State of Environment Report

Sikkim 2016



Development Alternatives

State of Environment Report

SIKKIM 2016










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1. ***Yumthang-Yaksa****, North Sikkim (Photo by Tashi D. Bhutia)*
2. ***Red Panda*** *(Ailurus fulgens) State Animal*
3. ***Blood Pheasant*** *(Ithaginis cruentus) State Bird*
4. ***Nobile Orchid*** *(Dendrobium nobile) State Flower*
5. ***Rhododendron*** *(Rhododendron niveum) State Tree*

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Foreword



Pawan Chamling
(Honoris Causa)
Chief Minister of Sikkim

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It is a matter of immense pleasure and pride that our beautiful State of Sikkim is taking a lead in consolidating the age-old tradition of man-nature affinity living together in harmony. The unique policy endeavour of our Government has brought people closer to Mother Nature.

I am glad to see that my eco-innovations viz. State Green Mission, Ten Minutes to Earth, Smritivans, declaration of Heritage Trees, Mith relationship with trees are now adopted as a way of life by the people of Sikkim. Tangible milestones of achieving 100% sanitation, 100% organic status, inscription of Khangchendzonga National Park as a World Heritage Site, about 4% increase in State forest and tree cover from 43.95% in 1993 to 47.80% in 2015, extension of State's wildlife protected area network from 14.25% in 1993 to 30.77% in 2016, global image of clean and green State are all evidences of our efforts of '**Green**' governance for over two decades. The environment conservation and protection initiatives of Sikkim are unique across the globe. The environment conservation policies such as ban on plastic carry bags, ban of chemical fertilizers, ban on firecrackers, ban on use of Styroforam products, ban on grazing in reserve forest, ban on killing of wildlife, ban on collection of medicinal plants from forest for commercial use,

Foreword

etc have all been very well accepted by the nature loving people of Sikkim. Through these policies, our State has shown ways of eco-friendly lifestyle and has significantly contributed in reducing the harmful impacts of global climate change.

Under our pro-people governance, I am happy to share that the people of my State have been receptive to and conscious of environmental concerns. Let me congratulate all the Sikkimese people for making Sikkim one of the top ten must visit places of the world as rated by Lonely Planet. Now, it is the noble duty of every citizen to maintain the legacy set by our governance.

Let me congratulate the State ENVIS Centre at Forest, Environment & Wildlife Management Department for bringing out this State of Environment Report for Sikkim. I believe that this report will aid the Government in decision support and sustainable policy interventions and will help each citizen in adopting more eco-friendly lifestyles for a better and brighter tomorrow.

With best wishes.



(Pawan Chamling)

Foreword



Tshering Wangdi Lepcha

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Sikkim is blessed with bountiful natural resources, rich biodiversity and its associated varied culture and heritage that form a way of life of the people of this tiny Himalayan State. The people of Sikkim relish lifestyles that are closely linked to nature. Living amongst hills and mountains, fluent rivers and streams, charming and echoing birds and wildlife, cool and clean air, water and organic food gives it all a healthy eco-system amidst challenges and hardship of mountain life.

We are all very grateful to the farsighted and visionary leader, our Hon'ble Chief Minister Shri Pawan Chamling, for conceptualizing a host of unique eco-friendly policies that have motivated all ages for positive environmental actions for sustenance of sustainable Himalayan lifestyles. The dynamic and farsighted state government has tailored its economic development in consonance with nature which has brought several national and international recognition to the State. The Hon'ble Prime Minister of India Shri Narendra Modi himself has been continuously speaking of our good works in different parts of the world. The people of Sikkim must be really proud that today Sikkim is recognised as a model State for clean and green campaign across the globe. While today Sikkim may boast of exemplary green policies and accolades received for it, it also poses fresh challenges and most importantly a responsibility and duty towards upkeep of the legacy set by the State Government.

It is my pleasure to present the 'State of Environment Report Sikkim 2016', which is a culmination of multi-stakeholder effort put in since its inception workshop on July 24, 2015 of which I was a part. This is the second State of Environment Report for our State. The first issue was published by our department during the year 2007. I congratulate the entire team of experts, especially our State ENVIS team and officials of my department for the hard work put in for publishing this report and hope that it will serve as a tool for sustainable development further.

With best wishes.

T. W. Lepcha

Preface



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Nestled in a varied and rich natural ecosystem, though extremely fragile, Sikkim has pioneered a host of unique policy interventions aimed at preserving the age-old natural and cultural practices and hugely applauded across the globe. Much credit goes to the State Government led by the most visionary and eco-friendly Chief Minister, Shri Pawan Chamling whose eco-friendly policies has taken Sikkim far ahead in the race to curb the impacts of global climate change. As a testimony to the concerted efforts of the State Government, the Chief Minister of Sikkim, Shri Pawan Chamling has been conferred with many national and international awards for initiating exemplary environmental actions.

The 'State of Environment Report Sikkim 2016' is a culmination of extensive multi-stakeholder consultative processes ensuring synergy between various socio-economic and environmental groups. This is only the second report of its kind for Sikkim, while the first issue was published by ENVIS of our department in the year 2007.

This report presents status and trends of environment in Sikkim over the past few years covering key ecological parameters such as air, water, land, forests and biodiversity, urbanization and puts forth a perspective on cross-cutting issues such as climate change. The report intends to serve as a baseline document for highlighting the environmental challenges in the State and the positive policy and action reforms in place. The report also intends to serve as a resourceful tool for policy makers and wide range of stakeholders.

I thank the Ministry of Environment, Forest and Climate Change for supporting us in this study. I thank all the stakeholders for their collaboration and significant contributions for bringing out this report. And I hope that this report will fulfill the objective of delivering sustainable developments.

Dr. Thomas Chandy, IFS
Principal Secretary –cum- PCCF

Acknowledgement

The preparation of the State of Environment Report Sikkim, 2016 has been a rewarding and collaborative journey that has benefited from the participation of a diverse spectrum of stakeholders who have contributed immensely to the report. We would like to take this opportunity to thank them all for their generosity in providing their time and effort.

We would extend our heartfelt gratitude to Dr. Thomas Chandy IFS, Principal Secretary- cum- PCCF, Forest, Environment & Wildlife Management Department, Government of Sikkim who envisioned the report as a valuable document to add to the state's repertoire of research based informative documents. We would also like to express our gratitude to the state's ENVIS Center for providing critical inputs, expectation setting at the inception of the report writing process and for facilitating access to various line departments and agencies for consultations and data collection. Shri. B B Gurung, Additional Director, FEWMD, Govt. of Sikkim and Mr. Rajen Pradhan, Senior Programme Officer, ENVIS have been our primary aides in the process. Contributions from Mr. M P Johnson, Statistical Advisor, and Dr. M. Salahuddin, Director, Ministry of Environment, Forest and Climate Change are also appreciated with heartfelt gratitude for their valuable inputs and comments on the draft report. We also thank all the eminent experts from various government departments who reviewed the report and provided valuable inputs for its betterment.

We also thank each one of the participants of the stakeholder consultation meetings for their feedback and suggestions. Some of the Ministries and Agencies that contributed actively include Forests, Environment & Wildlife Management Department; Urban Development and Housing Department; State Pollution Control Board Sikkim; State Biodiversity Board Sikkim; Water Security and Public Health Engineering Department; Rural Management & Development Department; Food Security and Agriculture Development Department; Sikkim Government College Tadong; Health Care, Human Service and Family Welfare Department; Science & Technology and Climate Change Department; Department of Economics, Statistics, Monitoring & Evaluation; WWF Sikkim; Mines, Minerals & Geology Department; Gangtok Municipal Corporation; Land Revenue and Disaster Management Department; Energy and Power Department; Tourism and Civil Aviation Department; Commerce and Industries Department; and Irrigation and Flood Control Department.

Lastly, we thank Mr. George C Varughese (President), Ms. Zeenat Niazi (Vice President) and Dr. K Vijaya Lakshmi (Vice President) from Development Alternatives Group for their guidance and mentorship for finalization of the SoE report. We also acknowledge the efforts of the report drafting team at Development Alternatives led by Ms. Gitika Goswami (Programme Director- Policy and Planning), comprising of Anindita Singh, Anshul Bhamra, Devender Giri, Kavya Arora, Mayukh Hajra, Dr. Pranay Kumar, Syed Abdul Aziz Ishaqi Farhan and Tarang Singh.

This acknowledgement section is a sincere effort to thank all for the contributions in this report including photographs, graphics and maps. Though, this is by no means an exhaustive list, and it does not seek to undermine the value of the multifarious support provided by those whom we have inadvertently missed to mention. We once again express our heartfelt thanks to all.

Contents

1. Overview		
1.1	Introduction	24
	1.1.2 Framework and Audience	24
1.2	Physiography	25
	1.2.1 Climate Characteristics	25
	1.2.2 Natural Resources	26
	1.2.3 Hazards and Disaster Vulnerability	27
1.3	Demography and Human Well-Being	27
	1.3.1 Population growth	27
	1.3.2 Human development and well-being and Migration	27
	1.3.3 Human settlements	28
1.4	Economy	28
	1.4.1 Industry	30
1.5	Global Frameworks and Sikkim	32
1.6	Conclusion	32
2. Air		
2.1	Introduction	36
2.2	Status and Trends	36
	2.2.1 Ambient Air Quality	36
	2.2.2 Indoor Air Quality	37
2.3	Pressures	38
	2.3.1 Vehicular Emissions	38
	2.3.2 Cooking and Heating Fuel	38
2.4	Impacts	38
	2.4.1 Health	38
2.5	Response	41
2.6	Recommendations	41
3. Water		
3.1	State	44
	3.1.1 Surface Water	44
	3.1.1.1 Rivers	44
	3.1.1.2 Glaciers	45
	3.1.1.3 Lakes	45
	3.1.1.4 Springs	48
	3.1.2 Ground Water	48
	3.1.3 Water Quality	48
	3.1.4 Water Resources Availability	49
3.2	Pressures	49
	3.2.1 Pressures from Agriculture	49
	3.2.2 Pressures from Energy	51
	3.2.3 Pressures from Tourism	52
	3.2.4 Pressure due to Climate Change	52
3.3	Impact	52
	3.3.1 Competition for Water and Decreased Allocation	52
	3.3.2 Drying Wetlands	52

	3.3.3 Receding Glaciers	53
3.4	Response	53
	3.4.1 *Dhara Vikas*	53
	3.4.2 *Pokhari Sanrakshan Samiti* (PSS)initiative	54
	3.4.3 Water Harvesting	54
	3.4.4 Flood Management Programme(FMP)	55
	3.4.5 Strengthening Water Storage Infrastructure	55
3.5	Conclusion and Recommendations	55
4. Land		
4.1	State	58
	4.1.1 Land Use Pattern and Forest Cover in Sikkim	58
	4.1.2 Agricultural land	58
4.2	Pressures	60
	4.2.1 Agriculture and Allied Sectors	60
	4.2.2 Disaster Risks	61
	1. Landslides	61
	2. Earthquakes	62
	3. Forest Fires	63
	4.2.3 Urbanization and development	64
4.3	Impact	64
	4.3.1 Degraded Land	64
	4.3.2 Loss of biodiversity	66
	4.3.3 Loss of human life and property	66
	4.3.4 Land Pollution	66
4.4	Response	66
4.5	Recommendations	67
5. Forests and Biodiversity		
5.1	Status	72
	5.1.1 Forests	72
	5.1.2 Human-biodiversity interactions	74
	5.1.3 Protected Areas	74
	5.1.4 Wetlands	78
5.2	Pressures	79
	5.2.1 Introduction of alien/exotic species	79
	5.2.2 Waste Management	79
	5.2.3 Man-animal conflict	79
	5.2.4 Climate Change	79
5.3	Impact	79
5.4	Response	79
5.5	Recommendations	81
6. Urbanization in Sikkim		
6.1	Introduction	84
6.2	Status and trends	84
6.3	Pressures on Environment	84
	6.3.1 Migration and new urban centers	86

	6.3.2 Land use and carrying capacity	86
	6.3.3 Housing	86
	6.3.4 Water and sanitation	86
	6.3.5 Electricity Consumption	88
	6.3.6 Tourism	89
6.4	Impact on Environment	91
	6.4.1 Land and water degradation	91
	6.4.2 Municipal Solid Waste Management	92
	6.4.3 Municipal Waste Water Management	92
	6.4.4 Biomedical Waste Management	92
	6.4.5 Hazardous Waste Management	92
	6.4.6 Air Pollution and Carbon Emissions	93
6.5	Response	95
	6.5.1 Smart Cities	95
	6.5.2 Swachh Bharat Mission (Urban) Mission	95
	6.5.3 Atal Mission for Rejuvenation and Urban Transformation (AMRUT)	95
	6.5.4 Town Planning Activities	96
	6.5.5 Asian Development Bank (ADB) assisted North Eastern Region Capital Cities Development & Investment Programme (NERCCDIP).	96
6.6	Conclusion and Recommendation	96
7. Climate Change		
7.1	Introduction	100
	7.1.1 Climate Monitoring Stations	100
7.2	Status & Trends	100
	7.2.1 Precipitation and Temperature	100
	7.2.2 Future Projections of Climate Change in Sikkim	101
7.3	Drivers	102
	7.3.1 Anthropogenic Emissions of Greenhouse Gases from Sikkim	102
	7.3.2 Land use, land-use change and forestry	103
7.4	Direct and Indirect Impacts of the Changing Climate	104
	7.4.1 Water -Melting of Glaciers	104
	7.4.2 Agriculture	105
	7.4.3 Biodiversity	105
	7.4.4 Urban and Rural Settlements	106
	7.4.5 Energy Sources	106
7.5	Sikkim's Climate Change Response Strategy	107
	7.5.1 Water	107
	7.5.2 Agriculture	108
	7.5.3 Biodiversity	108
	7.5.4 Urban and Rural Settlements	109
	7.5.5 Clean Energy	110
	7.5.6 Resource Mobilization: Education, Finance and Research	110
7.6	Conclusion and Recommendations	110
8. Conclusion and Way Forward		**114**
Annexures Page No. 118-124		

