ponds carefully can ensure that each one has a micro catchment and captures sufficient surface flow. A new strategy of creating artificial ponds at depressions and trenches along trekking trails to tap the surface runoff during the monsoon was also tried out (Figure 3). This climate change adaptation initiative also helped lower disaster risk by reducing landslides and damage to private lands downstream.

Figure 4.7

Strengthening water storage infrastructure: With increasing water scarcity during the winter months of February-April, the water storage infrastructure at the household, community and village levels needs to be augmented. It enables farmers to harness the flow of springs at night (which was earlier going to waste). The water that fills these tanks is used in the daytime for domestic purposes, minor irrigation of kitchen gardens and greenhouse crops, etc.

These water storage tanks, with the facility of roof-water harvesting, have helped transform many villages with acute drinking water security. Hundreds of tanks with capacities ranging from 10,000 to 40,000 liters have been built with funds from three national programs, namely MGNREGA, National Rural Drinking Water Programme (NRDWP), and Rashtriya Krishi Vikas Yojana (RKVY).

Figure 4.8

Reviving dry lakes by harvesting runoff from spring water sources: Reviving dry lakes by developing their catchment, desilting to enhance their water-holding capacity, and piping water from water sources has been initiated. Healthy lakes enable adequate groundwater recharge, which in turn supplements the dry-period discharge (baseflow) of springs and streams located downstream. There are quite a few natural dried-up lakes strategically located above drought-prone villages. These lakes were revived by piping runoff from water sources and functioned as recharge structures.

Figure 4.9

Example of Jalkunds: Jalkunds are a suitable technology for providing climate resilience and improving the livelihoods of small and marginal farmers in the Himalayan ecosystem. Almost 70 percent of Sikkim's rainfall is received during the rainy season. Hill farmers suffer from extreme water scarcity from November to March. Rainwater harvesting and efficient utilization holds promise for sustainable livelihoods in the hills. Jalkunds, a type of micro rainwater harvesting structure, help hilltop farmers in small-scale agricultural activities. Water stored in jalkunds can be utilized for multiple purposes, e.g. irrigating crops, rearing livestock, and domestic use.

4.3.5 Way forward for water security in Sikkim

The sustainability of springs and streams is vital to ensure water security in Sikkim, especially in the face of environmental change precipitated by a changing climate that brings with it longer winter droughts and intensive precipitation patterns, developmental interventions such as road networks, and changes in catchment land use and habitat quality. **There is a need for more studies on springs and streams, more detailed weather data, demand-side assessment of water availability status across spatial and temporal scales, and water supply and distribution systems**.

- **Leveraging funding from ongoing national programs:** Such programs can be leveraged to scale up initiatives to enhance rural water security. These programs include the Mahatma Gandhi National Rural Employment Guarantee Act, National Rural Drinking Water Mission, Integrated Watershed Management Programme, Rashtriya Krishi Vikas Yojana, etc (see table below).

- **Decentralized planning:** There is a need to pilot the preparation of village water security plans that will analyze the types of water sources available, their discharge patterns and location, demand-side analysis, design water supply systems in a participatory manner, and improve water use efficiency. These measures can help to shift from a top-down, contractor-driven approach to a bottom-up, people-driven one. This will result in a more sustainable and need-based preparation of village water security plans for the future and is the way forward.

Since rainwater is the only water available in villages in the mid-hills of the Himalayas, and since it is an increasingly uncertain resource, solutions will lie in storing it either above the ground in natural or artificial reservoirs, or underground in natural aquifers. Traditionally, afforestation was the main thrust in forests lands, but now there is a need to manage mountains as "water towers" by enhancing their groundwater recharge contribution, which will help both upstream and downstream communities by reducing flooding during the monsoons and increased base flow during the lean season. Ongoing national programs can be leveraged to fund these climate change adaptation initiatives. Scientific planning, a bottom-up approach, and building local capacity are the key challenges for the future.

Table 4.6 National programs to enhance rural water security in Sikkim

CCA initiative	*Type of activity*	*National programs facilitating mainstreaming*
Spring-shed development	Participatory planning, trenches, ponds, check dams, terracing of sloping lands, etc	MGNREGA, IWMP
Watershed development on hilltop forests	Participatory planning, trenches, ponds, check dams, etc	MGNREGA, IWMP
Revival of lakes by piping water from perennial water sources	Water supply pipeline, drainage structure to connect perennial water sources to lakes	MGNREGA, IWMP, NRDWP
Water storage tanks	At household, community, and village levels, with water from rooftops and springs during nighttime	MGNREGA, NRDWP, RKVY
Lift water supply schemes	At the village level, from downstream water sources	NRDWP

4.4. Forest

Background: Sikkim has a recorded forest area of 5,841 sq km, which is 82.31 percent of its geographical area (FSI 2009). Protected areas constitute 30.7 percent of the geographical area of the state. The Sikkim Himalayas fall under the Himalayan Bio-geographic Zone and Central Himalaya Biotic Province and have about nine forest types (Champion & Seth, 1968). However, as per Forest Survey of India (FSI) reports, forests in the state can be categorized into six types: Tropical Moist Deciduous, Subtropical Broad-leaved Hill, Montane Wet Temperate, Himalayan Moist Temperate, Sub-Alpine and Moist Alpine Scrub.

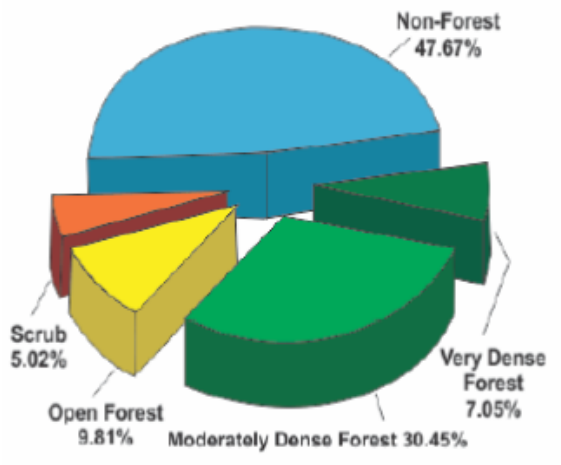
The carbon sequestration of Sikkim's forests is significant in India. Forests are classified as reserved (93.34 percent) and protected (6.66 percent). The Sikkim Himalayas have more than 26 percent of the country's flowering plants and are an important phytogeographical reserve. Sal, bamboo, and orchids are commonly found in the subtropical forests of the state up to a height of 1,520 m. In the temperate region, between 1,520 m and 3,960 m, oak, laurel, chestnut, rhododendron, fir, maple, and spruce are predominantly found. The higher elevations are the Alpine tundra. More than 4,000 plant species, including magnolias, blue poppies, gentians, and primulas, are found in Sikkim. The state's rich biodiversity suggests it has huge potential for developing eco-tourism.

According to the FSI, the area under dense forests seems to have marginally declined between 2001 and 2003, and then increased from 2003. The area under scrub vegetation also increased from 2001 onwards, but decreases from 2005 onwards.

Table 4.7 Forest Statics for Sikkim

Forest type in (Sq Km)	**2001**	**2003**	**2005**	**2007**
Dense forest	2,391	2,362	2,410	2,561
Open forest	809	900	852	696
Scrub forest	341	360	363	356
Total	3,435	3,622	3,625	3,713

Figure 4.10 Forest Cover of Sikkim (as per type)



Source India State of Forest Report 2019 Sikkim

Table 4.8 District-wise forest cover in Sikkim (2019)

	District	Total forest 2005 (Sq Km)	Total forest 2007 (Sq Km)	Change (Sq Km)
Sikkim	East Sikkim	679	699	20
	South Sikkim	529	571	42

Source India State of Forest Report 2019 Sikkim

4.4.1 Impacts of climate change on forests in Sikkim

Changes in geographic distribution of flora and fauna: Some birds, insects, mammals, and plants, including the snow leopard, are already showing changes in their geographic distribution, and have moved north or to higher altitudes in response to the observed changes.

Example: Butterflies are considered indicators of ecosystem change, and are useful in predicting environmental alterations (Chettri 2010a; Rákosy and Schmitt 2011). Due to their specific ecological requirements such as temperature, humidity, food plants, and egg-laying habitats, they are most likely to get affected by global climate change (Forister and Shapiro 2003; González-Megías et al. 2008)

In the Sikkim Himalayas, butterflies already indicate signs of climate change. Many species have extended their distribution in response to the changing climate. Most butterflies have narrow elevation ranges. Hence, the upward extension has further contracted their ranges making them more vulnerable. Upward range shift and contraction of the elevational and latitudinal range of butterflies have been observed in different parts of the world (Parmesan et al. 1999; White and Kerr 2006; Wilson et al. 2007; Forister et al. 2010)

Changes in the timing of seasonal events[47]**:** Phenology is the study of changes in the timing of seasonal events. As temperatures increase, spring and summer events take place earlier in the year. Evidence includes leafing, fungal fruiting, bird egg-laying, spawning of amphibians, the arrival of migrants, and insect emergence. Autumn events are occurring both earlier and later in the year, and the trends are less clear.
Changes to abundance and habitat preference: Climate change can also cause changes in habitat preference. For example, the red panda, Sikkim's state animal and, according to the International Union for Conservation of Nature (IUCN) ranking, a vulnerable species, may experience a change in habitat as its preferred habitat, the temperate ecosystem, starts shrinking.
Threat to high-altitude wetlands of Sikkim: Climate change, triggering glacier melt and erratic precipitation, may change the amount, duration, and time of runoff from glaciers, leading to an altered hydrological cycle, and hence altering the aquatic biota, physical and chemical habitat, and resource availability.
Increase in incidences of forest fires: As the climate warms, the soils are likely to be drier in the summer months, leading to less evaporation, less recycled moisture in the atmosphere, and hence less rain during summer. (Overpeck et al. 1990).
Impact on livelihoods: Climate change leads to degraded biodiversity of forests, and is likely to impact the quality and quantity of forest products. This could adversely impact the associated livelihoods of communities. Forest-based livelihoods and products include ecotourism, apiculture, sericulture, medicinal plants, cane, bamboo for small-scale cottage industries, and natural fibers.

4.4.2 Approaches for climate change adaptation in the forest sector

How can community forest management contribute towards adaptation to climate change in the Indian Himalayan Region (IHR)?
Community forestry is a branch of forestry that deals with forest management in a way that not only helps conserve forests but also helps enhance household income from timber and non-timber forest products (NTFPs). In addition, community forestry helps augment ecosystem services for local communities and beyond.
Joint forest management involves not only the forest department but also local-level institutions and to some extent NGOs. It helps make local communities aware of the fragility of forest resources and enables them to contribute towards the regeneration and protection of degraded forestlands. It empowers locals in the forest management decision-making process.

Example: The **Van Panchayats (VPs)** of Uttarakhand are among the oldest examples of participatory forestry institutions in India. Presently 12,089 of them manage about 16 percent of the state's total forest area. Despite their success, VPs have been facing challenges such as lack of adequate financial resources and appropriate incentives, signaling the need for policy, institutional and financial intervention (Negi and Dhyani, 2012).

There are diverse **traditional community forestry systems** and institutions in the northeastern Himalayan states. Large areas of forests are protected for practicing shifting agriculture (Jhum). Smaller areas of forests are also protected as sacred groves, such as those of the Khasis and Jaintias of Meghalaya. In Arunachal Pradesh, there are Anchal reserved forests protected for the livelihoods of the community that earn from the sale of forest products (Negi and Dhyani, 2012).

These community forest management practices have direct relevance to adaptation to climate change. They facilitate the conservation of, and increase in, forest cover and natural resources, and strengthen the socio-economic status of local communities. Ultimately this translates into an increased adaptive capacity of local communities to the threats of climate change.

How REDD+ can help in climate change adaptation: Reducing Emissions from Deforestation and Forest Degradation (REDD+) in developing countries is a process to pass on financial incentives to communities for halting deforestation and encouraging forest conservation, thereby enhancing forest carbon stocks. Forest-dwelling communities in India have successfully transformed the deteriorating state of their natural forests through sustainable management, thus avoiding deforestation and the subsequent release of CO_2 emissions into the atmosphere (UNFCCC, 2018).

[47] Climate Change and Alpine Flora in Himalayan Sikkim

The implementation of REDD+ activities can maintain and enhance ecosystem services important for the 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 contribute to the enhanced adaptive capacity of the communities.