List of Tables

Table Index	Table Name	Page No
Table 1.1	Sikkim Biodiversity at a glance	27
Table 1.2	Decadal Growth Rate	29
Table 1.3	Sex Ratio	29
Table 1.4	Literacy Rate	29
Table 1.5	Urbanization trends	29
Table 1.6	Urban Centers in Sikkim	30
Table 2.1	Annual Ambient Air Quality Index (AQI) in Sikkim for 2016	36
Table 2.2	AQI Description with Associated Health Impact	36
Table 2.3	Industrial Air Quality Annual Data of Sikkim (2015 and 2016)	37
Table 2.4	Annual NAAQS	37
Table 3.1	Major Tributaries of Teesta River	45
Table 3.2	Important Lakes of Sikkim	48
Table 3.3	Ground Water availability status and use in Hilly States of India	50
Table 3.4	Polluted River stretch of Sikkim	50
Table 3.5	Water Utilization by Different Sectors in Sikkim	51
Table 3.6	Sikkim's Hydroelectric Projects	51
Table 4.1	Land Use in Sikkim	59
Table 4.2	Crop Production (in metric tonnes) in Sikkim	60
Table 4.3	Number of Landslides	61
Table 4.4	Earthquake in Numbers and Magnitude	62
Table 4.5	Forest Fires	63
Table 4.6	Category-wise Distribution and Change in Wastelands (Area in Sq. Km.)	64
Table 5.1	Forest Cover of Sikkim	72
Table 5.2	Sikkim's Forest Cover in 2007, 2011, 2015	73
Table 5.3	Protected Area Network in Sikkim	76
Table 5.4	Distribution of Wetlands in Sikkim	78
Table 6.1	Urban Statistics - Sikkim	85
Table 6.2	Different types of Land Use Categories of Gangtok Town, 1975-2011	86
Table 6.3	Projections of water utilisation by sector in Sikkim	87
Table 6.4	PH value and Microbial activities of Urban Centres	87
Table 6.5	Electricity Consumption (in Kwh per annum)	88
Table 6.6	Important Tourist Spots	90
Table 6.7	Tourists Flow in Sikkim	90
Table 6.8	Municipal Solid Waste of Gangtok, Sikkim - Category wise (2016)	91
Table 6.9	Air Quality Data from 7 stations for the month of October 2016	93
Table 6.10	Air Quality Data from 9 industries in the year 2015 and 2016	94
Table 7.1	Energy Consumption in Sikkim	102
Table 7.2	Forest Cover Change Matrix	103
Table 7.3	Increase in Land cover change in Sikkim during 2006 and 2009	103
Table 7.4	Increase in area of glacial and high altitude lakes in Sikkim between 1976-2010	105

List of Figures

Figure Index	Figure Name	Page No
Figure 1.1	Sectoral Contribution to GDSP of Sikkim	31
Figure 1.2	Percentage Change in Workers	31
Figure 1.3	The SDGs Framework with its 17 goals	33
Figure 2.1	Vehicle population by type in Sikkim	39
Figure 2.2	Cooking fuel distribution of households in Sikkim	39
Figure 2.3	State-wise Acute Respiratory Infection (ARI) Deaths	40
Figure 2.4	State-wise Mortality Percentage due to Respiratory Diseases	40
Figure 2.5	Deepawali Noise Pollution Monitoring at Gangtok (2014 to 2016)	40
Figure 3.1	Land Diversion for Various Purposes	49
Figure 4.1	Crop Production (in metric tonnes) in Sikkim	60
Figure 4.2	Earthquake in Numbers and Magnitude in Sikkim	62
Figure 4.3	Degraded Land in Sikkim	65
Figure 5.1	Biodiversity in Sikkim	70
Figure 5.2	Forest Density in Sikkim	72
Figure 5.3	Wetland Areas in Sikkim	78
Figure 6.1	Tourist Flow in Sikkim	89
Figure 6.2	Trend of Vehicle Registrations	93
Figure 7.1	Rainfall Pattern in Sikkim	101
Figure 7.2	Temperature Pattern in Sikkim	101

List of Maps

Map Index	Map Name	Page No
Map 1.1	Administrative Divisions	24
Map 3.1	Distribution of Rainfall	44
Map 3.2	Drainage pattern	46
Map 3.3	Glaciers of Sikkim	47
Map 3.4	Planning of Dhara Vikas in Sikkim	54
Map 5.1	Forest Cover of Sikkim	73
Map 5.2	Protected Area Map of Sikkim	77

Abbreviations

ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AQI	Air Quality Index
ARI	Acute Respiratory Infection
BCM	Billion Cubic Meters
BOD	Biological Oxygen Demand
CDP	City Development Plan
CPCB	Central Pollution Control Board
DO	Dissolved Oxygen
DPRs	Detailed Project Reports
EEA	European Environment Agency
ENVIS	Environmental Information System
FMP	Flood Management Programme
GHG	Green House Gas
GHGE	Green House Gas Emission
GLOF	Glacial Lake Outburst Flood
GMC	Gangtok Municipal Corporation
GSDP	Gross State Domestic Product
HEP	Hydro Electric Project
IAP	Impact Assessment and Planning
IAQ	Indoor Air Quality
ICIMOD	International Centre for Integrated Mountain Development
IMD	India Meteorological Department
IPCC	Inter-governmental Panel on Climate Change
IPP	Independent Power Producers
IPR	Information and Public Relation
ISBEID	Indian State - level Basic Environment Information Database
ISRO	Indian Space Research Organisation
IWDP	Integrated Watershed Development Program
JFMC	Joint Forest Management Committee
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
KBR	Khangchendzonga Biosphere Reserve
MDG	Millennium Development Goal
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MLD	Million Litres per Day
MOSPI	Ministry of Statistics and Programme Implementation
NAAQS	National Ambient Air Quality Standards

NAMP	National Air Quality Monitoring Programme
NAPCC	National Action Plan on Climate Change
NEIPP	North East Industrial and Investment Promotion Policy
NERCCDIP	North Eastern Region Capital Cities Development & Investment Programme
NFHS	National Family Health Survey
NIDM	National Institute of Disaster Management
NMSHE	National Mission for Sustaining Himalayan Ecosystem
NPOP	National Programme on Organic Production
NRDWP	National Rural Drinking Water Programme
PA	Paris Agreement
PHED	Public Health Engineering Department
PMU	Project Management Unit
PSS	Pokhari Sanrakshan Samiti
QUMP	Quantifying Uncertainty in Model Predictions
RKVY	Rashtriya Krishi Vikas Yojana
RMDD	Rural Management & Development Department
RSPM	Respirable Suspended Particular Matter
SAC	Space Application Centre
SAPCC	State Action Plan on Climate Change
SBM	Swachh Bharat Mission
SCCC	State Climate Change Cell
SDGs	Sustainable Development Goals
SDMP	State Disaster Management Plan
SDPC	Sikkim Power Development Corporation
SIPMIU	State Investment Programme Management and Implementation Unit
SLIPs	Service Level Improvements Plans
SPCB	State Pollution Control Board
SREDA	Sikkim Renewable Energy Development Agency
SSDMA	Sikkim State Disaster Management Authority
SSPCB	Sikkim State Pollution Control Board
UDHD	Urban Development and Housing Department
ULBs	Urban Local Bodies
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Culture Organization
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	Volatile Organic Carbons



Mt. Khangchendzonga as seen from Gangtok
(Photo by IPR)

Executive Summary

Sikkim is regarded as one of the pioneering states in India with respect to pragmatic thinking and uptake of the developmental agenda. The state has been the first in the country to become organic, garnering global attention to boost its market and tourism potential. With international impetus on implementation of Agenda 2030 and the Sustainable Development Goals (SDGs), Sikkim has been aligning its developmental initiatives with the triple bottom line approach focusing on the environment, society and economy. The State of Environment Report, Sikkim 2016 is the most recent publication in the ambit being released by the Forest, Environment & Wildlife Management Department, Government of Sikkim, after the last state-level report published in 2007. The report analyses trends and challenges in the different realms with focus on air, water, land and biodiversity. Additionally, the report also contextualizes important impact phenomena such as urbanization, climate change and environmental pollution.

Development Alternatives, as the national host institute for SoE Reporting, has prepared this report under the aegis of the Ministry of Environment, Forest and Climate Change. Evolving through department level data collection, intensive collation and analysis, participatory exercises through multiple stakeholder consultations and subsequent data validation by the government, the report is a comprehensive document about the state's environment.

The spectrum of State of Environment Reporting spans across diverse methodologies and frameworks. This report has adopted the Pressure-State-Impact-Response (PSIR) framework for analysis of environmental issues, putting forth a holistic perspective. There is ample emphasis on depiction of the status quo, along with evident positive and negative trends that have profoundly impacted it. The narrative then progresses to discuss the environmental consequences, followed by the key response adopted to address the issue effectively. Each chapter begins with a brief introduction to the section, summarizing the importance of the natural resource in both the environmental and socio-economic context, supported by a logical content analysis is PSIR framework. The concluding section lists broad recommendations for addressing the challenge at hand.

The following sections are predominantly chapter briefs which present the key findings and the critical inter-linkages that need to be leveraged for sustainable and inclusive development in the state.

Executive Summary

OVERVIEW CHAPTER

The chapter summarizes the overall profile of Sikkim, ranging from the demographics, topography, and economic situation to its diverse biological bounty. It also reiterates the scope and purpose of the report as a user-friendly, relatable and policy oriented document. The section also captures snippets of Sikkim and its developmental agenda in coherence with the global sustainable development framework.

AIR

Air quality of Sikkim's urban centers remains decent at the current rate of population and vehicular growth. The state proactively monitors ambient and industrial air quality through a network of monitoring stations operated by the State Pollution Control Board. With an increase in the influx of tourists, along with higher income standards, state population and an increased number of vehicles in the state, air quality deterioration is a looming threat. The government has taken prohibitive action to tackle the issue by banning the burning of agricultural waste, leaves, litter, paper wastes and garbage within the State of Sikkim under Air Pollution Act 1981. The Government has also prohibited the manufacture, sale and use or bursting of all types of firecrackers within the State of Sikkim.

WATER

The Teesta and its tributaries, many glaciers and natural lakes and springs are major sources of water for the inhabitants. Sikkim's unabated reliance on freshwater resources is now threatened by climate change and increasing pressure on natural resources. The state also lacks sufficient groundwater retention owing to its hilly terrain and resulting quick run-off, making water shortages a potential challenge. Intensive agricultural practices and urbanization may also be contributing factors in water stress across the state. Dhara Vikas, a flagship programme of the government to revive natural springs is an innovative and laudable response measure.

LAND

A scarce resource in the state because of the terrain and disaster vulnerability, land is a valuable commodity. The state has a commendable 47.8% of its land under forest and tree cover, whilst agriculture and human settlements are other major land uses. Sustainable land management essentially demands a check on agricultural practices, disaster resilient planning and regulated urban expansion. The government has targeted policies and programmes to address the prevalent challenges.

FOREST AND BIODIVERSITY

One of the richest biodiversity-endowed states in the country, Sikkim boasts of conserved and scientifically managed ecosystems. 46.93% of its total geographical area is under protected reserves. Major challenges include poor land management practices, encroachment leading to man-animal conflict and adverse impacts of climate change. An extensive regulatory and conservation framework is in place to check biodiversity threats and losses.

URBANIZATION

Urbanization is an essential process for development of the state, though concentrated the trend in nine centers in the state exerts immense pressure on natural resource base in the area. Grave issues of solid waste management and environmental pollution are constantly emerging, with just the urban centers generating 74 metric tonnes of waste per day. Acceleration of policy responses and scientific management would be the key solutions to potential challenges.

CLIMATE CHANGE

Sikkim, as a result of its geographical location in the Himalayas, is highly vulnerable to climate change. Presence of glaciers and stream water dependence aggravates Sikkim's vulnerability to erratic climate events. The state also relies on river discharge for hydropower generation which is a sizeable contribution to its economy too. Climate change is expected to impact the biodiversity, hydrology and livelihoods in Sikkim. However, the state is actively driven to combat these effects, as apparent from responses ranging from its green mission to the ideational state action plan on climate change.

Some of Key Initiatives on Forestry, Environment & Wildlife Management by the State Government of Sikkim

The Government of Sikkim under the visionary leadership of the Chief Minister Shri Pawan Chamling has been following several exemplary environment conservation policies for over past two decades. As a testimony to the concerted efforts of the State Government, the forest cover of the State has increased by about 4% in the last twenty years and the Chief Minister of Sikkim, Shri Pawan Chamling has been conferred with many national and international awards for initiating exemplary environmental actions.

State Green Mission

The Government of Sikkim in 2006 launched a unique and innovative programme called "State Green Mission" for raising avenue plantations along the roads and beautification of all vacant and waste lands to further reinforce wide spread recognition of Sikkim being a Green State.

Ten Minutes to Earth

Ten Minutes to Earth is another novel, unique and innovative programme conceptualized and initiated by the Chief Minister during 2009 in which the 25th day of June every year from 10.30 AM to 10.40 AM is observed by every citizen of the State by dedicating ten minutes of their time in plantation, protection and conservation of Mother Earth.

Paryavaran Mahotsav

Announced by the Chief Minister Shri Pawan Chamling in 2013 Paryavaran Mahotsav is a people's programme observed throughout the State from 15th to 30th June every year. The State Green Mission and Ten Minutes to Earth have now become part of Paryavaran Mahotsav which is to be celebrated every year by all in the State. Cleanliness drives are also organized during this period to clean up our towns and cities.

Smritivan

The Hon'ble Chief Minister Shri Pawan Chamling evolved the concept of *Smritivan* in year 1999 with a noble idea of planting trees in memory of near and dear ones. *Smritivan* is a mass voluntary effort to generate active involvement of the people in planting trees in the drive for Green Sikkim. The objective of this scheme is to create *Smritivan* in every gram panchayat unit.

Mith Trees: In order to promote and revive the age-old tradition of forging brotherhood relationship with trees, the State Government has notified Sikkim Forest Trees (Amity and Reverence) Rules, 2017 that allows any person to associate with trees standing on his or her private land or on any public land by entering into a *Mith/Mit* or *Mitini* relationship with a tree or trees, in which case, the tree shall be called a '**Mith/ Mit tree'**; or by adopting a tree as if it was his or her own child in which case the tree shall be called an '**Adopted tree**'; or by preserving a tree in remembrance of a departed relative in which case the tree shall be called a '**Smriti tree**'.

Declaration of Heritage Trees: Recognizing the silvicultural importance and ecosystem values of the historically significant trees found all over the State that are intimately linked with the evolution of human

settlements and agrarian lifestyles of the people of Sikkim, the State Government has notified total 53 trees of girth class 20ft and above under forest land as "Heritage Trees" of the state under the Sikkim Forest (Preservation, Protection and Declaration) of Heritage Tree Rules, 2016.

Planting ten saplings for every tree cut in private land: The State Government has notified Sikkim Private and Other Non-Forest Lands Tree Felling Rules, 2006 in which for every tree felled, the applicant need to plant ten saplings of trees. When we fell one tree in our *bari* we need to plant ten saplings in its place. This has been a traditional practice in Sikkim and is provided in State laws. Panchayat members also supervise and ensure that people continue to maintain trees in their *bari* by planting ten seedlings for every tree cut which is a means of protection for them.

Ban on Grazing

Grazing in forest areas causes forest degradation so the Government took a decision to ban grazing in reserved forests and plantation areas in 1998. The effect of the ban is perceptible in the form of increased natural regeneration of forests and wildlife and improvement in water availability in nearby villages.

Ban on cutting, lopping and collection of *dhupi, nagbeli and mosses*: The State Government has banned cutting, looping and collection of any form, or leaves of dhupi (*Cryptomeria, Cupressus* etc), nagbeli (*Lycopodium*) and lheu (mosses) for decoration purposes for public or private function.

Ban on collection of medicinal plants from forest areas for commercial use: In order to ensure regeneration of medicinal plants species in forest areas for maintaining the ecological balance, the State Government has imposed ban on collection of all medicinal plants for commercial purposes from forest areas.

Ban on Plastic carry bags: Use of non-biodegradable materials like plastic carry bags has been banned in the State of Sikkim since 1997 as plastic cause permanent pollution in the soil.

Ban on Firecrackers: The State Government in 2014 imposed prohibition on the manufacture, sale and use or bursting of all types of firecracker including any sound emitting or illuminating type of firecrackers within the State of Sikkim as bursting of firecrackers make the environment polluted.

Ban on Burning of Agricultural Waste: The State Government in 2015 has imposed prohibition on the burning of agricultural waste, leaves, litter, paper wastes and garbage within the State of Sikkim. Agriculture wastes add organic manure to the soil so should not be burned.

Ban on Styrofoam: The State Government in 2016 notified ban on sale and use of disposable items such as cups, plates, spoons, containers etc made from Styrofoam throughout the State.

Ban on use of packaged drinking water bottles in State government functions: Sikkim is the first Indian State to ban the use of packaged drinking water bottles in government functions and meetings.

Ban on killing of wildlife: The State Government has imposed ban on hunting or killing of wild animals.

Ban on use of NSAID diclofenac: The State Government has banned the veterinary use of vulture-killer drug NSAID Diclofenac.

Ban on sale of *pan masala* and *gutka*: In the interest of public health, the State Government has banned the sale of *pan parag, pan masala, tulsi, madhu supari, tamanna, gutka supari, rajnigandha* and *pass pass* within the State vide Sikkim Government Gazette notification no. 90 dated 10/04/2002.

Introduction of Environmental Education in Schools: The State Government conceptualized and introduced eco-clubs and green funds in schools and colleges in the year 2000 and introduced compulsory environment education in schools till class VIII in the year 2002.

Chief Minister's Green School Rolling Trophy and State Green Schools Awards: In order to promote environment awareness amongst school children and to acknowledge the efforts of the school eco-clubs for their action towards environment protection and conservation, "Chief Minister's Green School Rolling Trophy and State Green Schools Awards" has been constituted to reward the best eight performing schools with cash prizes of Rs. 5 lakh to the best school, Rs. 1 lakh each to the four Senior Secondary and Secondary schools and Rs. 50,000/- each to one best Junior High School, Primary School and Private School as well. This State award scheme was constituted in the year 2011 and is presented during the State level World Environment Day celebration every year on 5th of June.

Some of the Major Awards and Recognition in Forestry, Environment and Wildlife Sector by Sikkim (1995-2017)

SN	Year	Awards and Recognition
1	1999	Shri Pawan Chamling, Chief Minister of Sikkim was adjudged the "Greenest" Chief Minister of India by Delhi-based Centre for Science and Environment (CSE).
2	2006	India Today ranked Sikkim as 1st amongst twelve eastern states of India in overall performance during the 4th State of States Conclave at New Delhi.
3	2008	Environmentally Sustainability Index (ESI) 2008 prepared by Chennai-based Centre for Development Finance (CDF) adjudged Sikkim as - 1st Rank/ BEST in Natural Resource Management - 1st Rank/ BEST in Reducing Pressure on Environment
4	2008	Rashtirya Nirmal Gram Puraskar for Sikkim: In a glittering award giving ceremony, Sikkim earned the distinction of being the first State in the country to achieve 100 percent sanitation. The award including citation and a gold medal was given away by the president of India, Smt. Pratibha Patil to the Chief Minister of Sikkim, Shri Pawan Chamling.
5	2009	ESI 2009 rated Sikkim as - 1st Rank/ BEST in Reducing Pressure on Environment - 1st Rank/ BEST in State's Response to Maintain Environment
6	2011	Organic Certification accredited by the National Programme for Organic Production (NPOP), India for wild harvest of products (*Aconitum heterophyllum* - tuber/root, Chiretta - whole plant, Seabuckthron - berries fruits, Seabuckthron - juice fruits) by Sikkim State Cooperative Supply and Marketing Federation Ltd.
7	2012	ESI 2011 released by CDF on June 5, 2012 rated Sikkim as - Environmentally most sustainable States of India - Best in State's Policy Response
8	2014	Khangchendzonga National Park declared as one of the top 100 global green destinations by a consortium of top global agencies working on environment and sustainable tourism.
9	2015	Gangtok ranked among the top 10 cleanest cities in India and third among the State capitals according to the *Swachh Bharat* ranking done by the Union Urban development Ministry during August 2015.
10	2015	Gangtok awarded as Cleanest Hill Station of the country by India Today Group at the Safaigiri Awards 2015.
11	2016	Sikkim declared as the first full-fledged Organic State of the country.
12	2016	ENVIS *(Environmental Information System)* Centre at Forest, Environment & Wildlife Management Department, Government of Sikkim was awarded the Best State ENVIS Centre by the Ministry of Environment, Forests & Climate Change, Government of India. The certificate has handed over by Shri Prakash Javadekar, Minister of State (Independent Charge) Environment, Forest and Climate Change during the inaugural function of National Evaluation workshop of ENVIS Centres held on 17th February 2016 at New Delhi.
13	2016	West District of Sikkim bagged the 'Cleanest District of India' award on the occasion of the 10th Civil Service Day awards ceremony in New Delhi held in April 2016.
14	2016	Hon'ble Chief Minister of Sikkim Shri Pawan Chamling received 'Certificate of Recognition' along with a cash prize of Rs. 5.0 lakh for making Gangtok the cleanest city in the North-East India from the Hon'ble Prime Minister of India Shri Narendra Modi at Shillong during May 2016. Hon'ble Chief Minister of Sikkim Shri Pawan Chamling also received 'Certificate of Recognition' for making Sikkim being recognized as the first open defecation free State in the North-East India.

SN	Year	Awards and Recognition
15	2016	The 40th World Heritage Committee on 17th July 2016 at Istanbul, Turkey inscribed Khangchendzonga National Park of Sikkim, India as a UNESCO's World Heritage Site on 'Mixed' criteria recognizing the outstanding universal values for its both natural and cultural significance.
16	2016	Khangchendzonga National Park, Sikkim listed amongst top 100 global sustainable destinations of 2016 by a consortium of top global agencies working on environment and sustainable tourism.
17	2016	Gangtok, the capital town of Sikkim declared as the Cleanest Tourist Destination of the country by the Ministry of Tourism, Government of India
18	2016	Shri Pawan Chamling, Chief Minister of Sikkim was conferred the prestigious Sustainable Development Leadership Award by TERI, New Delhi on 6th of October, 2016 at New Delhi.
19	2017	The Hon'ble Chief Minister of Sikkim Shri Pawan Chamling was conferred with the First Bhairon Singh Shekhawat Lifetime Achievement Honour in Public Service by the Hon'ble President Shri Pranab Mukherjee in Jaipur, Rajasthan on 15th of May, 2017
20	2017	The Hon'ble Chief Minister of Sikkim Shri Pawan Chamling was feted with a yet another global recognition as one of the winners of the 5th One World Grand Prix Award September 8, 2017 at Rapunzel Naturkost in Legau, Germany on occasion of the One World Festival for his pioneering work to transform Sikkim into an Organic State.

One World Award to the Chief Minister of Sikkim Shri Pawan Chamling on September 8, 2017 at Rapunzel Naturkost in Legau, Germany



Shri Pawan Chamling, Chief Minister of Sikkim was conferred the prestigious Sustainable Development Leadership Award by TERI, New Delhi on 6th of October, 2016 at New Delhi.



Shri Pawan Chamling, Chief Minister of Sikkim was conferred with the First Bhairon Singh Shekhawat Lifetime Achievement Honour in Public Service on 15th of May, 2017 at Jaipur, Rajasthan.



Shri Pawan Chamling, Chief Minister of Sikkim was conferred with 'Certificate of Recognition' for making Gangtok the cleanest city in the North-East India during May 2016.



Chapter 1

OVERVIEW



Rhododendron campanulatum subsp aeruginosum
(Pink flower form)



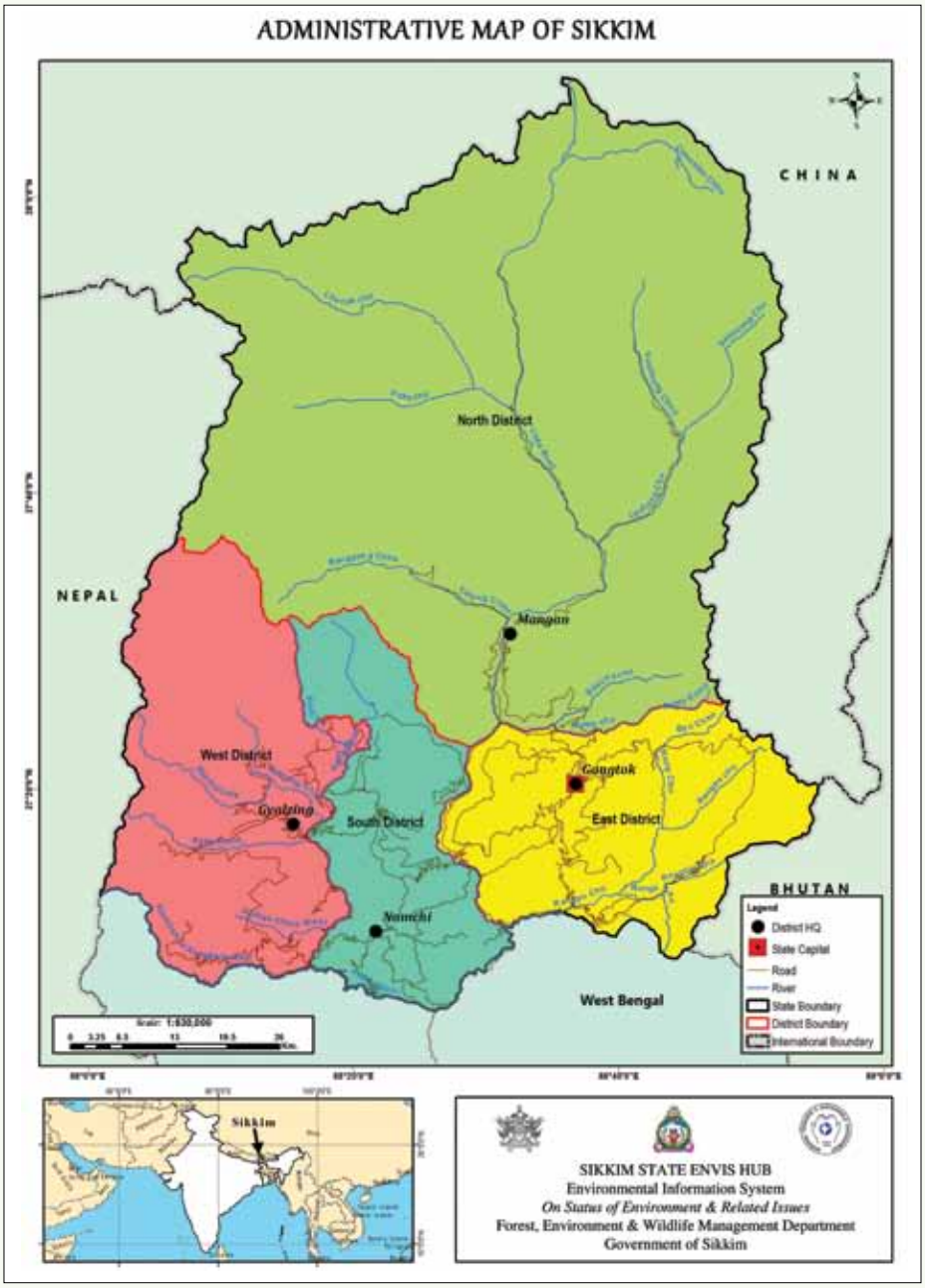
Sikkim is akin to a fairy tale land full of natural beauty, comprising the world's third highest mountain Mt. Khangchendzonga and a wealth of lush green forests and crystal clear rivers. This introductory chapter provides an overview of the report mandate, physiography, demography, biodiversity, climate, economy, industry and the global sustainable development frameworks in relevance to this heavenly state of India –Sikkim.

1.1 Introduction

Sikkim, a hilly State in the Eastern Himalayas, is one of the most beautiful states of India. It lies between latitudes 27° 04' to 28° 07' N (North) and longitudes 88° 00' to 88° 55' E (East) in the physiographic zone of Eastern Himalayas. The state shares its boundary with vast stretches of Tibetan Plateau in the north, Chumbi Valley of Tibet and Bhutan in the east, Darjeeling district of West Bengal in the south and Nepal in the west. The total geographical area of the state is 7096 km^2 and it extends to roughly 112 km from north to south and about 64 km from East to West. Sikkim has the world's third highest mountain, Mt. Khangchendzonga (8,596 m) located on the border of state with Nepal. It is divided into four districts – East district, West district, North district and South district with district headquarters at Gangtok, Geyzing, Mangan and Namchi respectively.