Example[48]: *The Partnership for Land Use Science (Forest-PLUS) in Karnataka*

The Partnership for Land Use Science (Forest-PLUS) is a collaboration between USAID and the Government of India to reduce deforestation and forest degradation and their consequences. Together with **the Karnataka Forest Department, they have developed GIS and remote-sensing tools, techniques, and methods to manage forested landscapes for climate change mitigation, biodiversity, livelihoods, and environmental services i**n Shimoga District as a model for other forested landscapes. Together Forest-PLUS and Karnataka Forest Department (KFD) have estimated and verified the 2001-14 trends in forest carbon, forest condition, land use, and land cover across 305,500 hectares. The work uses advanced remotely sensed (RS) models and analysis protocols that yield high-resolution maps of these trends.

The Forest-PLUS partnership with KFD also trains KFD staff in forest management for REDD+ and incorporates this instruction into Karnataka's forestry schools. This training includes collecting and analyzing forest data, designing interventions, writing field interventions into landscape management plans, and monitoring results for adaptive management.

What is an ecosystem-based adaptation (EbA)? It 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 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 of, and multiple social, economic, and cultural benefits for, local communities. This approach helps improve ecosystem functioning and secure the provisioning of ecosystem services. EbA is considered an efficient, sustainable, and low-cost approach to improve the resilience of communities and reduce their vulnerability to 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 cost less. Additionally, it would provide co-benefits such as increased biodiversity to the ecosystem and the communities. This is an example of a no-regret and 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 benefits 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).

Example: [49]

Motadaka and Nidumukkala villages in Andhra Pradesh are the best examples of successful and efficient forest management. Their involvement led to their social, economic and cultural development. Before 1995, these villages were underdeveloped and seeking government funds.

[48] http://ioraecological.com/success_stories/redd-in-karnataka-india/

[49] http://www.fao.org/3/XII/1023-C1.htm

Two schemes were sanctioned in these villages since they are near forests: **Joint Forest Management and Vana Samkshrana Samithi**. The table below provides some details.

Table 4.9

Joint Forest Management:					
Village	Area in sq km	Families	No. of employees	Fuel wood	Income
Motadaka	160	70	40	3.5 kg	$ 0.9
Nidumukkal	235	62	36	2.5 kg	$ 1.2
Vana Samrakshana Samithi:					
Village	Area in sq km	Families	No. of employees	Fuel wood	Income
Motadaka	66	20	8	2 kg	$ 620
Nidumukkal	82	32	10	2 kg	$ 580

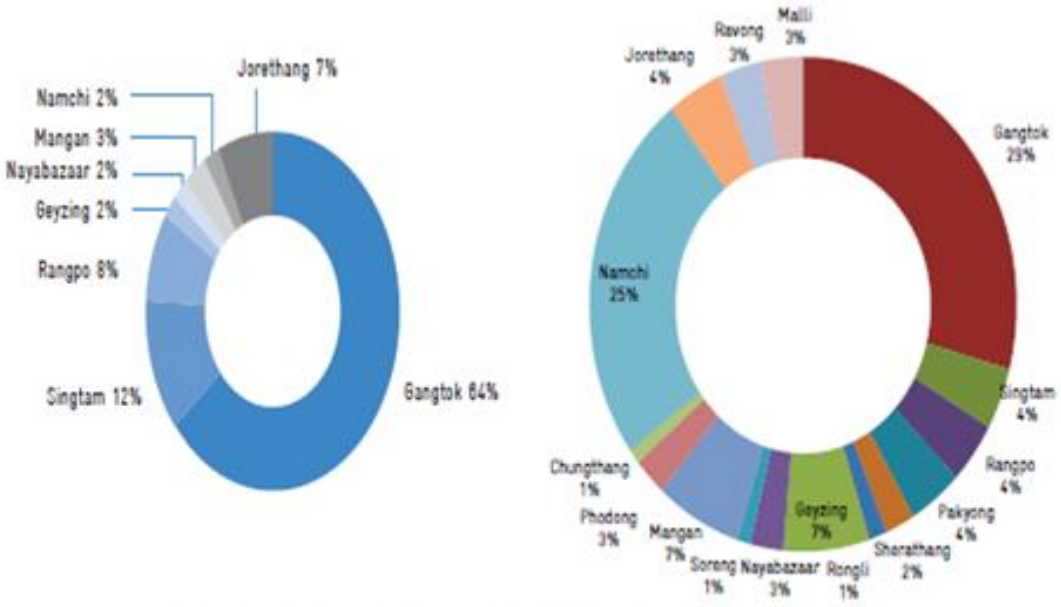
With the above example, the efficient management of the forests by the people and for the people has generated employment and incomes for the people who depend on the forests. Due to this, there is

- The ratio of expenditure on food items in total income increased.
- School enrolment increased, particularly the enrolment of girls.
- The villagers have established an adult literacy center. As a result, the number of visitors to the local library has increased.

4.4 Urbanization and disasters in Sikkim

Overview of urbanization in Sikkim: The state has four districts (North, South, East, and West), with a total population of 540,851 as per the 2001 Census. Despite a considerable increase in development activities which resulted in rapid urbanization and therefore an increase in urban population, only 0.05 percent of the state's total area is under urban use, with just over 11 percent of the population inhabiting its nine urban centers.
The gross density of the population in the state averages 76 persons per sq km. However, the density varies drastically. For East Sikkim, it is 297 persons per sq km, and for South Sikkim, it is 200 persons per sq km.
The total population of Sikkim was 137,725 in 1951. The rates of growth in 1951 and 1961 were roughly 1.9 percent and 4.2 percent respectively but saw a huge leap in 1981 with a decadal growth of 16.15 percent. The 2001 census recorded decadal growth of 11.07 percent.
Projected trends in urbanization: The State Strategic Urban Plan looks at developing a total of 16 urban centers by 2040, which includes the current nine centers. The proposed plan positions Gangtok and Namchi as parallel first-tier urban centers, with the two district headquarters of Geyzing and Mangan as second-tier urban centers in the West and North districts.
By 2040, the state's urban population is expected to more than double, from close to 200,000 to roughly 550,000. It needs to be noted that as per the 2001 census, the urban population of Sikkim was only 60,000, but as per the estimates of the Urban Development and Housing Department, the population of Gangtok is currently is 150,000 as against the 2001 Census Data of 30,000.

Figure 4.11 Overview of disasters



Population Projections Current (2001 Census) V's 2040 Sikkim; Sikkim Source CDP Sikkim

A 2012 study to prepare a multihazard disaster map for East Sikkim, covering all types of disasters, such as flash floods, landslides, fires, snow avalanches, drought, etc, **put nearly 80 percent of Gangtok municipal area in the medium to high-risk zone** (see table below).

Disasters such as **landslides,** mostly triggered by excessive rainfall attributable to climate change, are already a major threat in Gangtok city, **with more than 65 percent of the city's area and around 60 percent of its buildings in the medium to a very high-risk category** (see table below).

The National Institute of Disaster Management (NIDM) research ranks hazard vulnerability and zoning across India[50] based on six parameters: slope, land use, rainfall, geology, geomorphology, and tectonics. According to this research, the 11 Himalayan States (Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, and the seven northeastern states) and 2 Western Ghat States (Kerala and Goa) account for 88.6 and 98.7 percent of the total area under landslide Zone-IV and V of the entire country. **Sikkim, with a Landslide Hazard Index of 7.78, is India's second most landslide-prone state** after Mizoram (8.15)

[50] https://www.ndmindia.nic.in/images/gallery/scorecard1.pdf accessed on May 17, 2020

Figure 4.12 Multi-hazard and landslide vulnerability matrix for East Sikkim

Risk Matrix Chart

	Frequency /Likelihood						
5		EVERY YEAR		RIOTS			LANDSLIDE
4		2-10 YRS				FIRE	
3		11-20 YRS					EARTHQUAKE
2		21-30 YRS		DROUGHT		FLASH FLOOD	
1		31-50 YRS	HAILSTROMS, SNOW & AVALANCHES				
Score Of likely-hood		**Score of Impact**	**1 TO 7**	**8 TO 14**	**15 TO 21**	**22-28**	**29-35**
			Severity/ magnitude of damage				

Landslide Hazards

Hazards Category	% of Area	% of Household	Risk type
Very High Hazard	2.17	1.52	Very High
Medium High Hazards	32.97	21.95	High
Medium Hazards	45.00	40.49	Medium
Medium Low Hazards	18.23	33.86	Low
Low Hazards	1.64	3.58	Low

Source: Multihazard Risk & Vulnerability for Sikkim SSDMA[51]

Rapid urbanization coupled with climate change and unplanned development is multiplying factors that will lead to issues such as an increase in energy demand for heating and cooling, worsening air quality, increased risk of floods and landslides, and heat or cold waves. However, the most immediate threats that climate change, and especially increasing rainfall variability, bring is an increase in the frequency of disasters such as landslides, which can destroy houses, roads, infrastructure and human life.

Urbanization generally creates employment opportunities, provides a variety of socio-economic services and contributes to the development of infrastructure, which indirectly leads to socioeconomic growth in the hinterland (Tiwari and Joshi, 2016). However, sprawling and unplanned urban growth in fragile mountains has disrupted the critical ecosystem services, depleted natural resources, increased socio-economic inequalities, and increased the vulnerability of both towns and their fringe areas to a variety of natural risks (Anbalagan, 1993).

Rapid and unregulated urbanization has perturbed the hydrological regimes of Himalayan watersheds, reduced groundwater recharge, and decreased the availability of water for drinking, sanitation, and crop production. It has depleted forests and biodiversity, increased risks of natural hazards and disasters in urban and peri-urban areas, and it has increased the vulnerability of mountain inhabitants to water, food, livelihood, and health insecurity (Patra and Kantariya, 2014).

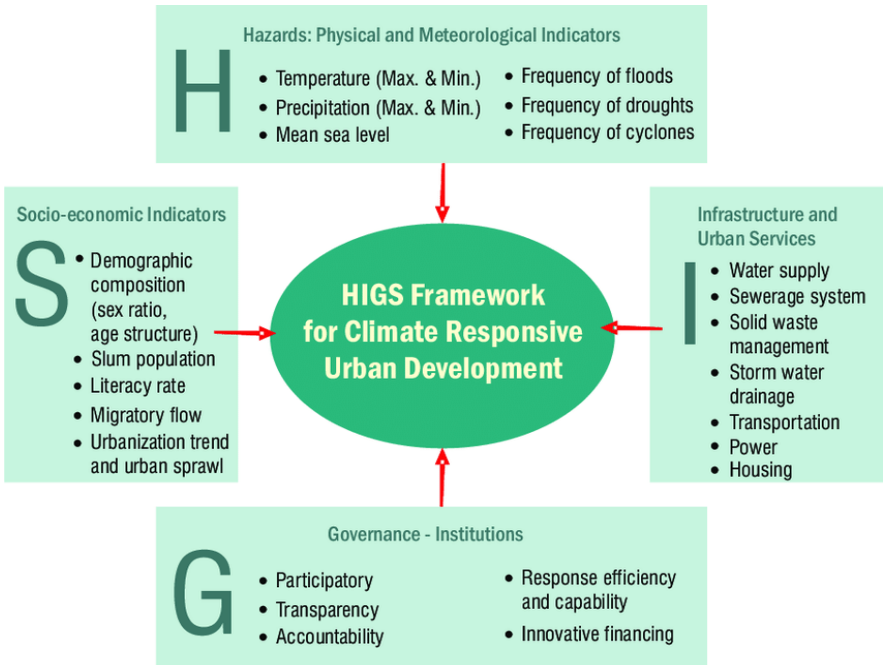
Moreover, climate change has stressed urban ecosystems by increasing the frequency, severity, and intensity of extreme weather events in densely populated Himalayan mountains (Durga Rao et al., 2014; Balk et al., 2009).

[51] http://www.ssdma.nic.in/Uploads/PdfFiles/multi_hazard_risk_and_vulnerability_assessment_of_sikkim.pdf

Environmental impacts of urbanization in the hills of Sikkim

- Most densely populated towns are in tectonically active locations and are therefore susceptible to slope failure and landslides.
- The natural components of the urban fringe zone are being degraded and depleted steadily and significantly through the expansion of urban land use, deforestation, habitat destruction, mining of materials for construction, waste and sewage disposal, and changes in traditional land use and resource

Figure 4.13



- management practices through the multiplier effect of urban growth (Tiwari and Joshi, 2015; 2016).
- Studies indicate that rapid urbanization and resultant land-use intensification have disrupted the hydrological regimes of Himalayan headwaters (Tiwari and Joshi, 2012a; 2012b; Ives, 1989).
- A large proportion of cultivated land and other areas are being encroached upon by rapid urbanization and the expansion of infrastructure, services, and economic activities in the Himalayas every year (Tiwari and Joshi, 2015; 2016).
- The expansion of urbanization and the population increase have led to the emergence and growth of a large number of slums.

Approaches to sustainable urban development in the hills

1. **Comprehensive climate change vulnerability assessment and mapping** should be carried out, taking into account critical parameters of **exposure, sensitivity, and adaptive capacity of the urban ecosystem**.
2. **A comprehensive urban land use policy** should be developed and implemented, taking into account conservation, development, climate change adaptation, disaster risk reduction, and the needs and priorities of towns.
3. **A participatory framework for the conservation of water resources,** particularly through reducing anthropogenic intervention in the urban headwaters, should be developed and implemented.

Framework for developing climate-resilient cities

Climate change is additional stress that only healthy and sustainable cities can deal with. Even under normal circumstances, a city needs to be functioning first. Only after that can resilience be achieved. To understand and analyze climate resilience measures for India's urban centers, we can use a framework based on four themes: **hazards, infrastructure, governance, socio-economic characteristics (HIGS).** The interplay of the four variables is important in understanding priorities and proximate causes of increased climate risks in India.

Findings: Himalayan cities such as Shillong, Dehradun, and Srinagar have a relatively small population. But they face major hazards such as **flash floods and landslides, caused by sudden heavy rainfall and cold waves. Inadequate drainage systems and poor sewage management make it difficult for them to address climate-induced risks**.

4.5.1 Way forward

1. **Climate-conscious development and spatial planning:** If climate change and variability are not proactively addressed, conservation plans will be less effective. Therefore, cities need to identify priority climate-resilient activities that help in adaptation to climate change.
2. **Sustainable urban development** Indicators: Monitoring and measuring service capacity play an important role in analyzing a city's capacity to cope with climate-related hazards. Some cities have a high degree of physical exposure to climate change and a limited capacity to respond to the challenge of adaptation, e.g. Shillong. Geographic location, precipitation and temperature indices, local topography, and even the livelihood profile of the population are some important factors that determine how vulnerable a city is. If city governance systems and local bodies do not ensure development that is in sync with the local climate and environment, the ability of its inhabitants and the government machinery to respond to extreme events is drastically reduced.
3. **Climate-informed urbanization:** A range of development activities can help reduce vulnerability to many climate change impacts. In some cases, "development as usual" may inadvertently increase vulnerability. For instance, new roads can be weather-proofed from an engineering standpoint, even taking the future climate into account, but they could trigger new human settlements in areas that are highly exposed to particular impacts of climate change, such as coastal zones vulnerable to sea-level rise.

CHAPTER 5: MONITORING & EVALUATION

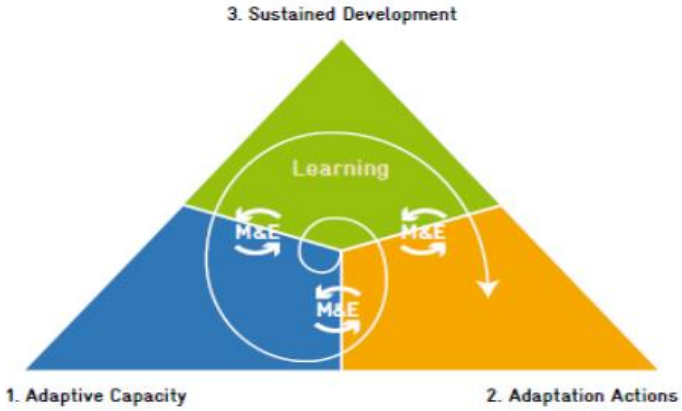
5.1 What is M&E?

M&E are different processes that work together to assess the performance of an intervention over time**.** **Monitoring** refers to an ongoing assessment of the intervention and progress made in achieving set of 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 it is 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 an enabling environment, drawing from different sources of knowledge, establishing 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 reveal underlying factors (such as inequality/rights/structural causes) for vulnerability. M&E helps identify successes and good practices, and capture failures and reasons for non-delivery.

Why is M&E an important tool? It 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 and 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 identifying strategies that are not working.

Figure 5.1

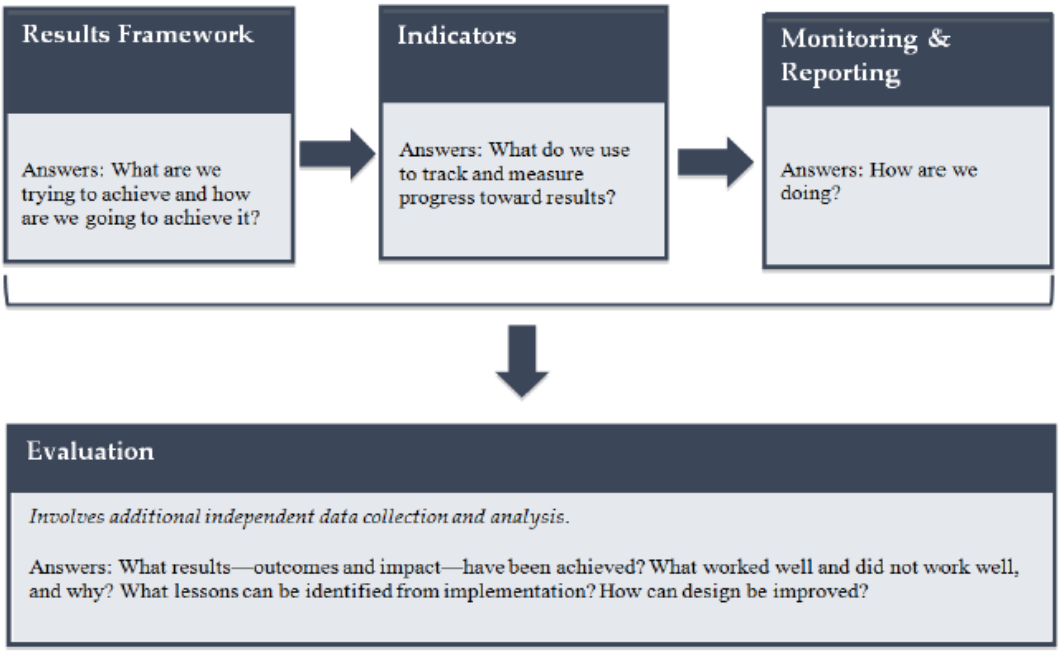


Three Dimensions of Adaptation

Basic components of M&E

Monitoring is used extensively by national- and state-level development agencies and financial institutions to assess the progress and effectiveness of projects and programs. The main components of M&E are mentioned below:

Figure 5.2



- **A results framework**—Result-based M&E is a management tool used to systematically track the 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.
- **Indicators** are the parameters to measure progress toward the intended results (outlined in the results framework) and 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, serves to take stock of progress and support routine management and accountability purposes.
- **Evaluation** is a separate analysis that draws upon all these components and involves additional independent data collection and analysis. It is in essence concerned with valuing. The Organization for Economic Cooperation & Development (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 fulfillment of objectives, development efficiency, effectiveness, impact and sustainability" (OECD 2002).

5.3 Why M&E for climate change adaptation?

There are many reasons why M&E should be an integral part of the adaptation intervention. Some of these are as follows:

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

- The monitoring and evaluation indicators help track and examine the progress of the intervention and measure the achievement of 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 effectiveness, and M&E plays a vital role in ensuring 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 that 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.
- M&E indicators allow comparison with respect to a baseline for different time periods, as well as comparisons between different interventions.
- M&E indicators help in identifying problems during the project, which in turn enables corrective action. The M&E process helps identify areas that need improvement and those that are satisfactory, so that future decisions for any new program can be made wisely.

5.4 Challenges in conducting climate change adaptation M&E

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 that are not necessarily unique to adaptation but require 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 program management cycle. The real impact of climate change adaptation may not be apparent for decades. Then how 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. Some locations are also likely to be affected deeply but by indirect means. For example, drought exacerbates rural-to-urban migration. Even if a city is not affected by more frequent and severe drought, an influx of rural poor from a neighboring region may overwhelm the city's services.

- **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 program 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 program cycle, and 'success' may constitute stabilization or preparedness rather than improved conditions. For example, a program to improve the capacity of a flood-prone region's administration to cope with disaster will not be tested if no flood occurs during the actual program cycle.

- **The 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 endeavor, all of

which vary widely. Moreover, many aspects of adaptation are 'soft' (e.g. institutional capacity, behavior change), and for some key dimensions, qualitative assessments are most appropriate. It may be difficult to aggregate community-level program 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 program. 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 program 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.

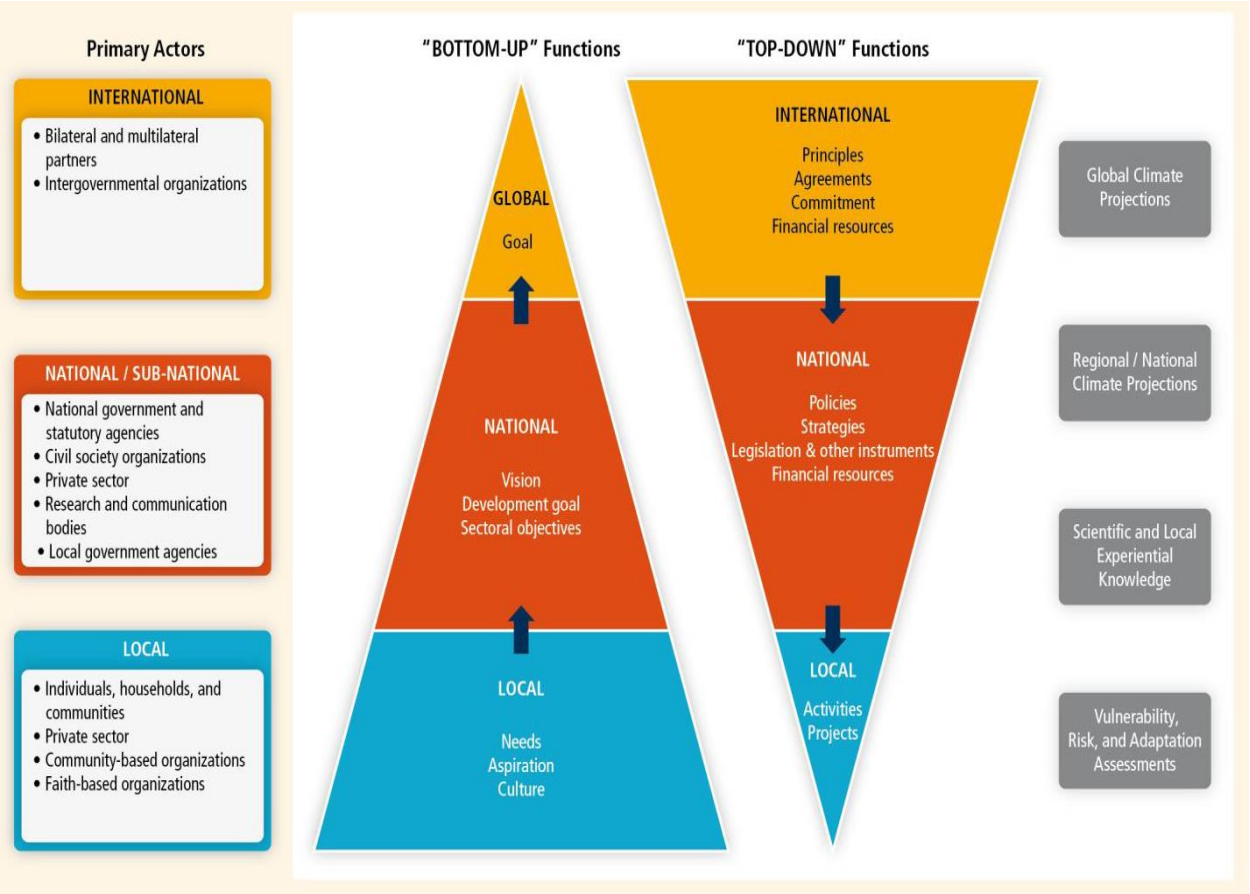
- **Diversity of key definitions and terms:** There has been a proliferation of climate change adaptation technical terminology. Basic concepts like adaptation and vulnerability are being defined in different ways by different agencies. There is considerable overlap and duplication of key terms; meanwhile, 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. the ability to adapt).

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.