1.1.2 Framework and Audience

Like its predecessors, the SoE Sikkim reports on the current status of various environmental factors of the State, based on the commonly accepted State-Impact-Response (PSIR) framework. This framework is adopted by leading developmental organizations like the United Nations Environment Programme



Map 1.1: Administrative Divisions

(UNEP) and the European Environment Agency (EEA). Although the report uses the PSIR frame as its reporting, the current report also includes discussions on Urbanization and Climate Change. The framework uses 'the causal network' approach to describe not only the state of a particular environmental feature such as Air, Land, Biodiversity, Water but also the pressures of the environmental changes, as well as the impacts of these perceived changes and the governmental and community led responses to them.

Just like the 2007 State of Environment Sikkim report, it is reiterated that this report is aimed at providing a policy oriented and a user-friendly overview of the state on various environmental attributes and trends over time and is meant for a non-specialist user. The objective of this report is not only to develop capacities of non-specialists, but also to make key policy and decision-makers familiar with ground realities so as to facilitate decision-making processes that affect the state's environment. This implies that the information available in this report is comprehensible and useful to a wide spectrum of stakeholders. This report must be seen as a summary of environmental information sourced mostly from different governmental departments and knowledge of the relationships between different components of the environment in a PSIR framework. This report does not intend to portray as a detailed scientific research.

1.2 Physiography

The State is walled on three sides by lofty mountain ranges of Greater Himalayas. The Singalila range runs along the western boundary and separates Sikkim from Nepal whereas the Donkya range forms the eastern boundary of Sikkim. The two trade routes between Sikkim and Tibet are through Nathu La and Jelep La Mountain passes.

The crowning glory of the State is the presence of the world's third highest mountain peak- Mt. Khangchendzonga (8,596 m)**.** It has five satellite peaks: Jano (7,710 m), Kabru (7,338m), Pandim (6,691 m), Narsing (5,825 m) and Siniolchu (6,888 m). The other important peaks are Rathong (6,087m), Simvo (6,811m) and Tolung (7,349 m). The northern portion of Sikkim, particularly beyond Chungthang, is the highest region of the State, which is sparsely populated with the Lachen and Lachung valleys being the only main centers of human settlements.
Sikkim is divided into the following physiographic zones:

a) Lower hills: 300 m to 1800 m

b) Upper hills: 1800 m to 3000m

c) Alpine zone: 3000 m to 4500 m

d) Snow land: 4500 m and above

The general slope of the State is from North to South. However, the degree of the slope varies from place to place. The slope in North district, except Teesta valley below Chungthang and in the north- eastern part of the East district is 600m per km**,** towards south. In the Teesta valley below Chungthang and in the area around Rabongla in the South district, the slope is between 300-600 m per km. The rest of the State consisting of the West District, southern portion of South District and extreme southwest part of North District have a slope of 150m-300m per km.

Glaciers are one of the important physiographic features of the State. They are mostly found in the North district. The most important one is Zemu Glacier, which is 26 km in length and is situated at the base of Mt. Khangchendzonga.

1.2.1 Climate Characteristics

Sikkim is a land of great climatic contrasts within very short distances. The climatic diversity is due to the difference in altitude and the configuration of mountain ranges from just 300m to 8000m above the mean sea level. The state can be divided into five varied climatic zones:

1. Subtropical Humid Type
2. Semi Temperate Type
3. Temperate Type
4. Alpine Snow-Forest Type
5. Alpine Meadow

The lowlands in the south, 800 feet to 5000 feet from MSL, experience a tropical climate. It has lush vegetation such as figs, laurel, Sal trees and bamboos. The temperate forest of oak, chestnut, maple, birch, alder, magnolia and silver fir dominates between 5000 feet and 13000 feet. Above 13000 feet is the alpine zone where juniper, cypresses and rhododendrons grow. The perpetual snowline lies at 16000 feet. Luxuriant forests cover over 47% of the land and more than 5000 species of plants have been recorded in Sikkim. Over 550 species of orchids grow in the tropical and temperate zones of Sikkim, which are essentially of epiphytic and terrestrial types.



Red Panda (Ailurus fulgens)
State Animal

1.2.2 Natural Resources

Sikkim is very rich in natural resources. It is home to nearly half of the nation's biodiversity. The State has one third of the country's flowering plants (Table 1.1).

The two major rivers of Sikkim are Teesta and Rangit, the latter being a tributary of the former. The melting of snow in the mountains and precipitation in the catchment areas feed these rivers, which play an important role in the cultural spectrum of Sikkim. A great part of the fables and customary lifestyles of the local people revolve around Teesta and Rangit. The rivers also support the livelihood of the local people besides nursing the rich biodiversity of the state.

The major soil types found in Sikkim are mountain meadow, brown red and yellow and lateritic soil. In South District, soils are derived from sandstone, phyllite, schisits, gneisses and colluvial materials. Soils are generally acidic to very acidic in nature, having soil pH between 5.0 and 6.0 (Sikkim, Ground Water Information Booklet, 2013).

Sikkim is part of the eastern Himalayan hotspot with wide topographical variation, varied climatic conditions and high annual precipitation, which make this region one of the richest regions of Himalaya in terms of physiography.

In spite of low accessibility, thick vegetation and soil cover, a number of base metal occurrences have been reported in Sikkim, majority of which are in the Daling group of rocks covering parts of West, South and East districts of Sikkim.

Table 1.1: Sikkim Biodiversity at a glance

Nature of Biodiversity	Number of species
Floral	
Flowering Plant	5500
Orchids	557
Rhododendrons	38
Conifers	16
Bamboos	28
Ferns and Ferns allies	362
Tree Ferns	9
Primula	30
Oaks	11
Medicinal Plants	1681
Lichens	506
Magnolias	12
Trees and tall Bamboos	717
Small grasses	257
Bushes	112
Fauna	
Mammals	>144
Bees	30
Beetles	994
Birds	568
Butterflies	689
Fishes	48
Frogs	16
Lizards and Snakes	92
Reptiles	33
Amphibians	50

Source: *http://sikenvis.nic.in/Database/Biodiversity_776.aspx*

1.2.3 Hazards and Disaster Vulnerability

The state of Sikkim nested in the Himalayas is vulnerable to natural hazards, which include Earthquake, Landslide, Cloud Burst and Flash Flood, Forest Fire, Avalanche and GLOF, Hailstorm, Thunderstorm and Lightning, Drought and Windstorm (Sikkim SDMP, 2015).

The state is located in the high risk seismic zone IV of the Indian seismic zoning map because of the tectonic movement of Indian plate into the Eurasian plate (Sikkim SDMP, 2015). This also makes the state susceptible to landslides owing to the slope instability, weak composition of the soil or rock structures. The situation further aggravates due to rain, flooding, seismic events, removal of vegetation, construction activities, etc. It is also at risk due to flash floods caused by cloud bursts in the higher reaches of the state. The high precipitation along the river basin causes damages to life, livestock and properties. Further, the close proximity to Bay of Bengal causes cyclonic effects over the state very often causing heavy incessant rainfall and windstorms leading to extensive damages to the standing crops directly affecting the livelihood of the people (Sikkim SDMP,2015).

1.3 Demography and Human Well-Being

The total population of the State is 6,10,577 (Census of India, 2011). In terms of population, it is the least populated among the States and Union territories in the country.

1.3.1 Population Growth

The decadal growth rate of population has shown a sharp decline to 12.89 per cent during the period 2001-11, from 33.06 per cent during 1991-2001. The population is unevenly distributed, with East Sikkim being densely populated and North Sikkim being sparsely populated mainly due to the varied topography of the state.

As per Census 2011, the population density of the state is 86 persons per square kilometer. The maximum concentration of population is in the East District i.e. 297 persons per square kilometer. The minimum concentration of population is in the North District, i.e., 10 persons per square kilometer due to the rugged terrain and topography (Table 1.2).

There has been an improvement in sex ratio of Sikkim from 875 females per 1000 males in 2001 to 890 females per 1000 males in the 2011, although this still remains to be less than the national average of 940 (Table 1.3).

1.3.2 Human Development and Well-Being and Migration

From the year 2001 the literacy rate has improved in Sikkim. As per Census 2011 the total literacy rate is 81.4%, with the male and female literacy rates being 86.60% and 75.60% respectively.

A recent study revealed that large scale migration occurred during 1970-1990 with the growth rate of 50.77% to total population (Bhutia & Srivastava, 2014). Further, 65.02% of migrated population is present in the eastern district due to the proximity to the State capital Gangtok and increased urbanization. The large scale of migrant population is deemed to affect the demographic pattern and socio-economic profile of Sikkim.

1.3.3 Human Settlements

Sikkim is predominantly a rural state. Urban population accounts for nearly 25 percent (1,53,578) of the total population (6,10,577).

Urban development is not uniform throughout the State. The four districts of the State have nine urban centers in total. The East district is the most urbanized one and accounts for nearly eighty percent of the total urban population. This has been discussed in detail in the Chapter on Urbanization.

1.4 Economy

Sikkim's economy is primarily agrarian, though there are other sectors also like horticulture, tourism, mining, forestry, industries etc. Sikkim is rich in bio-diversity and natural beauty, making it a sought after tourist destination.

It is evident that the contribution to Sikkim's economy from agriculture and allied sectors has been on the decline, along with that from primary[1] and tertiary sectors[2] (Figure 1.1). There has been an increasing trend observed in the secondary sector[3]. Higher growth rate attained by the construction sector as well as electricity, gas and water supply was the reason of increase in the contribution from the secondary sector. Tertiary sector contribution was also on the decline since the hotels and restaurants grew at a slower rate (Planning Commission, 2008). Sikkim reported the lowest percentage of population that is below the national poverty line, which is accounted as 8 percent.

As per Census 2011, out of total nine towns, only a single town i.e. Gangtok belong to class I with the population size of 100,000 and above. There are no towns under classes II and III with the population size of 50,000 to 99,999 and 20,000 to 49,999 respectively in Sikkim.

Three towns namely Namchi, Rangpo and Nayabazar-Jorethang fall in class IV category with a population size of 10,000 to 19,999. Singtam and Rhenock towns fall in class V with the population size of 5,000 to 9,999 while Mangan and Gyalshing fall in class VI with the population size of less than 5,000. The urban local bodies of Sikkim are detailed in Table 1.6.



Students enjoying thier way to school (Photo by IPR)

Table 1.2: Decadal Growth Rate

State/District	Population 2011	Percentage Decadal Growth	Density persons per square kilometers	
	Persons	2001-11	2001	2011
Sikkim	**610,577**	**12.89**	**76**	**86**
North District	43,709	6.53	10	10
West District	136,435	10.69	106	117
South District	146 ,850	11.65	175	196
East District	283 ,583	15.73	257	297

Source: *Census of India, 2011*

Table 1.3: Sex Ratio

Districts	1971	1981	1991	2001	2011
Sikkim	**863**	**835**	**878**	**875**	**890**
North District	853	789	828	752	767
West District	937	906	915	929	942
South District	909	854	892	927	915
East District	791	797	859	844	873

Source: *Census of India, 2011*

Table 1.4: Literacy Rate

State/District	Literacy Rate in Percentage					
	Persons		Males		Females	
	2001	2011	2001	2011	2001	2011
Sikkim	**68.08**	**81.4**	**76.04**	**86.60**	**60.40**	**75.60**
North District	67.2	78	75.69	83.30	55.39	71.00
West District	58.8	77.4	66.82	83.50	50.11	70.90
South District	67.3	81.4	74.29	86.50	59.72	75.80
East District	74.7	83.9	81.20	88.50	66.80	88.50

Source: *Census of India, 2001and 2011*

Table 1.5: Urbanization Trends

Year	Total Population	Urban	% of Urban to Total
1951	137725	2744	1.99%
1961	162189	6848	4.22%
1971	209843	19668	9.37%
1981	316385	51084	16.15%
1991	406457	37006	9.10%
2001	540851	59870	11.07%
2011	610577	153578	25.15%

Source: *Census of India, 2011; City Development Plan-Gangtok City*

Table 1.6: Urban Centers in Sikkim

S. No	Name of The ULB	Status	Population
1	Gangtok Municipal Corporation	ULB	100286
2	Namchi Municipal Council	ULB	12190
3	Rangpo Nagar Panchayat	ULB	10450
4	Nayabazar-Jorethang Municipal Council	ULB	10244
5	Rhenock Census Town	CT	5883
6	Singtam Nagar Panchayat	ULB	5868
7	Mangan Nagar Panchayat	ULB	4644
8	Gyalshing Municipal Council	ULB	4013

Source: *Census 2011 *Gyalshing Nagar Panchayat has been upgraded to Gyalshing Municipal Council in 2015*

***The Jorethang Nagar Panchayat and Nayabazaar Notified Town Area have been combined to form the Nayabazaar-Jorethang Municipal Council in 2015*

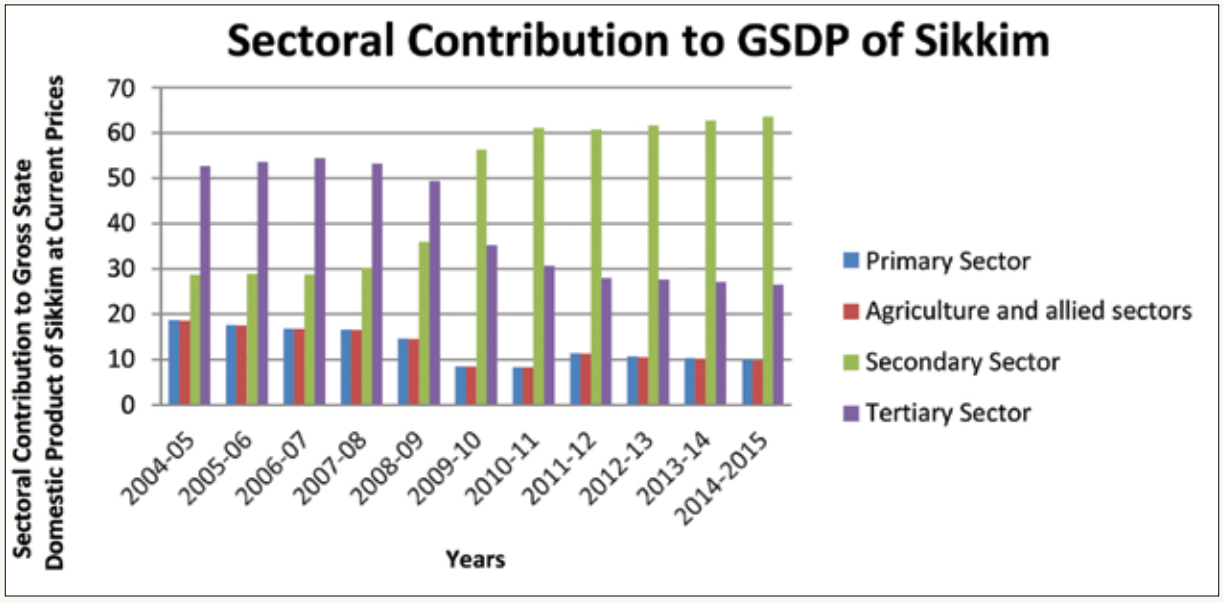
1.4.1 Industry

The State of Sikkim has been balancing both industrialization and environment. Although the state is lagging behind in industrial development, it has successfully attracted considerable investments from pharmaceutical companies in the last five years. Tax incentives provided under the North-East Industrial and Investment Promotion Policy 2007 and additional incentives provided by the State Government have played an important role in attracting these investments. During 2007–10, the State attracted around 14 companies with a total investment of Rs.25,000 million. Sincere efforts are made to promote small scale and medium scale industries based on agriculture and forest products. Simultaneously, Government is making sincere efforts to promote traditional arts and crafts such as wood carving, cane bamboo work, carpet weaving, *thanka painting* and traditional handlooms. In the year 2014-2015, Sikkim's industrial sector contributed to 61.28% of Gross Domestic Product of the State. This sector has witnessed a growth of 32.44% from the year 2004-05 onwards.