5.5 Addressing CCA M&E challenges across scale

The field of CCA M&E is expanding rapidly, with many new M&E systems being designed and implemented around the world, and examples available for others to learn from global to local levels. While most climate change impacts are experienced locally (e.g. floods, reduction in crop yield, or spread of disease), these localized impacts can have national and international ramifications that require action beyond the local level. To be effective, CCA interventions — and therefore CCA M&E — must address issues across scales. Effective and efficient adaptation policies and programs often require coordination and collaboration across local to national (and sometimes international) organizations and institutions. A striking example is the heat waves and fires in and around Moscow in 2010, which affected wheat exports and had global consequences (Shaposhnikov et al. 2014)

Figure 5.3



System of actors and functions for managing disaster risk and adapting to climate change (Lal et al. 2012)

5.7 Types of adaptation M&E efforts, approaches/frameworks

A review of M&E-relevant activity on adaptation reveals three broad categories of efforts:

1. **Community-based initiatives** are largely informed by anthropological studies on livelihoods and dominated by NGO-driven activities with a bottom-up, participatory ethic.
2. **Program- and project-based efforts**, driven largely by the global development community, and drawing heavily on rural development approaches and professional project management.
3. **National policy initiatives**, which began with the UNFCCC National Adaptation Programmes of Action (NAPAs) and disaster risk reduction initiatives but are increasingly comprehensive and strategic.

Adaptation M&E can be applied for different reasons, e.g. to assess the effectiveness of an adaptation measure or the implementation of an adaptation strategy. Defining the purpose of M&E and how its results will be used to support the adaptation process is a prerequisite for deciding on an approach and method for M&E. The following table matches different purposes for M&E of adaptation with existing methods and approaches.

Table 5.1

Purpose	What approaches or methods support this purpose?	Focus

M&E framework for projects/programs (To monitor whether an adaptation **project** is proceeding according to plan and achieving its intended results)	UNDP Adaptation Policy Framework (Lim and Spanger-Siegfried 2004)	Guidance on designing and implementing projects to reduce negative impacts and enhance beneficial consequences of climate change
	GEF Adaptation Monitoring and Assessment Tool (AMAT)	Tracking tool for adaptation progress used under the LDCF/SCCF results framework
	Results-Based Management (RBM) and Logical Framework reviewed by OECD	The Framework used by agencies such as Canadian International Development Agency (CIDA), Department for International Development (DFID), Directorate-General for International Cooperation (Netherlands - DGIS), Japan International Cooperation Agency (JICA), Swiss Development Cooperation (SDC), and Swedish International Development Cooperation Agency (SIDA) for adaptation-related projects in Asia, Southeast Asia, Pacific Islands, etc. Five categories of adaptation activities were assessed using RBM and Logical framework
	Pilot Program for Climate Resilience (PPCR), Climate Information Fund (CIF)	Guidance and reporting tools for five core indicators at the national and project level
	Guidebooks include those prepared by GIZ (2021), and WRI/GIZ (2011) (2012), WRI/GIZ (2011)	Monitoring using a theory of change
Framework linking adaptation with development objectives (To monitor whether a (sub)-national adaptation plan or strategy is being implemented and achieving its intended results)	WRI 6-step framework on behalf of GIZ (Spearman and McGray 2011)	6-step framework as a practical tool for tracking success and failure of adaptation interventions in the context of development agenda
	Tracking Adaptation and Measuring Development (TAMD) by IIED (Brooks et al. 2013)	Two-track approach for evaluating adaptation progress at the macro level to inform high-level decision-making
	UKCIP AdaptME toolkit (Pringle 2011)	Applied at different levels and sectors for evaluating adaptation progress and performance
National-level audits and reviews **(**To monitor and evaluate the **collective performance** of numerous adaptation programs and/or projects)	International Organization of Supreme Audit Institutions (INTOSAI WGEA 2010)	Guidance on auditing the government response to climate change including adaptation interventions
	International Initiative for Impact Evaluation (3iE) (Prowse and Snilstveit 2010)	Impact evaluation methodology to be utilized in assessing the impacts of adaptation interventions
	OECD review of national M&E systems (OECD 2015)	Review of national M&E systems to identify lessons learned and inform future development of adaptation policies and programs
	Progress, Effectiveness and Gain M&E tool by LDC Expert Group	This process-focused monitoring tool uses the 10 essential functions of the NAP process as its foundation and establishes expected outcomes and metrics that can be used to measure progress in each of the functions.

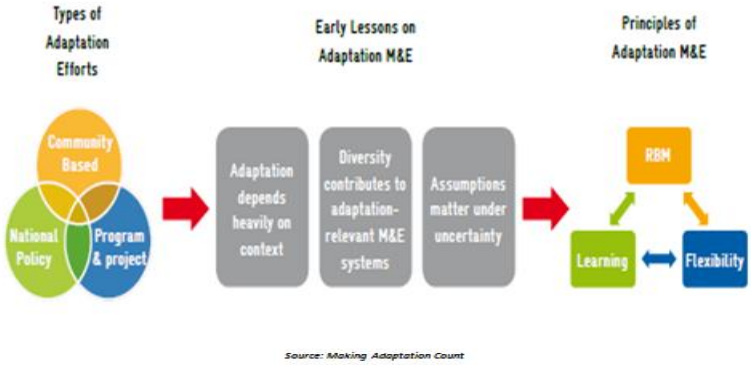
Principles for adaptation M&E

Based on the review of M&E for adaptation, three principles are the basis for developing adaptation M&E systems. The figure below illustrates the progression from early adaptation efforts, through early lessons for adaptation M&E, leading to the three principles of adaptation M&E as described in this section.

Design for learning: Since many uncertainties surround how climate change will unfold and what will constitute successful adaptation, the learning function of M&E will provide critical benefits to society. Without attention to learning as the core function of M&E, we are unlikely to capture successful efforts at autonomous adaptation, avoid maladaptation, or amass lessons about what works.

Manage for results: M&E systems used to assess the quality of adaptation must account for factors that affect long-term changes, even if they cannot be definitively measured in a given implementation period. Results-based management (RBM) captures the quality of implementation efforts and the results of those efforts. RBM supports efforts to meet periodic targets and captures evidence for reflecting on what leads to intended and unintended changes.

Figure 5.4



Source: Making Adaptation Count

Maintain flexibility: The M&E systems developed to track progress for adaptation must support flexible approaches conducive to learning and RBM. The example below describes the flexible model employed by the Watershed Organization Trust in India for watershed management, which now incorporates climate change adaptation.

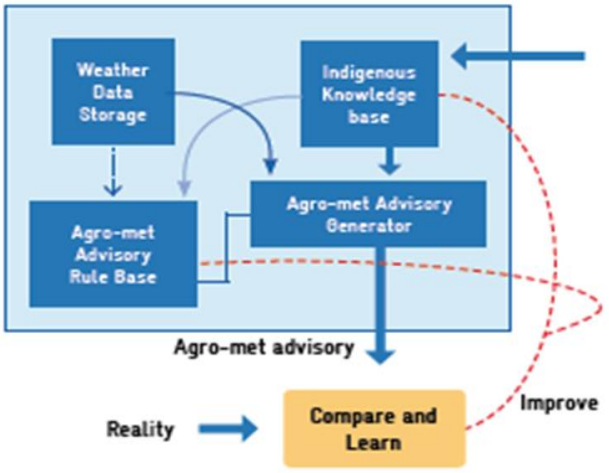
Figure 5.5 Example

Box 2. Watershed Organisation Trust: Using M&E to Stay Flexible

Since 1993, the Watershed Organisation Trust (WOTR) has worked to help rural Indian communities improve their access to and the quality of their water resources. WOTR takes an innovative approach to watershed development that has enabled it to scale up and expand throughout India over the past few years. Its model for watershed management is shaped by broad public participation, emphasis on local knowledge, and consistent use of monitoring to enable flexibility at multiple levels.

WOTR has developed an integrated project model for watershed restoration that can be implemented in each village according to its specific geographic, environmental, and socioeconomic context. Participation provides the key to this flexibility. Each project employs an approach called Participatory Net Planning, which emphasizes application of local knowledge throughout planning, implementation, monitoring, and learning. WOTR also employs training and capacity-building programs, and has found that these activities help sustain an intervention that the local populations have constructed themselves, with the capacity for future modification of the model based on emerging needs or climatic variations.

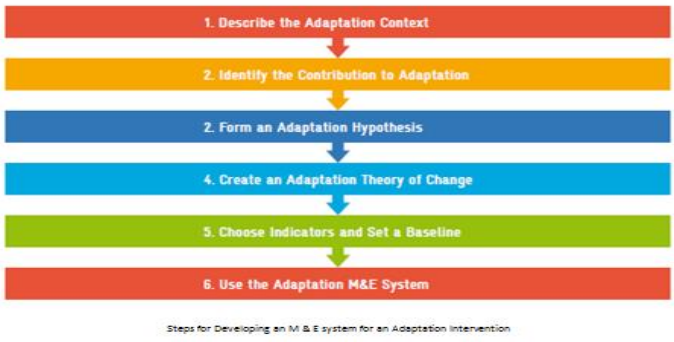
While WOTR's work began as a novel approach to development, it now has begun to leverage its flexible model for adaptation to climate change. WOTR's monitoring has found that while the overall quantity of rainfall in many regions has already begun to decrease, its watershed restoration efforts have collectively enabled an increase over the same period of time in the amount of water captured through the watershed. WOTR has also launched several integrated climate adaptation pilots that include agrometrology, crop planning and management, water budgeting, water distribution, biodiversity initiatives, and market linkages. Lessons from monitoring these initiatives will be used to tailor the WOTR model to better support development under a changing climate.



5.8 Applying M&E for CCA interventions

To develop an M&E system, practitioners need to first identify the key factors associated with the planned program, policy, or project that could trigger desired changes and positive impacts. While each adaptation intervention will be at a different stage of planning when creating an M&E system to track results and may have a different focus on expected results, a well-designed M&E system forms the basis for asking the right questions at the right time. Taking each of these points into account, a six-step process for developing an M&E system for an adaptation intervention (See figure below).

Figure 5.6



Steps for Developing an M & E system for an Adaptation Intervention

For each step, **examples are provided that readers may choose to follow, or from which they may borrow ideas relevant to their initiatives.**
Did not understand the purpose of the two numbered points below. Please insert a line of introduction e.g. "These are resources to guide readers to…"

1. ***Adaptation made to measure:*** *A guidebook to the design and results-based monitoring of climate change adaptation projects, second edition by* ***GiZ*** *(https://www.adaptationcommunity.net/?wpfb_dl=52)*
2. ***Making Adaptation Count:*** *Concepts and Options for Monitoring and Evaluation of Climate Change Adaptation, by* ***WRI (****http://pdf.wri.org/making_adaptation_count.pdf)*

The above materials give readers a range of options for tailoring their M&E system to the particular needs and context of a given intervention. The options detailed provided above are not comprehensive but provide a menu of several practical and relevant methodologies and tools.

5.8 Experiences with adaptation M&E

Example 1: *Monitoring adaptation in an estuary in India*

The Sundarbans estuary in West Bengal faces increasingly frequent and intense storms and heavy rains. Proposed adaptation measures include controlled flooding, building freshwater storage, and introducing salt-tolerant crop varieties. Biophysical indicators like sediment deposition rates, increased availability of freshwater through project activities, and yield improvements on saline soils are monitored and interpreted to assess the effects of adaptation measures. Results are used to compare the performance of different adaptation options and to aid subsequent decision-making.

Lessons learned for developing and M & E system in an Indian Adaptation project

- Adaptation M & E systems benefit from a combination of biophysical and social indicators.
- Adaptation M & E systems should be designed for inform future decision making.

Example 2: *Evaluating Germany's national adaptation strategy*

The German Adaptation Strategy is organized along 15 priority areas such as health, agriculture and tourism. An extensive consultation process was started in 2010, involving government authorities, academic institutions and

NGOs to identify indicators of climate impacts and adaptation progress for each of these priority areas. Particular attention has been given to existing sectoral M&E systems. In total, 126 indicators have been suggested and are now under review by the respective ministries.

Lessons learned from developing an M&E system for German Adaptation Strategy

- It is often more difficult to determine indicators for adaptation response than for climate impacts.
- Selecting a number of representative indicators for each action field requires extensive exchange among experts and stakeholders.
- Involving all major bodies and specialized authorities is important to ensure acceptance and smooth operationalization (since data is collected by numerous bodies)

Example 3: ***The results framework of the Adaptation Fund***

The Adaptation Fund established by the parties to the UNFCCC provides direct access to funding for concrete adaptation projects and programs in developing countries. As part of the Adaptation Fund's results framework, adaptation projects need to develop a context-specific M&E system while also selecting indicators from a list of pre-defined standard indicators derived from the fund's goals and outcomes. These quantitative indicators can be aggregated to the portfolio level and thus help assess the achievements of the Adaptation Fund. The list of standard indicators and guidance on their measurement can be found in the 'Results framework and baseline guidance'[52], which also includes general principles on knowledge management as well as a step-by-step guide on developing a results framework for adaptation projects.

Lessons for Developing M & E Framework for The Adaptation Fund

- Standard indicator requires a clear definition and guidance on how to measure them In order to be comparable across projects.
- Due to diversity of Different contexts, tracking project results also requires context specific indicators.

Key questions to consider while using an adaptation M&E system:

1. 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?
2. 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?
3. How are the intervention partners involved in the monitoring and verification of results?
4. 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?
5. 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?
6. 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?

[52] http://adaptationfund.org/sites/default/files/Results%20Framework%20and%20Baseline%20Guidance%20final%20compressed.pdf

CHAPTER 6: MODULE FOR DISTRICT-LEVEL OFFICIALS ON CLIMATE FINANCE

What is climate finance and why is it important?

While there is no universally agreed definition of climate finance, UNFCCC defines it as "local, national, or transnational financing — drawn from public, private and alternative sources of financing — that seeks to support climate change mitigation and adaptation actions. This includes financing that aims at reducing emissions, enhancing sinks of greenhouse gases (GHGs), and reducing the vulnerability and increasing the resilience of human and ecological systems to negative climate change impacts" (UNFCCC, 2012)

Mobilization of adequate and predictable resources for climate action is a must for limiting the increase in global temperature to between 1.5 and 2 degrees Celsius above pre-industrial levels and enhancing the ability to adapt to the adverse impacts of climate change and foster climate resilience, as enshrined in the Paris Agreement. Article 9 of the Agreement covers various issues about climate finance as agreed by signatory parties (developed and developing countries) during the negotiation process. In particular:

- ✓ It puts the onus on developed countries, such as the US and Europe, to take the lead in mobilizing climate finance from a wide variety of sources, instruments, and channels, to assist developing countries with mitigation and adaptation.
- ✓ Developing countries such as India can provide financial support voluntarily.
- ✓ It emphasizes the balance between adaptation and mitigation.
- ✓ It emphasizes country-driven strategies and priorities, and needs of developing countries.
- ✓ It calls for transparent and consistent information on the support provided by developed countries to developing ones.
- ✓ The first global stocktaking of the Agreement, which is scheduled for 2023, will include an assessment of climate finance flows from developed countries.

Without mobilization of adequate resources for climate action, the world will fall short of the goal of limiting the global temperature increase to between 1.5 and 2 degrees Celsius. This will have a catastrophic impact on natural ecosystems and human well-being. India is at particularly high risk: as per the Global Climate Risk Index 2020, it is among the top five countries affected by climate change. In terms of economic losses, India is in the top spot (Germanwatch, 2019). Without timely action, climate change will have a profound impact on India, as the increase in extreme events, erratic rainfall, frequent drought, glacier melt, sea-level increase, and storm surges will affect agricultural productivity, migration, and conflict, as well as food, water and energy security (World Bank, 2013).

Climate finance architecture (stakeholders, mechanisms, and instruments)

I. Global

Global climate finance architecture is complex, involving several stakeholders and institutions that provide finance through various instruments and mechanisms. Some of these are listed in the table below:

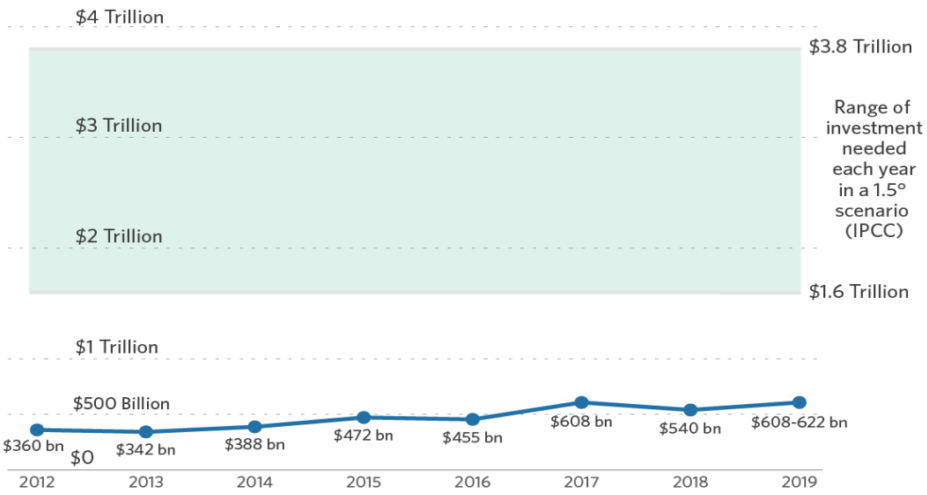
Table 6.1

Bilateral institutions (of developed countries)	UNFCCC financing mechanisms (public)	UNFCCC financing mechanisms (market-based for private sector)
Examples: - DFAT (Australia) - DFID (UK) - GIZ, KfW (Germany) - JICA (Japan) - USAID (US) - SDC (Switzerland) - AfD (France)	- Green Climate Fund (GCF) - Adaptation Fund (AF) - Global Environment Facility (GEF)	- Clean Development Mechanism (CDM) - Joint Implementation (JI)
Non-UNFCCC mechanisms and institutions	**National funds**	**Private-sector investments**
- UN Agencies - Multilateral Development Banks (MDBs) such as the World Bank, Asian Development Bank, New Development Bank, etc. - Climate Investment Funds	- India National Adaptation Fund for Climate Change (NAFCC) - Indonesia Climate Change Trust Fund - Amazon Fund (Brazil) - South Africa Green Fund	Direct and indirect investment by businesses, commercial banks, venture capitalists, private equity, and other financial institutions in - clean sources of energy such as solar, wind, etc. - environment- friendly technologies such as electric vehicles

Current trends in global climate finance flows

Despite the focus on climate finance in the Paris Agreement and the presence of multiple stakeholders, current flows are much lower than what is required to achieve a 1.5-degree goal. As per a recent assessment by Climate Policy Initiative (CPI), global climate finance flows are estimated to be in the range of $608-622 billion, vis-à-vis the requirement of $1.6-3.8 trillion annually.

Figure 6.1



Source: (CPI, 2020)

Existing climate finance flows are skewed towards mitigation. An inadequate amount goes towards improving the resilience and adaptive capacities of frontline communities and vulnerable groups (such as farmers). Moreover, financing for adaptation and resilience is almost exclusively provided by governments, as the participation of the private sector in relevant areas such as water or disaster risk management is limited.

Mechanisms and instruments

Mechanisms and instruments of climate funding have also evolved and diversified over time. One of the mechanisms that has become popular for channeling international climate finance is direct access. Under direct access, funds are channeled through accredited National Implementation Entities (NIEs) of developing countries that can meet certain fiduciary and Environment Social and Governance (ESG) requirements instead of multilateral banks or UN agencies. This approach was pioneered by the Adaptation Fund (AF) and later on adopted by the Green Climate Fund. In India, GCF direct access entities include NABARD, SIDBI, Yes Bank, and IDFC Bank (Climate Funds Update, 2020).

Other mechanisms include climate financing with a thematic focus on specific sectors, geographies or groups. Climate Investment Funds (CIFs) administered by the World Bank in partnership with other regional banks, such as Inter-American Development Bank (IADB), Asian Development Bank (ADB) and the European Bank for Reconstruction and Development (EBRD), are good examples of this mechanism. Each CIF focuses on a particular area, such as clean technology, climate resilience, renewable energy for low-income countries, forest investments, energy storage, etc. (Climate Investment Funds, n.d.)

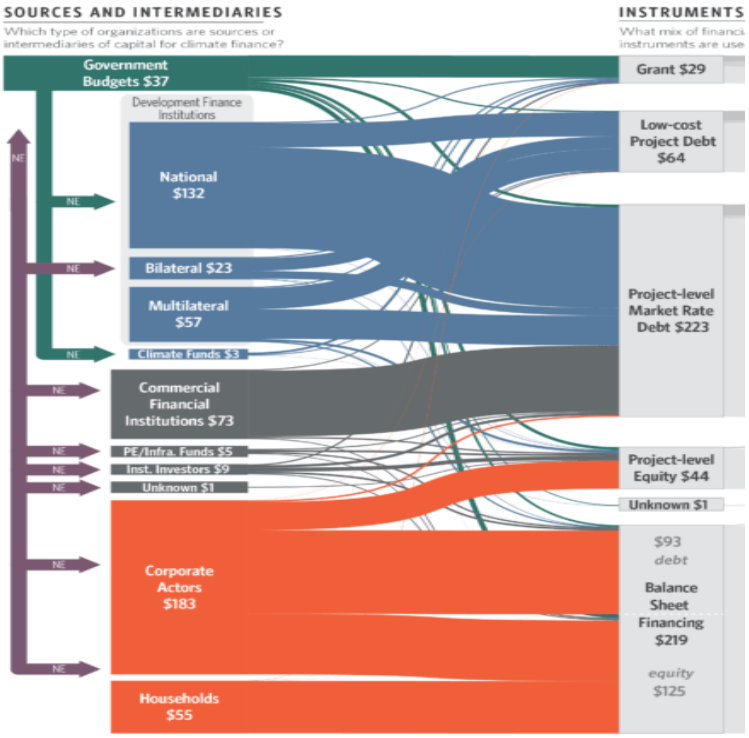
Instruments

Climate financing involves the use of a wide array of financial instruments, depending on the source of funding. Funding from government budgets is primarily in the form of grants-in-aid. Other national and international sources of public finance, such as development banks, bilateral agencies and multilateral banks, provide a mix of grants, low-cost concessional debt and market-rate debt. Private direct investments in climate projects involve both equity and debt financing, either at the project level (project financing) or company level (balance sheet financing). Instruments also include risk-financing products such as guarantees and parametric or

indemnity-based insurance products. Crop insurance under the Pradhan Mantri Fasal Bima Yojna (PMFBY) is an example of a climate-risk financing instrument as it remunerates farmers in case of crop damage.

Green bonds have emerged as an important source of financing in the country as well as globally. India is the second-biggest issuer of green bonds in emerging markets, after China, with more than $10 billion in issuance by private and public-sector entities such as ReNew Power and the State Bank of India. Green bonds are issued as per the guidelines of the Securities and Exchange Board of India (SEBI).

Figure 6.2



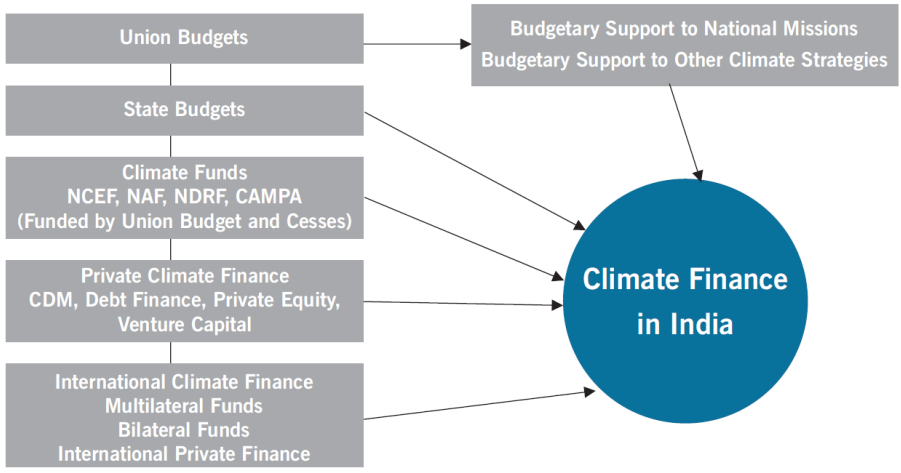
Source- and instrument-wise break-up of average global climate finance flows of $579 billion in 2017-18

Source: (Climate Policy Initiative, 2020)

II. National architecture

In India, the Climate Change Finance Unit (CCFU) of the Ministry of Finance is the apex agency for handling matters related to climate finance. The national climate finance architecture also involves other entities and mechanisms of fund mobilization and allocation:

Figure 6.3



Source: (CBGA, 2017)

Some examples of how India has mobilized funds internally for climate action and accessed climate finance from international sources are below:

Table 6.2

Internal Mobilization	
National Adaptation Fund for Climate Change (NAFCC)	• NAFCC is India's flagship fund, set up in 2015 to provide support for adaptation projects. So far, it has provided grant assistance of INR 847 crore for 30 projects. The fund is administered by the Ministry of Environment, Forests & Climate Change, with NABARD as its implementation agency.
Compensatory Afforestation Fund (CAF)	• CAF was set up by a Supreme Court order in 2002. The fund is administered by the Compensatory Afforestation Fund Management and Planning Authority (CAMPA) at the national and state levels. It receives funds paid by developers for compensatory afforestation, which are distributed between national and state funds in a 90:10 ratio. • In 2019, the government of India released INR 47,436 crore to various states for afforestation, contributing to India's Nationally Determined Contribution (NDC) for creating an additional carbon sink equivalent to 2.5 to 3 billion tons of carbon dioxide by the year 2030.
Budgetary allocations	• The Indian government makes annual budgetary allocations for various missions such as Green India Mission, National Solar Mission, National Mission for Enhanced Energy Efficiency, National Water Mission, National Mission on Sustainable Habitat, etc., which support India's mitigation and adaptation efforts under the Paris Agreement. Expenditure under the missions is overseen by the ministries in charge of these missions. • Similarly, budgetary allocations are made annually for flagship schemes such as MGNREGA, PMKSY, etc. with climate co-benefits.
Subsidies	• The government of India uses subsidies as a tool to incentivize the use and adoption of environment-friendly technologies and processes by the private sector (households and businesses). • For example, under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) II, the government has provided incentives of INR 10,000 crore (100 billion) for three years up to 2022 to create demand for electric vehicles and to set up charging stations. In the past, the government has offered generation-based incentives (GBI) to attract private-sector investments in renewable energy.