Industries in Sikkim

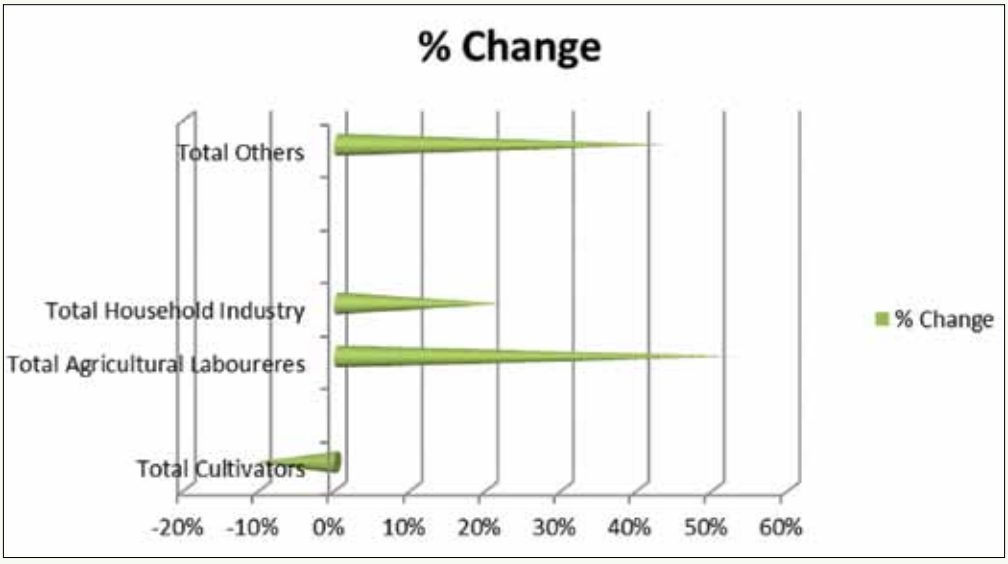
Figure 1.1: Sectoral Contribution to GSDP of Sikkim



Source: *Statistical Journal 2015, Department of Economics, Statistics, Monitoring and Evaluation Government of Sikkim*

[1] Primary sector includes agriculture, forestry, fishing, mining and quarrying.
[2] Secondary sector include manufacturing, industry, building and construction work
[3] Tertiary sector include transport, communication, commerce, administration and other services

Figure 1.2: Percentage Change in Workers



Source: *Human Development Report Sikkim, 2014*

1.5 Global Frameworks and Sikkim

Significant achievements in terms of global frameworks and research in climate change have been made since the last SoER Sikkim 2007. The IPCC report (2014) and various other research works since 2007 have pushed our knowledge and understanding of climate change. There is now a global consensus on the nature and scale of human-induced climate change. The focus is now on adaptation and mitigation actions. Even more recently we have the Paris Agreement, one of the most ambitious climate change agreement so far. The Paris Agreement (PA) stresses the importance of mitigation and adaptation measures as well as loss and damage due to climate change. Sikkim SAPCC (State Action Plan on Climate Change) has prioritized adaptation over mitigation, although most measures have co-benefits for each other. The Sikkim SAPCC does not have any formal mechanism to address the loss and damage arising from extreme and slow on-setting climatic impacts yet. India's Nationally Determined Contributions help Sikkim as a state to relook and redefine its targets in the light of the new agreement.

The targets defined by Millennium Development Goals (MDG) Project of the United Nations Millennium Summit of 2000 are now updated with the new Sustainable Development Goals (SDGs). This creates a new way of reporting on the state of the environment. Some of the environmental specific SDGs are: goals 6, 7, 12, 13, 14 and 15; that address environmental protection (both land and water), clean water and energy access and climate change.

These frameworks help to push towards achieving environmental sustainability with regards to climate change, loss of biodiversity and a shortage of basic environmental resources. Therefore, they act as key indicators for environmental performance. Global frameworks are important for guiding the national and local actions. It becomes relevant for a State like Sikkim to aim at the convergence of the below mentioned global frameworks.

1.6 Conclusion

The State of Environment Report (2016) Sikkim is a key tool for driving towards sustainable development. It gives a screenshot on how Sikkim's environment has changed over the past 10 years and allows acknowledgement of achievements, and further acts as a guide to adjust and realign policies and activities where the status is poor or environmental degradation is present or worsening.

This report consists of three parts, an introductory overview section, thematic chapters that focus on different components of the environment, and the third section that focuses on two of the processes that are affecting Sikkim's environment the most.

The State of the Environment report also includes few recommendations in each chapter but has a final conclusion and the way forward chapter, which discusses some of the recommendations that can be taken up by the government.. This gives an idea of what needs to change on the policy and practice front in order to secure a more desirable future for the environment. Issue such as climate change, even though only one of the many environmental challenges the State faces, prevails throughout all chapters. Sikkim's culture is also identified as a significant shaping force in terms of environmental performance and therefore each chapter allocates a response towards the traditional practices that prevail for responsible environmental management.

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Figure 1.3: The SDGs Framework with its 17 goals



Source: *United Nations*

Chapter 2

AIR



M. G. Marg, Gangtok



This chapter focuses on air pollution. The issue is analyzed in Pressure-State-Impact-Response framework. Though Sikkim has maintained fairly good quality of air throughout the State, air pollution is a growing threat in future to human health and the natural environment. The chapter also highlights unique initiatives taken by the State Government.

2.1 Introduction

Sikkim has been blessed with a rich and clean environment along with proactive citizens. The health of its air, studied in conjunction with the levels of noise becomes an integral part of the state of Sikkim's environment. Compared with other Indian states, air and noise pollution in Sikkim remain well within the prescribed national standards. Proximate, anthropogenic causes of air and noise pollution in Sikkim include pollution from heating and cooking fuel in houses, and vehicles and industries which in turn are impacted by underlying causes of development and modernization.

According to the State Pollution Control Board, Sikkim currently has eight air quality monitoring stations sanctioned and operating under the National Air Quality Monitoring Programme (NAMP) which situated in major town areas throughout the State. Intermittent ambient air quality monitoring has been performed at 7 locations across the state for the month of July to December in 2016. Similarly Industrial air quality measurement for 9 industries has been carried out during 2015 and 2016. Sikkim State Pollution Control Board (SPCB) has also been monitoring noise levels in and around Gangtok, the state capital around the time of Diwali since 2015 as a proactive measure.

2.2 Status and Trends

According to Section 2 (b) of Air (Prevention and Control of Pollution) Act, 1981, air pollution has been defined as 'the presence in the atmosphere of any air pollutant.' Section 2(a) of the Act defines air pollutant as 'any solid, liquid or gaseous substance (including noise) present in the atmosphere in such concentration as maybe or tend to be injurious to human beings or other living creatures or plants or property or environment.' The revised National Ambient Air Quality Standards currently in place were notified by the CPC Bin 2009 and measure the concentration of 12 air pollutants (Sulphur Dioxide-SO_2, Nitrogen Dioxide - NO_2, PM10, PM2.5, Ozone - O_3, Lead - Pb, Carbon Monoxide - CO, Ammonia - NH_3, Benzene-C_6H_6, Benzo (a) Pyrene-BaP, Arsenic- As and Nickel-Ni) under outdoor air quality. The indoor air monitoring guidelines are currently in the draft stage and include measurement of temperature, relative humidity, CO_2, Respirable Suspended Particulate Matter (RSPM), Volatile Organic Carbons (VOCs), O_3 and CO.

2.2.1 Ambient Air Quality

The ambient air quality monitored by the State Pollution Control Board Sikkim at seven stations throughout the State for the year 2016 (July to December) shows that Sikkim's ambient air quality is good and within the permissible limits at all towns.

Table 2.1: Annual Ambient Air Quality Index (AQI) in Sikkim for 2016

Station	District	AQI for 2016
Rangpo	East Sikkim	**55**
Singtam	East Sikkim	**40**
Ravangla	South Sikkim	**26**
Namchi	South Sikkim	**23**
Pelling	West Sikkim	**21**
Chungthang	North Sikkim	**23**
Mangan	North Sikkim	**21**

Source: *State Pollution Control Board, Sikkim (Average AQI for 2016 taken from the month July to December)*

Table 2.2: AQI Description with Associated Health Impact

Good (0–50)	Minimal Impact	**Poor (201–300)**	Breathing discomfort to people on prolonged exposure
Satisfactory (51–100)	Minor breathing discomfort to sensitive people	**Very Poor (301–400)**	Respiratory illness to the people on prolonged exposure
Moderate (101–200)	Breathing discomfort to the people with lung, heart disease, children and older adults	**Severe (>401)**	Respiratory effects even on healthy people

While Sikkim still possesses good to satisfactory ambient air quality, with an increase in the influx of tourists, along with higher income standards, state population and an increased number of vehicles in the state, an detrimental trend could be observed in the coming years causing degradation in the quality of air.

2.2.2 Industrial Air Quality

Industrial air pollution is a new but important concern for Sikkim, with the government's initiatives to open the state's economy by providing various incentives to industries such as those under the North East Industrial and Investment Promotion Policy (NEIPP,2007). The State Pollution Control Board monitored the air quality around 9 industrial sites in East and South Sikkim during 2015 and 2016 (Table 2.3). The annual values (Table 2.4) for pollutants are taken as measurement standards. The annual monitoring reveals that emissions are within the permissible limits for a majority of the monitored locations as can be seen below. However, two locations in East Sikkim have exceeding levels of NO2, PM10 and PM2.5 for both the years.



Zydus Sikkim
(Pharmaceutical Industry in Sikkim)

Table 2.3: Industrial Air Quality Annual Data of Sikkim (2015 and 2016)

Sl. No.	Name of Industry	Location	District	2015				2016			
				SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$
1	Golden Cross Pharmaceutical Pvt. Ltd.	Mulukhey	East	18	56	73	34	5.7	11.1	61.4	31.9
2	Alkem Laboratories Ltd.	Kumrek	East	14	51	61	39	7.55	27.85	54	20.9
3	Cipla Pharmaceutical Ltd.	Kumrek	East	14	34	58	21	9.5	47.5	58.5	26.5
4	Torrent Pharmaceutical Ltd.	32 No. Middle Camp	East	27.17	31.17	90.17	52.33	28	33	82.5	47.5
5	Zydus Wellness Sikkim	Mamring	South	BDL	11.6	53.5	25.5	10	26.3	72.4	29
6	Zydus Healthcare	Bagey Khola	East	BDL	BDL	34.9	21	5.9	10.7	63	31.85
7	Sun Pharma Laboratories Ltd.	Setipool	East	BDL	10	43.66	27.6	10	28	51	17
8	Denzong Albrew Pvt. Ltd.	Mulukhey	East	7.6	32.55	45	10	4	27	40	14
9	Godrej Consumer Products Ltd.	Mamring	South	6	23	41	16	12.5	39	43.5	17.5

Source: *State Pollution Control Board, Sikkim*

Table 2.4: Annual NAAQS

Annual Contaminant Levels $\mu g/m^3$	SO_2	NO_2	PM10	PM2.5
	50	40	60	40



Vehicular Traffic at Hospital Dara, Gangtok

2.3 Pressures

The quality of air in Sikkim is within the current norms set by the NAAQS in a majority of places, though the presence of NO_2, $PM_{2.5}$ and PM_{10} in some industrial areas exceed the CPCB norms (see Table 2.3 and 2.4). This section lists some of the immediate and future pressures of air pollution in the state.

2.3.1 Vehicular Emissions

Exhaust emissions from petrol and diesel vehicles constitute a major pollution hazard to the environment. With an increase in registration of vehicles within Sikkim as well as increasing daily inflow of tourists into the city through road (the only available mode of transportation), contribution of vehicular emissions to air pollution is set to increase in the coming years.

The number of registered vehicles has increased 3.6 times between 2000 and 2012, as can be seen in figure 2.1. The increase in vehicle population over the years of different vehicles can also be seen in figure 2.1. While the quality of air in the state is still of a moderate to good quality, an increase in the number of vehicles poses immediate threats to Sikkim's air quality.

2.3.2 Cooking and Heating Fuel

Sikkim shows a similar trend (Figure 2.2) in its use of cooking fuel as the rest of the country with nearly 50% of its rural population using bio mass as their cooking fuel and nearly 90% of its urban population using clean cooking fuel (*Census of India*, 2011). Biomass includes easily available fuel for burning such as firewood, crop residue, and cow dung while clean cooking fuel includes compressed natural gas, piped natural gas, as well as electricity. Use of biomass can be seen in poorer households, in rural areas as well as in geographically remote areas that lack access and connectivity to clean energy sources. Lack of access to clean cooking and heating fuel is a leading cause in poor Indoor Air Quality (IAQ) which results in numerous respiratory diseases in women and a higher mortality rate in children less than 5 years of age.