Capital markets	• In 2017, Securities Exchange Board of India (SEBI) issued rules for the issuance of green bonds, whose proceeds can only be used to finance green projects. • Both private and public companies, such as SBI, ReNew Power, Indian Railway Finance Corporation, and India Renewable Energy Development Agency, have issued green bonds.
Access to international sources	
Green Climate Fund (GCF)	• Established under the UNFCCC, this is the largest source of concessional climate finance, with over $10 billion mobilized for investment in adaptation and mitigation. GCF supports country-driven projects and programs, and operates through a network of national, regional, and international direct access entities and national designated authorities across the world. Its financial instruments include grants, loans, equity and guarantees. • In India, NABARD, SIDBI, Yes Bank, IDFC Bank, IL&FS Environmental Infrastructure Services Ltd are the GCF's direct-access accredited entities, and the Ministry of Environment and Climate Change is the national designated authority. There are several other accredited international agencies, such as UNDP, UNEP, and Asian Development Bank, that can also be approached for GCF funding (Green Climate Fund, n.d.). • GCF has approved three projects in India, with total financial assistance of $177.8 million (in loans and grants). Project areas include coastal resilience, groundwater recharge and rooftop solar panels.
Adaptation Fund (AF)	• The Adaptation Fund is another key project financing mechanism under the UNFCCC. It has been operational for more than a decade and has supported 87 projects globally with grant assistance of nearly $600 million. • In India, it has supported six projects with grants totaling $9.86 million. These include climate-proofing of watershed development projects in Tamil Nadu and Rajasthan, conservation and management of coastal resources in Andhra Pradesh, and enhancing the resilience of small and marginal farmers in West Bengal.
Clean Technology Fund (CTF)	• CTF is a climate investment fund that provides resources for low-carbon technologies with significant potential for long-term greenhouse gas emissions savings. It has supported several renewable energy projects in India with long-term concessional loans. The fund is administered by multilateral

development institutions such as the World Bank and Asian Development Bank.

India's climate financing requirement

India's climate finance requirements are onerous given the size of the economy and population. It is estimated that India's Nationally Determined Contributions under the Paris Agreement would require $2.5 trillion until 2030 at 2014-15 prices. Adaptation efforts are estimated to require $206 billion between 2015 and 2030. The Economic Survey 2020-21 highlights the need for efficient allocation of limited resources. It also emphasizes careful estimation of the cost of climate action and possible sources of funding (Government of India, 2021).

Challenges

Coordination, management and mobilization of climate finance is a challenge at the country-level due to several factors, including lack of green tagging of budgets, limited resources, and involvement of multiple stakeholders. One of the biggest barriers is the limited availability of funds. Climate solutions often involve higher upfront costs (also called 'greenium') which can be unaffordable without technology transfer or concessional funding from other development partners. So while climate actions (e.g. adoption of low-carbon technologies or interventions to build the climate resilience of poor and vulnerable groups) are integral to the country's sustainable development agenda, decision-makers often face a challenging task to prioritize them. Immediate concerns such as controlling the pandemic may hamper the government's abilities to make longer-term commitments for climate action.

Funds to implement State Action Plans for Climate Change (SAPCCs) have to be primarily mobilized through state budgets, with support from the Centre. Without holistic evaluation and the climate tagging of budgets, it is hard to assess which schemes are contributing to climate resilience, to what extent, and how their climate co-benefits can be maximized.

While climate actions and strategies under SAPCCs are collated and prioritized by the state environment departments/agencies, the implementation responsibility is with respective line departments and the funding is allocated by the finance department. This creates room for implementation or funding gaps in SAPCC implementation, as the line departments and finance authorities often have multiple constraints, as well as priorities and objectives to achieve. For example, a state's ability to take concessional or market-based debt for a climate project depends on its existing level of debt and available borrowing space as per the Fiscal Responsibility and Budget Management (FRBM) regulations, besides other factors.

Without taking into consideration local climatic data and vulnerability assessment in planning and designing schematic interventions, it is hard to assess what would be the additional cost of implementing climate actions and strategies identified in the SAPCC. Mainstreaming of climate information in planning and budgeting is limited in India. Other factors, such as limited flexibility of fund utilization under implementation guidelines, limited awareness and limited technical capacity of government officials, can affect climate finance flows.

Coordination can also get complex between state and national governments. Access to international climate finance from sources such as the GCF, AF, and multilateral banks, as well as allocations under central schemes with climate co-benefits, involve the decision or approval of the Government of India, which has to prioritize competing requests from other states and weigh factors such as national priorities, availability of funds, inter-ministerial allocations, debt sustainability, etc.

Climate finance at the sub-national and district level

Public expenditure (such as social security transfers, expenditure on management of natural resources, etc.) by state governments in areas such as agriculture and allied sectors, water, disaster management, and urban and rural development, has multiple climate co-benefits, especially in terms of building resilience and adaptative capacity at the grassroot level. It is potentially the largest source of climate finance at the state level, complemented by other sources, such as:

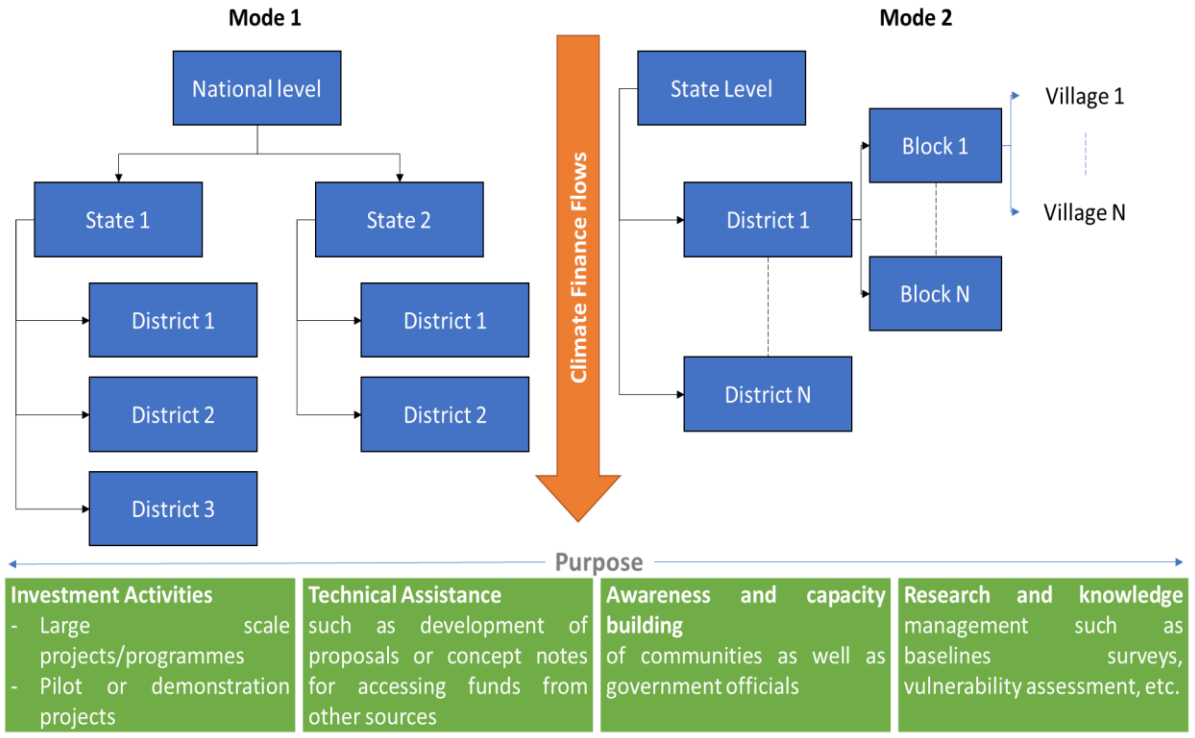
- ✓ National funding under centrally sponsored schemes (CSS), central sector schemes as well as national funds such as CAMPA, NDRF, NAFCC and NCEEF.
- ✓ Finance assistance provided by development finance institutions such as NABARD and SIDBI to state governments.
- ✓ Private sector investments in environment-friendly technologies.
- ✓ External assistance from multilateral and bilateral organizations

However, climate co-benefits of public expenditure are often not explicitly understood or documented, or are not prioritized, due to several factors, including:

- ⊗ Lack of awareness and technical knowledge about climate relevance and sensitivities and ways to integrate them with development schemes
- ⊗ Lack of supporting data and evidence at the local level
- ⊗ Lack of leadership or willingness to go beyond business as usual
- ⊗ Operational inflexibilities
- ⊗ Non-availability of funds
- ⊗ Other factors such as staff shortage or prioritization of other immediate sustainable development issues

Climate finance ultimately trickles down to districts from the national (Mode 1 in the chart below) or state level (Mode 2) for implementation of solutions required to address the adverse impact of climate change.

Figure 6.4



At the district level, most of the funds flow through the district treasury, making it an important source of funding for climate action, especially adaptation and resilience. However, for certain centrally sponsored schemes, funding also comes directly from societies or agencies created for their implementation.

Source: (CBGA, 2020) and (SJHIFM, NA)

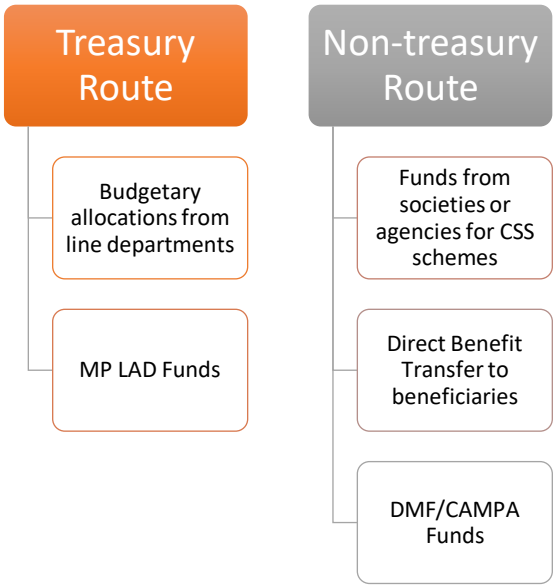


Figure 6.6

Climate-responsive budgeting

Climate-responsive budgeting

Climate-responsive budgeting is a useful tool to mainstream climate actions in annual planning and budgeting process. Fundamentally, it involves review of expenditure incurred by governments to understand what climate co-benefits it would deliver (both adaptation and mitigation) . Accordingly, annual budget allocations, and design and prioritisation of of government schemes based on their climate relevance and sensitivity could be undertaken.

Various approaches to climate-responsive budgeting have been adopted by national and sub-national governments across the world. For example, Odisha annually reviews its budget estimates across priority sectors to map schemes/programs that need to be prioritized for building resilience or mitigation benefits, and further identifies interventions under prioritized schemes that are vulnerable to climate change and require additional proofing efforts (Government of Odisha, 2020).

Role of district-level officials

Even though most decision-making, including mobilization and allocation of climate finance, happens at the state or national level, district officials have a key role to play in ensuring effective utilization of of finance for combating localized climate-related challenges.

Since they work directly with impacted communities and groups, they are best positioned to understand what the existing or emerging vulnerabilities are, and how they can be addressed cost-effectively. In fact, along with impact communities, district officials are repositories of local knowledge which is otherwise inaccessible to national stakeholders and decision-makers.

In this context, district officials have four key functions in ensuring mobilization of necessary resources for climate action at the district level:

Table 6.3

Identification and prioritization of project opportunities	✓ Climate finance is scarce. Hence, it is not possible to financially support all eligible climate action project opportunities at a given time ✓ Prioritization of projects can be based on factors including their sustainable development benefits, target population, urgency, impact potential, the potential for scaling or replicability, etc.

	✓ It is important to include impacted communities and groups in the consultation process
Preparation of robust proposals	✓ Often it is hard to get funding for dedicated climate projects because of several reasons, including the lack of scientific linkages between climate change and the need to implement a particular project, the distinction between project activities, a "business as usual" approach, etc. ✓ To the extent possible, developing strong scientific linkages and supporting them with other relevant documents, such as stakeholder consultations, vulnerability assessment, and feasibility studies, help build decision-makers confidence in allocating funds
Supporting integrated planning and budgeting for climate action	✓ Climate-proofing existing development works may require additional fixed or recurring expenses ✓ Realistic assessment of additional costs and other resources (such as staff), clear communication, and integration of these requirements (with justification) in annual district/block development plans helps in building awareness and clarity about funding requirements among concerned authorities at the state and national levels
Leveraging public co-financing and exploring other sources of funding	✓ There are several national schemes with climate co-benefits. Similarly, several state-run schemes have climate co-benefits too. Wherever possible, funding under these schemes should be fully utilized (subject to operational guidelines) to reduce the requirement of additional climate finance. ✓ Securing co-financing from existing sources also enhances the attractiveness of projects for gap funding from other sources ✓ A good example of this is Sikkim's Dhara Vikas project. It leverages co-financing from MGNREGA and the National Adaptation Fund for Climate Change (NAFCC). ✓ If co-financing is not available from an existing source, this should be communicated to the authorities concerned, so that they can explore other avenues such as bilateral/multilateral aid for such projects

- ✓ Besides funding support from national and state governments, the local administration can explore other sources, such as CSR or District Mineral Foundation (DMF) funds, for implementing local climate projects.

To conclude, the availability of and access to finance from dedicated climate finance sources are limited, and far from adequate to meet India's onerous requirements. In particular, funding for adaptation and resilience is scarce compared to mitigation, and adaptation projects depend heavily on government funding. Therefore, it is important to optimally utilize the public expenditure under development schemes such as MGNREGA, Jal Jeevan Mission, and National Initiative on Climate Resilient Initiative, for building the adaptative capacity and resilience of frontline communities and vulnerable groups. Measures such as the integration of climate information in development planning and climate-responsive budgeting can help governments cost-effectively achieve this objective.

ANNEXURE 1

Exercises – Day 1

Terms and definitions

Objective: To understand and be comfortable with commonly used terms related to climate change.

Key terms to cover in the session: Global warming, greenhouse gases, greenhouse effect, climate change, climate change mitigation, climate change adaptation, adaptive capacity, carbon footprint, ecosystem, vulnerability, weather, climate, temperature, climate variability, risk, probability, resilience, climate resilience, climate risk assessment, climate risk management

Proposed methodology: Game

The terminology game can be played either in teams or individually. It is played in two rounds. In Round 1, participants are provided a worksheet in which they match terms (Column A) with their definitions (Column B). They also get two open-ended questions to discuss and jot down points. Round 2 consists of a PowerPoint quiz, and participants pick the correct answer from multiple choices. The tally from both rounds is added to determine the final score. The participant or team with the highest score can be given a prize.

Reference Materials: IPCC/UNFCC terminology

Duration: 20 minutes

Timing	Purpose/ objective	Methodology	Material/facilitator
15 minutes	Basic terminology	1. Facilitator introduces the session and its objectives. **Team / individual work** 2. Print four sets of the selected terms and definitions in large fonts. 3. Divide participants randomly into four groups and assign them four tables. Ask each team to elect a team leader. If the number of participants is low, keep it individual rather than team-based. 4. Provide each team one set of slips with the terms and definitions. 5. Ask each team or individual to discuss and match the terms and definitions. 6. Ask the team or individual to display their work on the wall (optional).	• Sets of paper slips with selected terms • Flip charts and markers
15-20 minutes	Basic terminology	7. Run through the pre-prepared PowerPoint quiz and facilitate a discussion to check team or individual results. 8. A definition, and later the relevant term, are displayed on screen, and teams need to check whether their answer is correct. Teams or individuals with the correct answer gets one point. 9. Bonus point if the team can translate the term into volunteers'/community language. 10. Each team picks a representative to answer the open-ended questions. 11. At the end of the game, facilitator explains to the participants that there are many definitions and only the most	• Flip charts and markers • Projector

		appropriate/common ones for our work are selected. 12. PowerPoint quiz: Five (or more) multiple choice questions. Team with most points wins. 13. Open discussion: What other terms do participants come across commonly in their work, how do they deal with them, etc.	

Examples of definitions

- ***Weather:*** The set of meteorological conditions – wind, rain, snow, sunshine, temperature, etc – at a particular time and place
- ***Climate***: Local weather conditions — temperature, precipitation (rainfall, snow, etc.), humidity, sunshine, cloudiness, wind, and air pressure **– averaged over a long period of time** (normally 30 years), taking account of the *average conditions* as well as the *variability of these conditions*.
- ***Climate change:*** A significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer) due to natural changes (such as changes in the sun's intensity or oceanic circulation) and human activities. Today we use the term for changes induced by human activities that alter the gaseous composition of the atmosphere due to the release of greenhouse gases, in particular CO_2 (such as burning fossil fuels or deforestation).
- ***Global warming***: The progressive rise of the earth's surface temperature, thought to be caused by the enhanced greenhouse effect. Global warming may be responsible for changes in climate patterns.
- ***Greenhouse gas (GHG)***: Naturally occurring and human-made gases that trap infrared radiation as it is reflected from the Earth's surface, trapping heat and keeping the Earth warm. The six main GHGs whose emissions are human-caused are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
- ***Vulnerability***: Vulnerability depends on sensitivity to certain hazards/stressors and adaptive capacity (ability to adapt or cope with the stress/hazard).

Group discussion question

What are the main barriers to mainstreaming or integrating climate change adaptation into your overall departmental work?

Examples of quiz questions

Q1 Which of the following greenhouse gases has the biggest impact on climate change?

- Water vapor
- Methane
- Carbon dioxide
- Ozone

Q2 What is the difference between **weather, climate, and climate change?**

Q 3 *Can the terms **'global warming' and 'climate change'** be used interchangeably?*

- *Yes, they refer to closely related processes, and people understand what you are referring to when you use either one*
- *No, these are completely separate processes and should not be confused*

Q 4 Which Sustainable Development Goal aims to limit/address climate change?

Q 5 Which SDGs are the most important for Sikkim and directly related to its important sectors, such as agriculture, water, and forests?

Q 6 How does Sikkim's performance compare with other states on achieving SDGs? (GHG emission per capita, change in forest cover etc.)

Q7. How are the average annual temperature and average annual precipitation projected to change in Sikkim in the coming years (medium term)?

Answers for reference

Answer 1: Carbon dioxide
Water vapor is the most common greenhouse gas, but its levels are reasonably constant. Methane and ozone are more potent than carbon dioxide, but they are present in smaller quantities. Burning of fossil fuels such as petrol and coal has seen carbon dioxide levels in the atmosphere increase from 280 parts per million 200 years ago to 430 parts per million today.

Answer 2:

- **Weather** refers to short-term atmospheric conditions.
- **Climate is** the **weather** of a specific region averaged over a long period of time.
- **Climate change** refers to long-term and significant **changes** in climate measures such as temperature, precipitation or wind.

Answer 3: ***Yes,*** When the ocean, land and air get warmer (global warming) and when things change in the climate system (climate change).
Explanation: These terms are often used interchangeably. Global warming was commonly used in the 1980s to describe how human activities, such as the burning of fossil fuels and deforestation, were increasing the heat-trapping gases in the atmosphere that have been causing the planet to warm. But scientists have learned that raising the temperature of the atmosphere, oceans and land also results in large-scale climatic changes, such as changes in rainfall patterns. Both global warming and climate change are happening, and it is okay to use either term, though 'climate change' is a broader term for changes occurring due to the increase in greenhouse gases in the atmosphere.

Ans 4: Goal no 13

Answer 5:

- ***Water*** is directly related to **Goal 6** (Target 6.1 is to achieve universal and equitable access to safe and affordable drinking **water** for all by 2030, and Target 6.2 is to achieve access to adequate and equitable sanitation and hygiene for all, and end open defecation, by 2030, paying special attention to the needs of women and girls, and those in vulnerable situations)
- ***Agriculture:*** Although nearly all SDGs are related to sustainable agriculture practices, ***Goal 2 (ending hunger)*** is the most closely related as (Target 2.4 is to *ensure sustainable food production systems by 2030, as well as to implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality).*
- ***Forests.*** **Goal 15 (life on land)** aims to "protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage **forests**, combat desertification, and halt and reverse land degradation, and halt biodiversity loss".

Answer 6:

- Sikkim ranks third after Nagaland and Himachal Pradesh among net Carbon Sink States, absorbing 346 tCO2/crore rupees.
- Compared to the last forest survey, Sikkim added around 2 percent of forest cover.
- On **Goal 2,** Sikkim ranks seventh. On **Goal 6,** it ranks 19th, and on **Goal 13,** it ranks 20th.

Answer 7: The average annual temperature is projected to increase, and average annual precipitation is projected to decrease.

Exercises – Day 2

Climate-proofing exercise to prioritize and mainstream adaptation activities
Objective: To enhance participants' knowledge on how to mainstream and prioritize climate change in local programs
Proposed methodology: Group discussion
Each group is given a hypothetical scenario, based on which it has to make decisions and arrive at adaptation strategies to be implemented by members' departments.
Duration: 50 to 60 minutes
Sample flow of the group discussion

1. **Problem:** You are a program manager from the department of health, animal husbandry, etc., in Sikkim. Come together to identify solutions for increased heat stress in the state.

2. **Steps for climate-proofing**

a) Analysis: Is the situation affected by current or long-term climate scenarios? Is there any reference material – primary or secondary sources of information such as research studies, Met department data, regional studies, etc? Is CCA introduced or factored into participatory assessment tools? What are the main challenges?

b) Project design, formulation and planning: Can this be done through a Vulnerability and Capacity Assessment exercise? Do we need to factor in community plan from a future scenario? What are the possible adaptation measures or solutions? What are some current schemes that could help in implementing the activity? Which concerns are the top priorities, based on time scales, need or financial resources?

c) Implementation and monitoring: How would you monitor the progress of the activity?

d) Evaluation: What could be the intended benefit or expected results? Could there be any unexpected results (positive or negative)? What could be the challenges?