2.4 Impacts

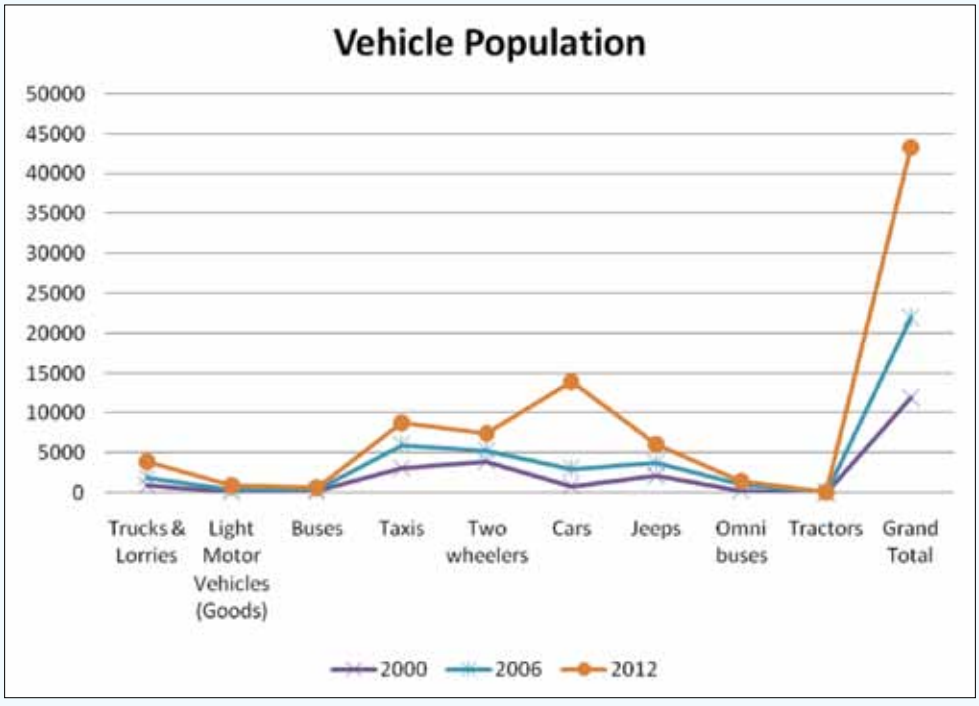
2.4.1 Health

Air pollution leads to a significant amount of mortality and morbidity in all developing countries. The incidence of respiratory diseases is very high in Sikkim (15.3%) which is much higher than the Indian Standard of 4.77% (NFHS, 2017). The state-wise medically certified deaths due to diseases of respiratory systems in 2011 are higher than Indian average of 9.71%. Although, poor air quality is one of the contributing factors here, the high incidence of tobacco abuse in both women and men in the state could also be another major contributor to poor respiratory health (*National Family Health Survey–4*, 2017).



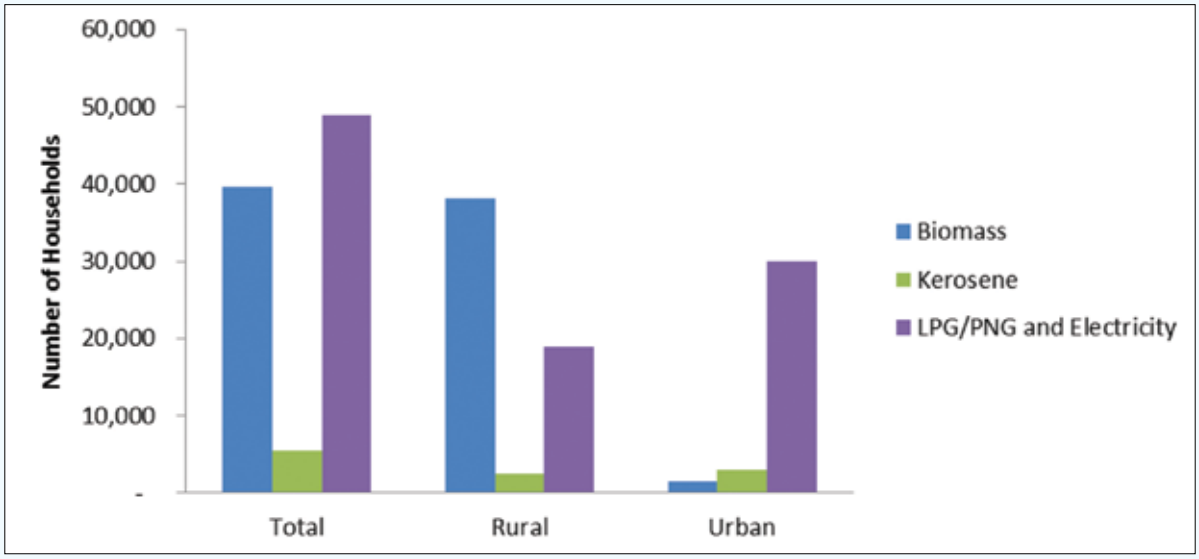
Use of firewood for cooking

Figure 2.1: Vehicle population by type in Sikkim



Source: *Sikkim Road Transport Department*

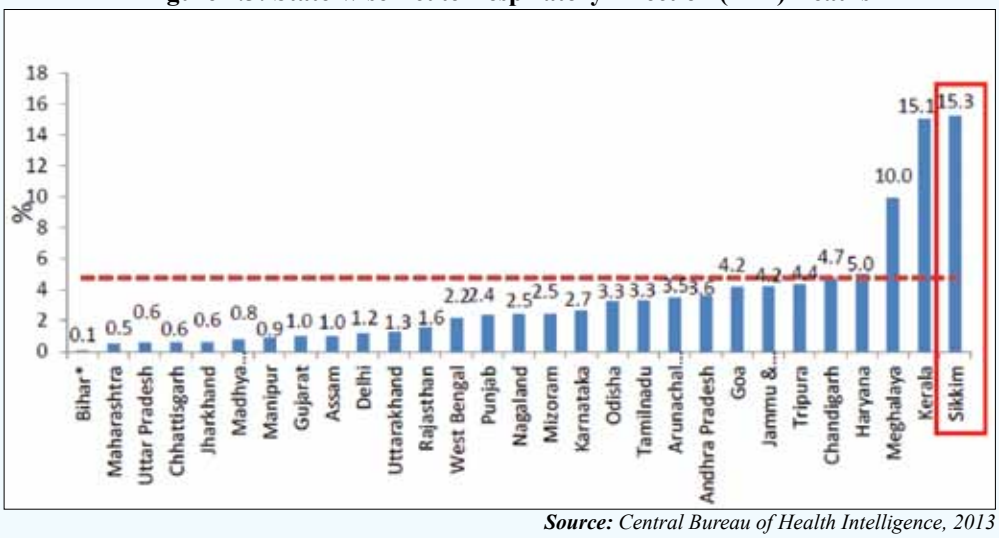
Figure 2.2: Cooking fuel distribution of households in Sikkim



Source: *Census of India, 2011.*

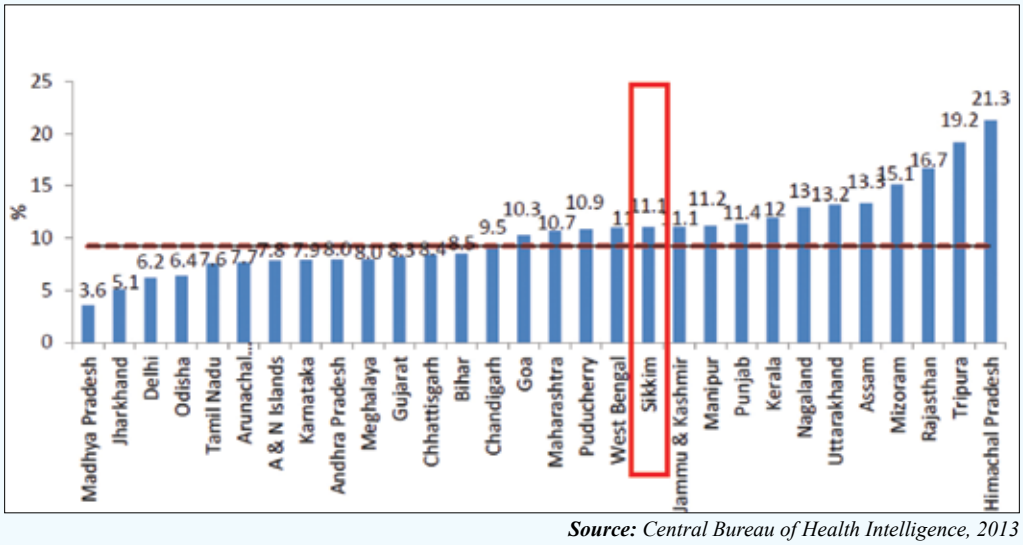
Note: Data included is only for households involved in indoor cooking.

Figure 2.3: State-wise Acute Respiratory Infection (ARI) Deaths



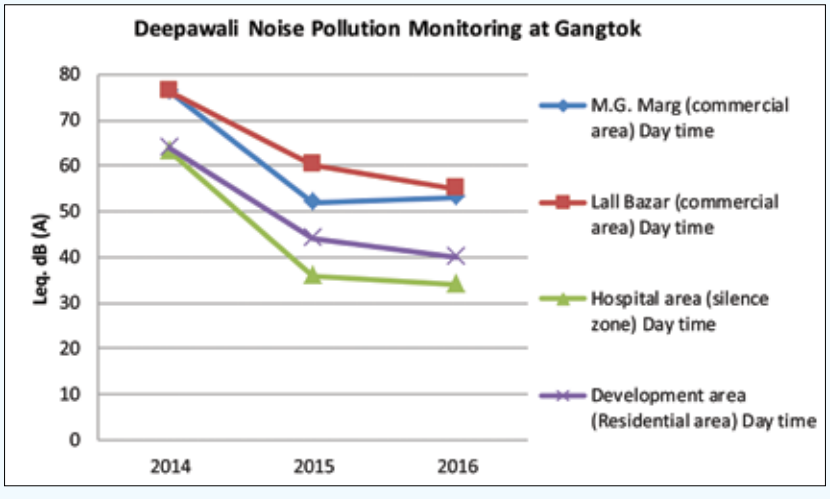
Source: *Central Bureau of Health Intelligence, 2013*
**The red line indicates the All India Value*

Figure 2.4: State-wise Mortality Percentage due to Respiratory Diseases



Source: *Central Bureau of Health Intelligence, 2013*

Figure 2.5: Deepawali Noise Pollution Monitoring at Gangtok (2014 to 2016)



Source: *State Pollution Control Board Sikkim*

2.5 Response

Sikkim State Pollution Control Board (SSPCB) has a regular Ambient Air and Water Quality Monitoring Programme to assess the status of pollution in the natural environment. These monitoring programmes are funded by the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India.

The State Government in consultation with the State Pollution Control Board has prohibited the burning of agricultural waste, leaves, litter, paper wastes and garbage within the State of Sikkim under Air Pollution Act 1981. This prohibition shall, however, not cover the use of processed agricultural wastes, leaf litter, and garbage as fuel and controlled burning of forest litter for the purpose of scientific management of forest fires.

Sikkim Government has banned the manufacture, sale, and use or bursting of firecrackers during 2015 which as a proactive step towards reducing air pollution. The State Government has also distributed smokeless *chulla* in North and West district in order to reduce the magnitude of indoor air pollution. Some of the other steps are – formulation of Public Transport Policy 2005-2006 and promotion of a dynamic fuel policy.

The noise level monitored during Deepawali festival from 2014 (Figure 2.5) onwards shows decline in noise level after implementation of firecracker ban in the entire State with effect from December 2014. It can be attributed to the fact that people have refrained from using firecrackers and the collective initiative taken by the general public and the State government to reduce air and noise pollution has been successful.

2.6 Recommendations

One of the major recommendations for the State is to ensure regular monitoring of both its ambient air as well as indoor air. Although ambient air monitoring has been done by the state in a sporadic way, there has been no monitoring done for its indoor air quality. This becomes of utmost importance in majority of the state which is rural and where biomass is used as the preferred fuel for indoor cooking. The impacts of IAP cannot be measured without a preliminary monitoring on IAQ. This is especially important for the health of women and children, who bear the brunt of such life circumstances.

Additionally, regular checking of vehicular emissions needs to be undertaken considering the 3.6 times increase in vehicle ownership among the people of Sikkim from 2000-2012. In the coming years, with rising influx of tourists (and the only mode of travel being road) as well as industrialization of the state, pollution through transport and non-transport vehicles could become a leading cause of air pollution for Sikkim. Therefore, both ownership and daily inflow of vehicles will have to be monitored and remedied to ensure a healthy air environment for the state.

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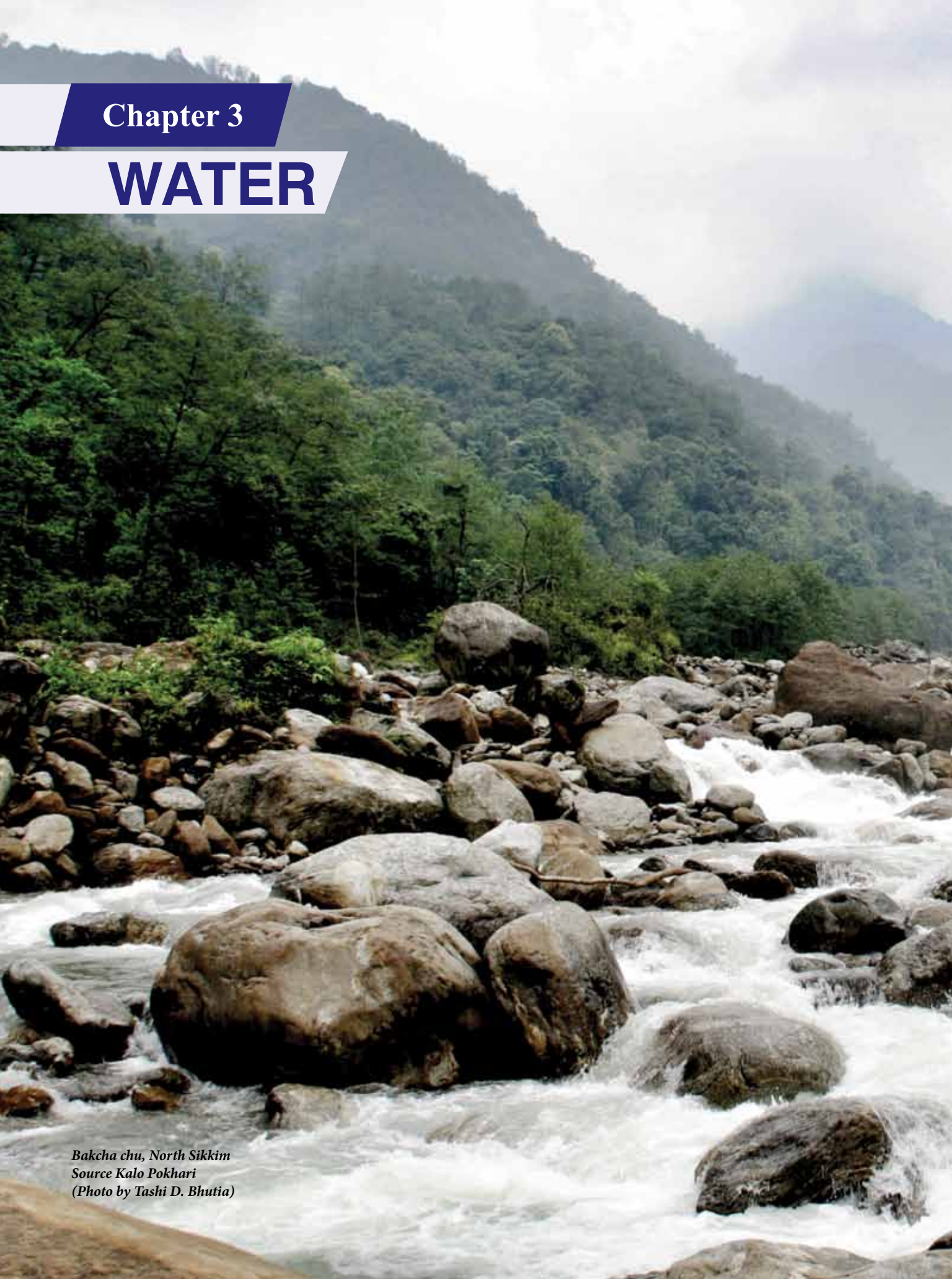
Water Resources

CPCB 2014 *National Ambient Air quality Status and Trends-2012*Central Pollution Control Board and Ministry of Environment, Forest and Climate Change

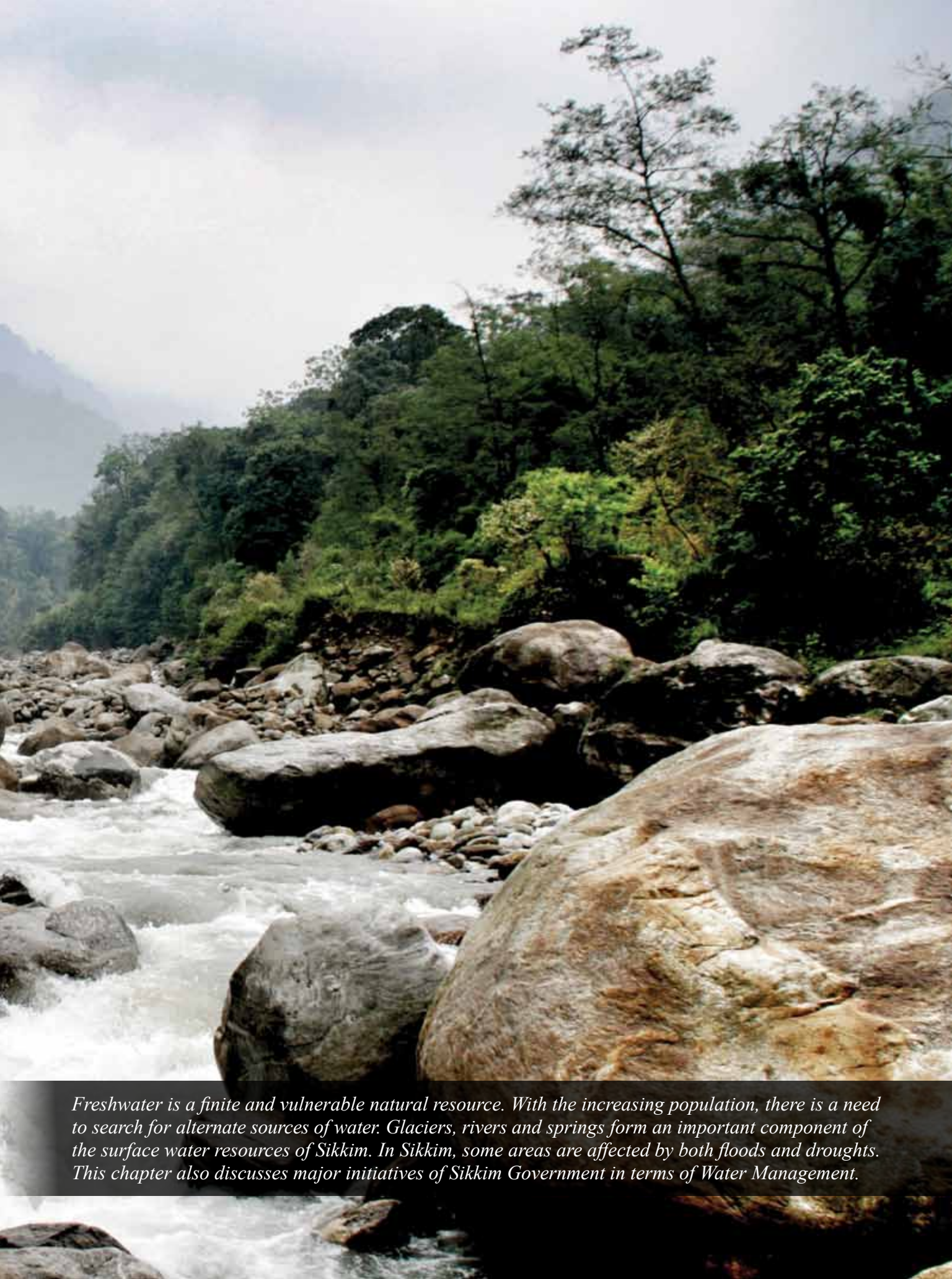
FEWD 2011 *Schemes and Policies Implemented from 1995-96 till 2010-11*

Chapter 3

WATER



Bakcha chu, North Sikkim
Source Kalo Pokhari
(Photo by Tashi D. Bhutia)



Freshwater is a finite and vulnerable natural resource. With the increasing population, there is a need to search for alternate sources of water. Glaciers, rivers and springs form an important component of the surface water resources of Sikkim. In Sikkim, some areas are affected by both floods and droughts. This chapter also discusses major initiatives of Sikkim Government in terms of Water Management.

3.1 State

The State of Sikkim is gifted with enormous water resources available in the form of rivers and natural springs. As per data from the Department of Science, Technology and Climate Change, Government of Sikkim there are altogether 84 glaciers in the Teesta Basin covering an area of about 440.300 sq km. Sikkim receives a fairly good amount of rainfall which is a vital factor for availability of water resources in any region. The mean annual rainfall is minimum at Thangu (82mm) in North Sikkim and maximum at Gangtok 3494 mm in East Sikkim (NIDM, n.d.). South and West part of Sikkim due to their location in rain shadow areas receive lesser rainfall. There is a strong need for ensuring water security in Sikkim due to its dependence on springs, streams and rainfall for drinking water and irrigation.

This chapter discusses the state of water bodies in Sikkim, with the pressures on them due to tourism, agriculture and climate change. It then explores the impacts that are being caused leading to how the Government and community is responding.

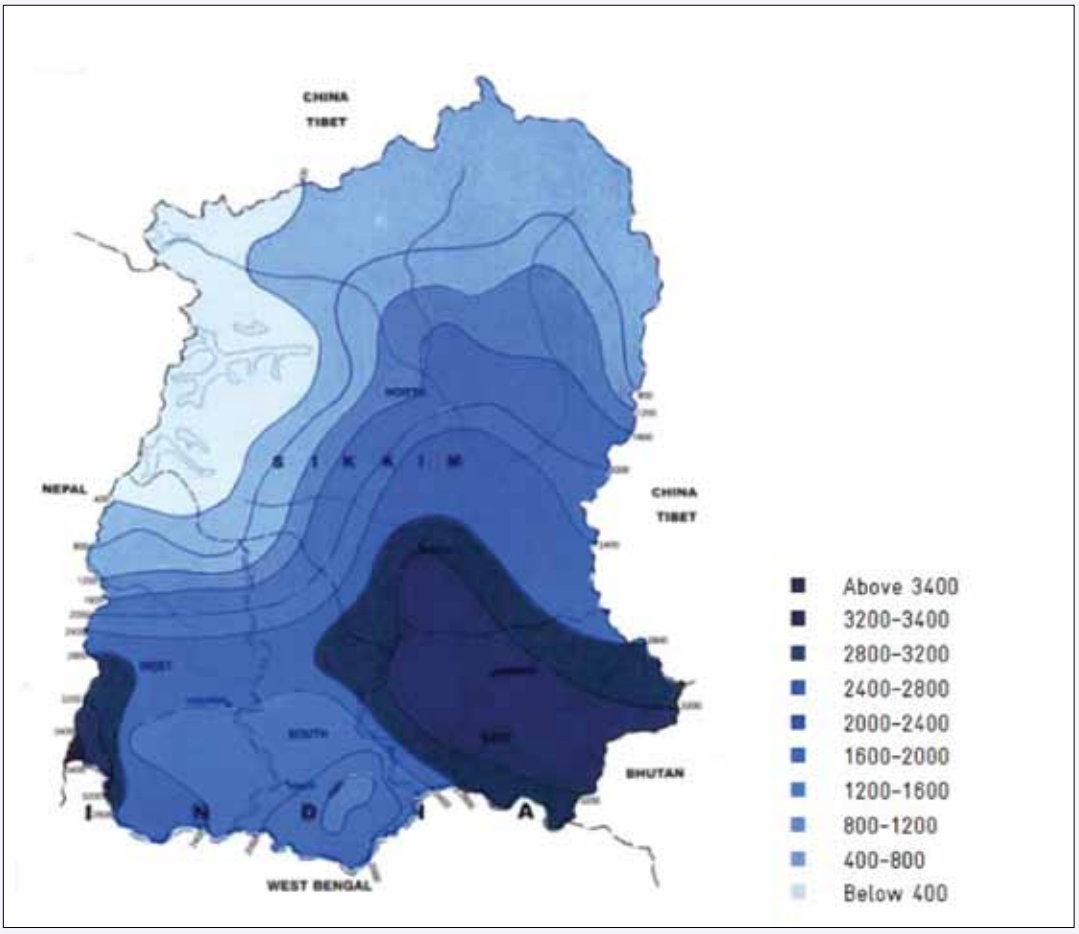
3.1.1 Surface Water

Glaciers, rivers and springs constitute important components of the surface water resources of Sikkim.

3.1.1.1 Rivers

Teesta is the significant waterway framework in the State, which starts as Chhombo Chhu from a chilly lake Khangchung Chho at a height of 5,280 m. The chilly lake lies at the nose of the Teesta Khangse glacier, sliding from Pauhunri top (7,056 m) in the north-western heading. Along its course from its inception to the fields, the stream gets seepage from various tributaries on either side of its course.

Map 3.1: Distribution of Rainfall



Source: *Sikkim State Action Plan on Climate Change (2012-2030), Government of Sikkim*



Zemu Glacier, Date of Photo : October 24, 2013
(Photo by Sangay G. Bhutia)

There are more tributaries on the eastern flank that are shorter in course, though the fewer tributaries on the western flank are longer with bigger seepage territories, thus contributing significantly more quantum of water release to the Teesta River.

Table 3.1: Major Tributaries of Teesta River

Left Bank Tributaries	Right Bank Tributaries
Lachung Chhu	Zemu Chhu
Chakung Chhu	Rangyong Chhu
Dik Chhu	Rangit
Rani Khola	
Rangpo Chhu	

The most important tributary of river Teesta is Rangit. At Melli, Teesta merges with river Rangit.

3.1.1.2 Glaciers

Sikkim has 84 glaciers in the Teesta Basin covering an area of about 440.300 sq km. The important glaciers in Sikkim are Zemu, Rathong and the Lhonak. The Zemu glacier is the largest and the most famous glacier of the eastern Himalayas. This is about 26 km in length and is situated in a large U-shaped valley at the base of the Mt. Khangchendzonga in the north-western Sikkim. The Teesta River rises from the snout of Teesta Khangse glacier. Various ice falls and water falls have formed at the junction of the tributary glaciers with the Zemu glacier.