3. **Situations or problems to be given to the group**

Group 1: Floods or landslides
Group 2: Increasing rates of vector- and water-borne diseases (seasonal Influenza, etc.)
Group 3: Very high-intensity rainfall and urban flooding
Group 4: Increasing cases of heat stress

Timing	Purpose/objective	Methodology	Material/facilitator
10 minutes	To have better climate-smart programming	1. Facilitator introduces the session and its objectives (slides 1- 2) 2. Facilitator asks participants, "How can mainstreaming be effective?" 3. Facilitator gathers some responses, and then presents and explains that	Discussion Flip charts Markers Projector

		mainstreaming should be done at two levels: ▪ Strategic level that leads to policy change ▪ Operational/local Implementation 4. Facilitator explains what mainstreaming means at the strategic level (slide 3) 5. Facilitator explains what mainstreaming means at the operational level (slides 4-5)	
40 minutes	Group work 1 on PCM	6. Facilitator divides participants into 4 groups based on project cycle management (PCM): ▪ Group 1: Analysis ▪ Group 2: Design ▪ Group 3: Implementation and monitoring ▪ Group 4: Evaluation 7. Group work should discuss key actions to be done for each step of the PCM 8. Each group presents its work. Facilitator leads groups to identify what is missing for each step 9. Facilitator summarizes the session	Discussion Group work Flip charts Markers Post-it Notes
End of session			

ANNEXURE 2

1. Mapping of nodal departments in Sikkim

Sector	Department	State level	East Sikkim	South Sikkim
Water	Department of Rural Development	✓	✓	✓
	Department of Water Resources	✓	✓	✓
	Department of Forests	✓	✓	✓
Agriculture (Horticulture & Livestock)	Food Security and Agriculture Development Department	✓	✓	✓
	Indian Council for Agriculture Research	✓	✓	✓
	Department of Horticulture	✓	✓	✓
	Animal Husbandry and Veterinary Services	✓	✓	✓
Forests & Biodiversity	Department of Forests & Environment	✓	✓	✓
Disaster Management	Sikkim State Department for Disaster Management	✓	✓	✓
Planning & Finance	Department of Planning	✓		
	Department of Finance	✓		
Knowledge Management/ Capacity Building & Local Governance	State Institute for Rural Development and Panchayat Raj	✓		✓
	State Institute for Public Administration	✓		
	Directorate of Panchayat Raj	✓	✓	✓
	Department of Science and Technology	✓		
Urban Habitation	Department of Urban affairs	✓		
	Municipal Corporations	✓	✓	✓

2.Evaluation of government schemes and existing training to address climate change

Sector	Department	Training content	Orientation towards addressing climate change
Water	Department of Rural Development	Carrying out flagship Dharavikas program since 2008 in three districts. Aims to rejuvenate natural springs and redevelopment of watersheds. Also running the National Adaptation Fund Supported Village Water Security Plan in more than 800 villages. Villagers are trained in development of gram panchayat plans, micro-planning, skill development, livelihoods, and marketing. Self-help groups, common interest groups, user groups and community-based organizations are trained in community empowerment, vermicomposting, backyard poultry, etc.	None
	Department of Water Resources/Irrigation	Senior and mid-level: Governance of urban water supply, irrigation and sanitation systems, new water treatment technologies, water quality management, maintenance and management of water supply, irrigation and sewerage systems, decentralized planning, development and governance in rural water supply as per the Government of India guidelines in the National Rural Drinking Water Programme, quality assurance and e-procurement, disaster management.	None

		Junior level: Water supply and distribution management, quality in construction, disaster management, construction management and safety in construction, rules and laws pertaining to the department, inventory management. Field-level staff: Training in supervising the execution of storage tanks and other structures. Maintenance of cement consumption registers, and record-keeping of all the material, training in assembly, fitting, installation, maintenance and repair of plumbing pipe fixtures, fittings for water supply and sanitary and drainage systems.	
Agriculture (Horticulture & Livestock)	Department of Agriculture Development	Knowledge of improved agricultural techniques, integrated pest and disease management, efficient water management practices, commercial crops for improving crop productivity and generating employment, course on organic farming quality and quantity produce of agriculture, course on financial and Operationalization of SREP (Strategic Research Extension Plan) through ATMAs (Agriculture Technical Management Agencies), market-led extension, organic farming and balanced use of fertilizers. Sustainable agriculture development, IPM (Integrated Pest Management) and bio-control, INM (Integrated Nutrient Management), soil and water conservation, weed management, safe and judicious use of pesticides, quality control of seeds and fertilizers, application of remote sensing. Principles and practices of management of cereals, effective application of insecticides. Agriculture extension workers: Latest techniques in improving crop production and vegetable cultivation, organic farm management practices, weed control in vegetable crops, integrated nutrient management and balanced use of fertilizers, IPM, bio control and pest management, safe and judicious use of pesticides, soil and water management, soil sampling, testing and soil health cards.	None
	Department of Horticulture	Advances in nursery production techniques, in vitro propagation for disease-free plant material, nursery raising of fruit crops of economic importance, orchard management, canopy management, layout, soil and water management including micro irrigation techniques, integrated nutrient and pest management, new promising varieties of fruit crops, training in productivity improvement, advances in integrated nutrient and pest management and organic farming, precision horticulture, organic certification, advances in post-harvest management of horticulture, cultivation of medicinal and aromatic plants, post-harvest processing techniques	None
Forest & Biodiversity	Department of Forest & Environment	Training is being provided in forest laws, forest offence cases and procedures, nursery and plantation techniques, basic forestry principals and fundamentals for forest workers, forest accounting and procedures, seed nursery and technology; joint forest management, management of wildlife sanctuaries, procedures for private sales; range management information systems; zoo management; gender sensitization; micro planning; orientation course for range officers; wildlife census; forest fire prevention and awareness; management and conservation of Non-Timber Forest Produce medicinal herbs; participatory management/ techniques; formation and management of self-help groups; eco-tourism; nature awareness training camps. Orientation course for forest guards on techniques to tackle forest fires in the area.	None
Disaster Management	Sikkim State Department for Disaster Management	Training is conducted to generate awareness about the provisions of the Disaster Management Act, 2005; orientation and awareness on disaster management and its various aspects; preparation of disaster management plans; preparation of response plans; training to perform emergency support functions assigned to the departments; training in integration of disaster risk reduction into development plans and policies; training in mitigation measures and plans; community awareness and IEC; damage and needs assessment; conducting mock drills; training of all the new entrants into government services, training in urban risk reduction, safe construction practices, school safety, post disaster needs assessment, training of trainers on disaster risk reduction for NGOs and master trainers on drought mitigation, flash floods risk mitigation and management, landslide mitigation by geosynthetic management of water supply after disaster, emergency handling during disasters, DM training for elected representatives of panchayati raj, urban local bodies, etc.	None
Planning & Finance	Department of Finance	An introduction to the planning process in the government; preparation of budget and nominal rolls; preparation of excess and surrender statements;	None

		reconciliation of accounts with the Accountant General and diversion of funds; procedure for effecting purchases of stock, store and stationery articles; annual physical verification of stores; handling of cash and writing of cash books; audit, inspections and CAG reports.	
	Department of Planning	None	None
Knowledge Management	Directorate of Panchayati Raj	Basic training for gram panchayat representatives and panchayat secretaries/sahayaks; key provisions of select developmental schemes of the government; development of community leadership, public dealing and effective communication; critical social issues in HP; key provisions of Right to Information (RTI) Act and social audit. Training for elected representatives of panchayat samiti and zilla parishad: introduction to panchayati raj, Acts and rules, different committees of panchayati samiti/zila parishad, district plan formulation, convergence issues, devolution of power, flagship and rural development schemes, RTI Training module regarding financial management for elected representatives of Panchayati Raj Institutions (PRIs): Revenue-earning mechanisms of gram panchayat; taxation mechanisms, preparing budgets and others.	
	Department of Science & Technology	Senior technical staff: Climate change, mitigation and adaptation; climate change modeling, vulnerability assessment; wetland management; biodiversity conservation; disaster management; remote sensing and GIS; environment audit of buildings for schoolchildren; disaster management for schoolchildren and professionals; remote sensing for scientists/professionals; edusat for schoolchildren. Climate change and environmental planning and administration: Climate change modeling; clean development mechanism, greenhouse gas inventory, vulnerability assessment, environment impact assessment; project management (skills; environmental laws; basic GIS; courses enhancing scientific temper; environment monitoring; soil and land pollution management; disaster management designing of training and social mobilization skills; Himalayan ecosystem conservation techniques including wetland management, glacial protection.	None

3. Ongoing climate change adaptation activities

Sector	Department	State level	Specific climate change concerns to be addressed by departments
(Source: Discussions with Sikkim government officials, March 2020)			
Water	Department of Rural Development		This department is engaged in creating durable and directly productive economic assets such as water conservation works that ensure availability of adequate water, implemented through state and central government programs such as MGNREGA, Indira Awaas Yojana, etc. All activities done through various programs are highly climate-sensitive, and therefore need enablers for long-term sustenance of the assets created in a changing climate scenario. For example, water conservation activities would require an estimate of how much water is needed, how this can be met, and in the event of extreme events such as high rainfall, floods and droughts, how water storage structures can be protected and evapotranspiration rates can be reduced
	Department of Water Resources		This department works to enhance accessibility to irrigation and control floods. Although Sikkim's irrigation infrastructure needs are minimal, the investment that the department makes every year to maintain storm water drainage infrastructure is huge. Therefore, for storm drainage works to be sustainable, it is essential to understand the extent of flash flooding, likely areas or disaster-prone areas, the extent of rainfall in risk zones, and water bypasses available in case of GLOFs.

Agriculture, Horticulture & Livestock	Food Security & Agriculture Development Department		This department works to support sustainable agriculture through the management of natural resources and soil health, organic and risk mitigation. It promotes potato, vegetable, ginger and tea development, which are high-value cash crops. It provides assistance on fertilizers, development of vermicomposting units, soil testing, and plant protection from pests and diseases. Extreme scarcity of water for irrigation and difficult geography make agriculture one of the most difficult sectors to manage. Protecting crops from extreme climate events is one of the main concerns to ensure food security and livelihoods in the state. Thus the departent must focus on: (i) Assessing the likely impacts of climate change on crops grown in the state (ii) Assessing the impact of climate change on soil nutrient capacity and productivity (reasons for acidic soil) (iii) Identifying crops suitable for the changing climate scenario (iv) Identifying steps to help farmers grow appropriate cultivars (v) Protecting and preserving indigenous biodiversity that is resistant to climate stress (vi) Ensuring that demand for organic manure is met
	Department of Horticulture		The department oversees floriculture, harvesting of medicinal plants, cash horticulture crops such as oranges, etc. It runs schemes such as National Horticulture Mission and the One Crop One Zone Policy. To maximize the state's capacity to grow crops, officials must understand the implications of climate change on horticultural produce (key commercial fruit and flower cultivation) and best ways to adapt and maximize production.
	Animal Husbandry & Veterinary Services		The livestock department oversees the promotion and veterinary services required to manage the massive demand for eggs, poultry, meat, and dairy products in the state. A large proportion of livelihoods in rural Sikkim are from this sector, hence department officials must understand: ○ The implication of climate change on domestic animals/poultry (heat stress, mortality rate, vector-borne diseases, and foot and mouth disease. (ii) The adaptive capacity of native and hybrid or foreign varieties
Forest & Biodiversity	Department of Forest & Environment		This department oversees afforestation through both natural and artificial regeneration. It also undertakes soil and water conservation activities on mountain slopes in and around forest areas, and works to prevent forest fires. In order to protect plant and animal biodiversity, and maximize the value of forest ecosystem services, officials need to be aware of: (i) The likely impact of climate change on forests, vegetation, biodiversity and produce (ii) The impact of warmer winters in relation to forest fires (iii) Options for adaptation, e.g, identification of vegetation appropriate for warmer temperatures (iv) Extent of likely intensity of extreme events, to plan for protection of watersheds within forests.
Disaster Management	Sikkim State Department for Disaster Management		Sikkim faces a high risk of landslides and heavy precipitation, and therefore neeeds disaster management that is anticipatory in nature. This can be done by integrating climate change into development plans to minimize destruction due to natural disasters. Efforts must also made to develop and upgrade institutional arrangements to link knowledge of climate change with that of the causes of disasters.
Planning & Finance	Department of Planning		Sikkim's planning department oversees infrastructure development. It has a critical role in managing, compiling and approving demands from all departments for infrastructure development. Therefore the department needs to be aware of short- and long-term gains and losses in project such as, for example, the development of hydropower.
	Department of Finance		This department helps prioritize actions required for climate-proofing in each sector and ensure fund availability for the same.
Knowledge Management, Capacity Building & Local Governance	Directorate of Panchayati Raj		The department must be strengthened so that proper representation from all departments can be ensured by drafting Gram Panchayat Development Plans. Officials need to be aware of how to come up with holistic development plans that factor in local disaster risks, climate projections and socio-economic structures in the village..
	Department of Science & Technology		This department must have more manpower and a greater say in the development trajectory of the state.
Urban Habitation and Health	Department of Urban Affairs		The department is in charge of urban transportation/mobility planning, land use, preparing guidelines for disaster-free construction, and urban waste management. Its officials need to be aware of: (i) The minimum and maximum carrying capacity of Gangtok city, a tourist spot, both in Business As Usual (BAU) and in a disaster scenario

			(ii) The implication of Gangtok's expansion for natural resources and how it could aggravate disasters driven by climate change (iii) Waste management solutions such as landfill, incineration, organic manuring plants and other possible solutions
	Department of Public Health		The disease prevalence pattern is likely to change with the changing climate, with a possible increase in vector-borne diseases. Officials must take stock of the likely impacts of climate change on the state's future disease profile, and must design strategies in advance.