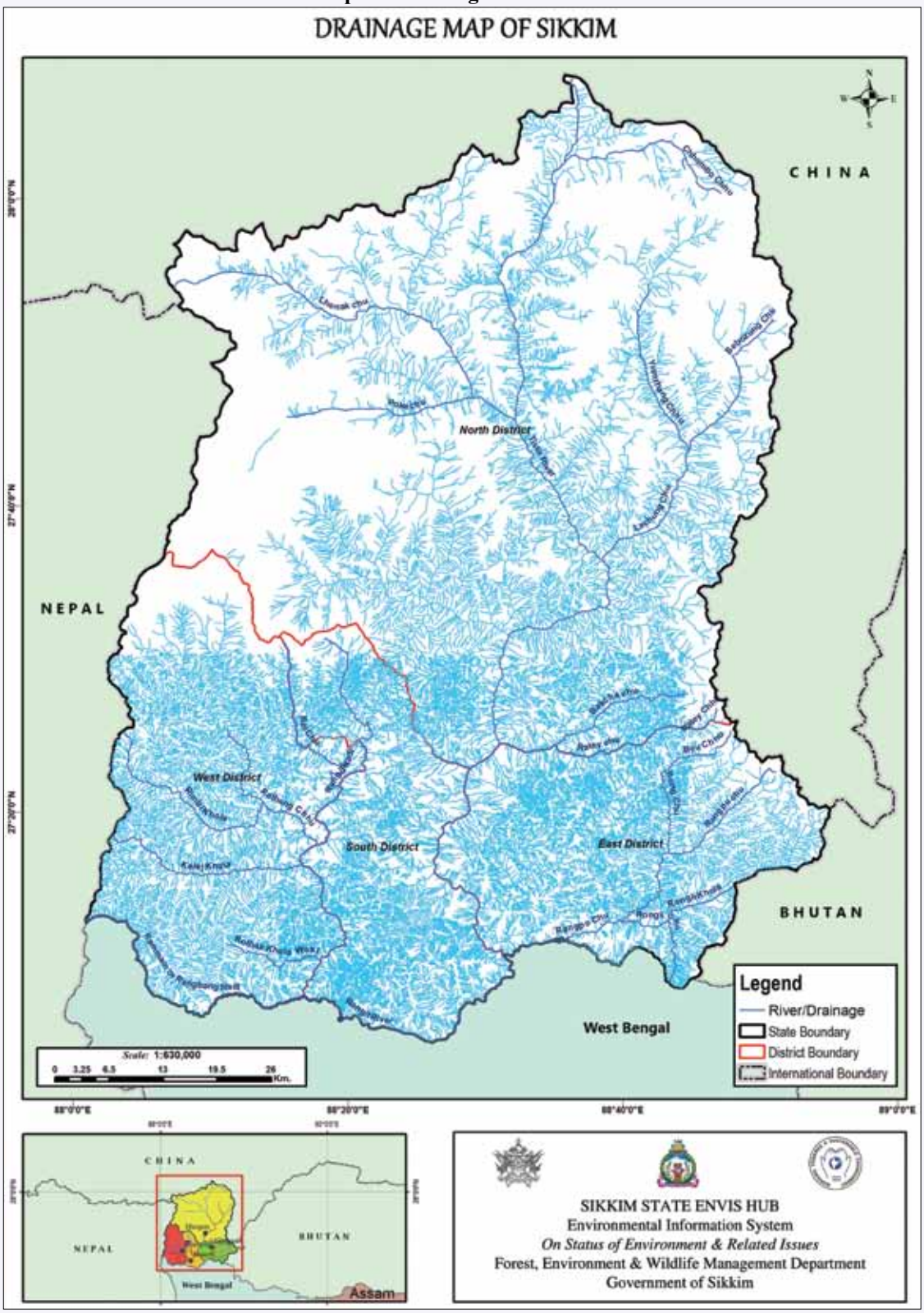
The Rathong glacier is source of the Rangit river. This glacier is fed by Mt. Rathong (6678m) and other icy peaks of the region. As per a study, the present snout of this glacier has retreated 460 meters during the last 33 years (Luitelet.al,2012). The Lhonak is also one of the major glaciers of eastern Himalayas. It is a popular trekking spot with an altitude of about 4720m. This glacier resides in North Sikkim District.

3.1.1.3 Lakes

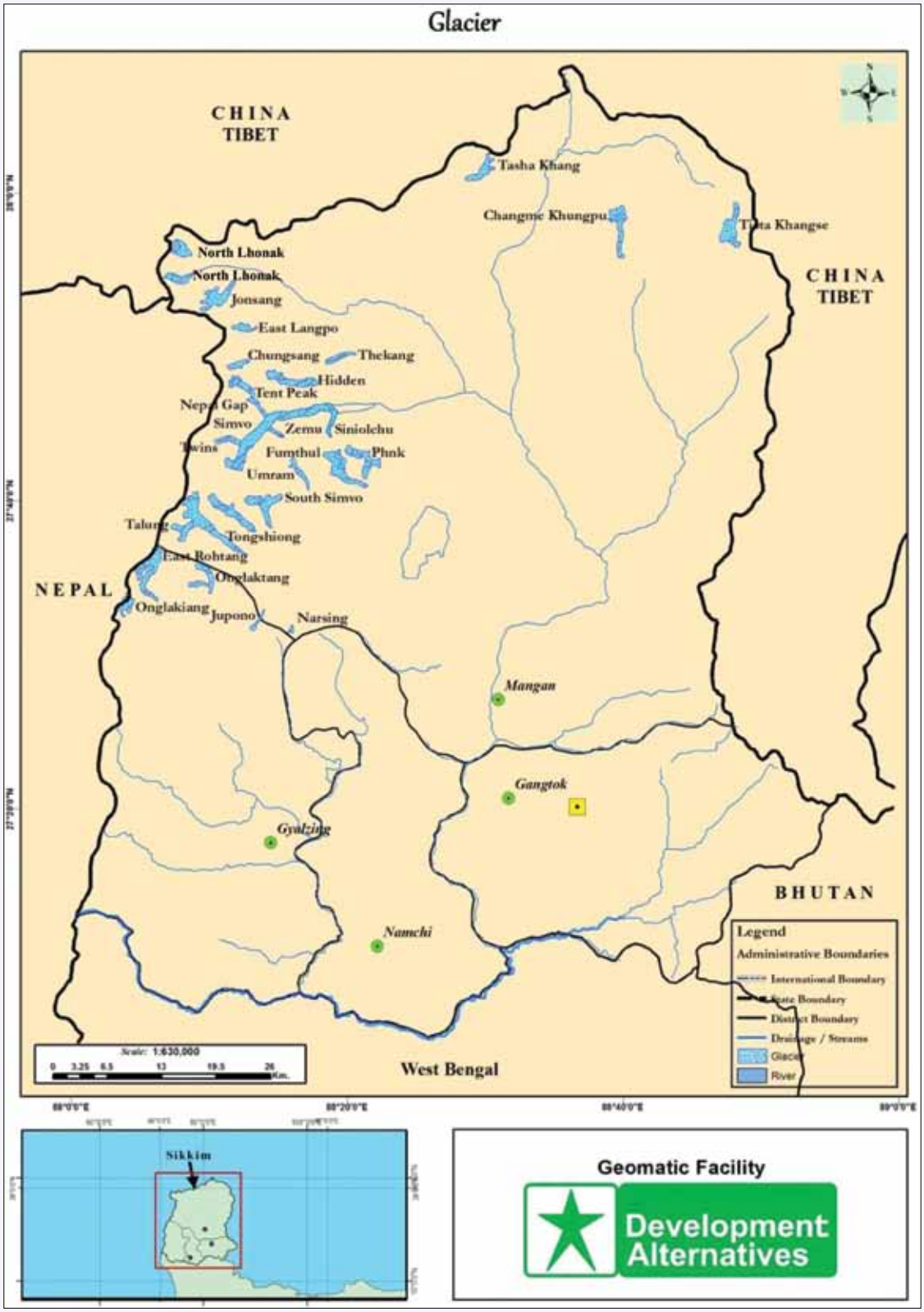
Sikkim boasts of many beautiful natural lakes in the world. Few of the lakes are discussed below.

Tsomgo Lake or Changu Lake is around 40 kilometers far from Gangtok. This tranquil and blessed lake is arranged at an elevation of 12,000 feet on the Gangtok-NathuLa roadway. It is about one kilometer long, oval in shape and 15 meters deep. It is also home to Brahmini ducks, besides being a stopover for various migratory birds. The lake remains frozen during the winter months

Map 3.2: Drainage Pattern



Map 3.3: Glaciers of Sikkim



Source: Topographical and Forest Resource Atlas of Sikkim, 2015

up to mid-March. Between March and August, it is possible to see a variety of flowers in bloom, including the Rhododendrons, various species of Primula, blue and yellow Poppies etc. Its surrounding is an ideal habitat for the red panda and different species of birds.

Memencho Lake, the source of river Rangpo chu, lies between the mountains below the Jelepla Pass. The lake receives water from the melting of snow from adjoining places and monsoon rain. It is famous for trout fish and pisciculture is practiced here. It is located at a height of 12,500 ft.

Khecheopalri Lake of West Sikkim is located at an altitude of 1700 m above the mean sea level. The lake watershed has mixed broad leaved forests and agricultural land with a total area of 12 sq. km, having two villages, which includes 91 ha specifically as the lake's watershed area. The lake is subjected to a high influx of tourists. It is also considered sacred and a good number of pilgrims visit the water body. Significant land use change during the past four decades has culminated in its deterioration.

Sikkim has 534 lakes (SAC, ISRO 2011) with a total area of 3325 ha, some of which are listed in the table below.

Table 3.2 Important Lakes of Sikkim

Name of the Lake	District
Gurudongmar	North
Cholamu	North
Sima Choka	North
Memencho	East
Changu (Tsomgo)	East
Bidang Cho	East
Khed-Cheod-Palri (Khecheopalri)	West
Lam Pokhari	West
Laxmi Pokhari	West
Dud Pokhari	West
Samiti Lake	West
Ram Laxman	West
Majur Pokhari	West
Panch Pokhari	South

3.1.1.4 Springs

Springs are natural characteristics in Himalayan geo-hydrology and the major source of house hold and drinking water for the people. They have been a vital pointer of the status of underground water and water-table over the raised land. Along these lines, the number of springs increases amid the rain storm season and reduce amid the drier season. Sikkim has always been known for its thermal springs, which are found all over the State. These waters have a great therapeutic value because of the presence of fluorine and sulphur. The most important ones are those located at Reshi, Yumthang and Ralang.

Several seasonal springs surface during the rainy season. Locally known as "*mulphutnu*", they have always served as a major source of domestic and drinking water in both rural and urban areas. A straight forward geomorphic clarification of *mulphutnu* is the steady ascent of the water table because of water getting accumulated under the ground for a longtime together. As the water level underground rises, it hits the stone surface or different out lets and gushes out through a cracks or any type of outlet, to serve as a decent and consumable well spring of water for three months to half an year. There might be enduring springs that fill in as a source of drinking water for the entire year (Khawas, 2004).

3.1.2 Ground Water

Sikkim, being a hilly State, has a low storage capacity of rain water due to the quick run off. The net ground water availability of Sikkim is 0.046bcm (billion cubic meters).The total annual draft for Sikkim is 0.010 bcm, of which 0.003 bcm is earmarked for irrigation and 0.07 bcm for domestic and industrial uses (Tambe,2012).

In terms of net groundwater availability, Sikkim is a niche higher than Mizoram and Nagaland but lower than Tripura. It is observed that the total annual draft also follows the same trend. But, Sikkim is considered to be the highest in the sphere of ground water development. In terms of availability of ground water, four districts of Sikkim fall under the safe category.

3.1.3 Water Quality

Seasonal variation impacts the water quality in Sikkim. Sikkim solely depends on surface water bodies. Springs flow from the water reserved in the underground bowels of the rock strata, which have been recharged with rain water. The recharging will take place only if there is vegetation, otherwise the ground will not soak water which will quickly flow

down the valley and will get lost. As per CPCB report (2010), at least 55% of the water quality (surface water) samples are not complying with pH and 84% are not confirming to BOD (Biological Oxygen Demand). While on other parameters such as DO (Dissolved Oxygen), Conductivity, FC (Fecal and Total Coliform) are all ideal as per required in a riverine environment. This can be interpreted as decline in overall surface water quality.

The Central Pollution control Board monitors water quality of Sikkim under MINRAS (Monitoring of Indian National Aquatic Resources) programme. Five rivers of Sikkim are monitored at 14 locations by Central Pollution Control Board. All the 14 locations are not complying with the water quality criteria. The rivers in which these 14 locations are situated are - Dikchu, Maney Khola, Rangit, Rani chu and Teesta. The polluted rivers of Sikkim are in priority class V. The criterion for priority V is monitoring a location having the BoD between 3-6 mg/l. The polluted river stretches in Sikkim are provided in the table below.

It was observed that the water run-off and, hence, the water supply to the public in Sikkim was irregular. If East Sikkim received plenty of water throughout the year, the South district suffered from huge shortages several times.

Based on the water demand and supply, field surveys were done primarily in two major cities, namely Namchi in South Sikkim and Gangtok in East Sikkim. Many villages in the vicinity of Namchi have extreme water shortages throughout the year. The State of Sikkim may face water crisis due to its hilly location especially in places like Namchi, Rangpo, Singtam, Gangtok (PHE Sikkim,n.d.).

3.1.4 Water Resources Availability

The state of Sikkim is characterized with enormous water resources available through various rivers and hill streams. However, are cent study revealed that the region, despite being a water feeder to planar India, suffered water shortages and crisis in the South district, one of the most populated districts after East Sikkim (Tiwari, 2012). This is partly due to land availability constraints and unawareness regarding water conservation techniques.

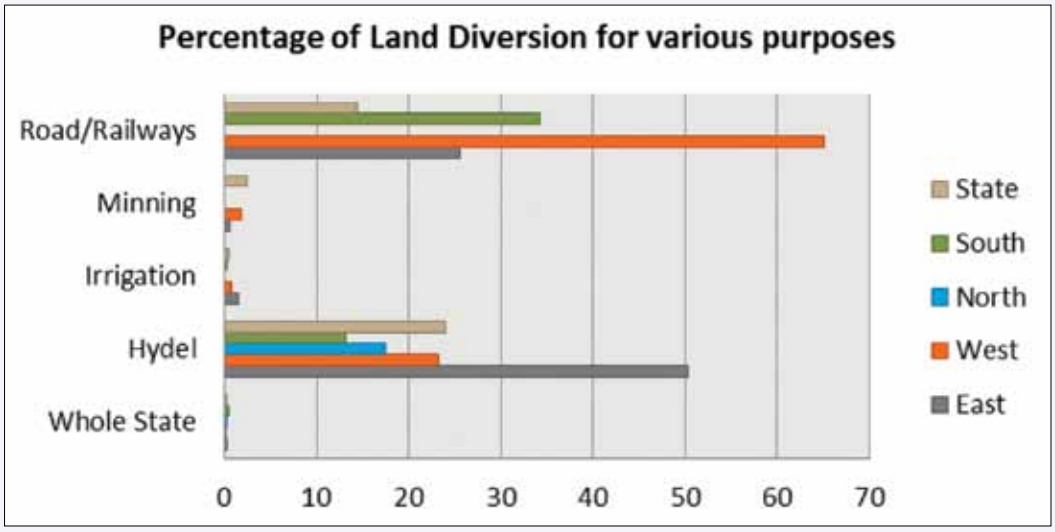
3.2 Pressures

Increasing water demand due to the ever-growing population and pollution are the major pressures on the water sector in Sikkim. The Sikkim State Water policy highlights that the principal use of water has been for irrigation. But as a growing State, there are increasing demands for water for diverse purposes namely: domestic, hydropower, agriculture, industrial, recreation etc.

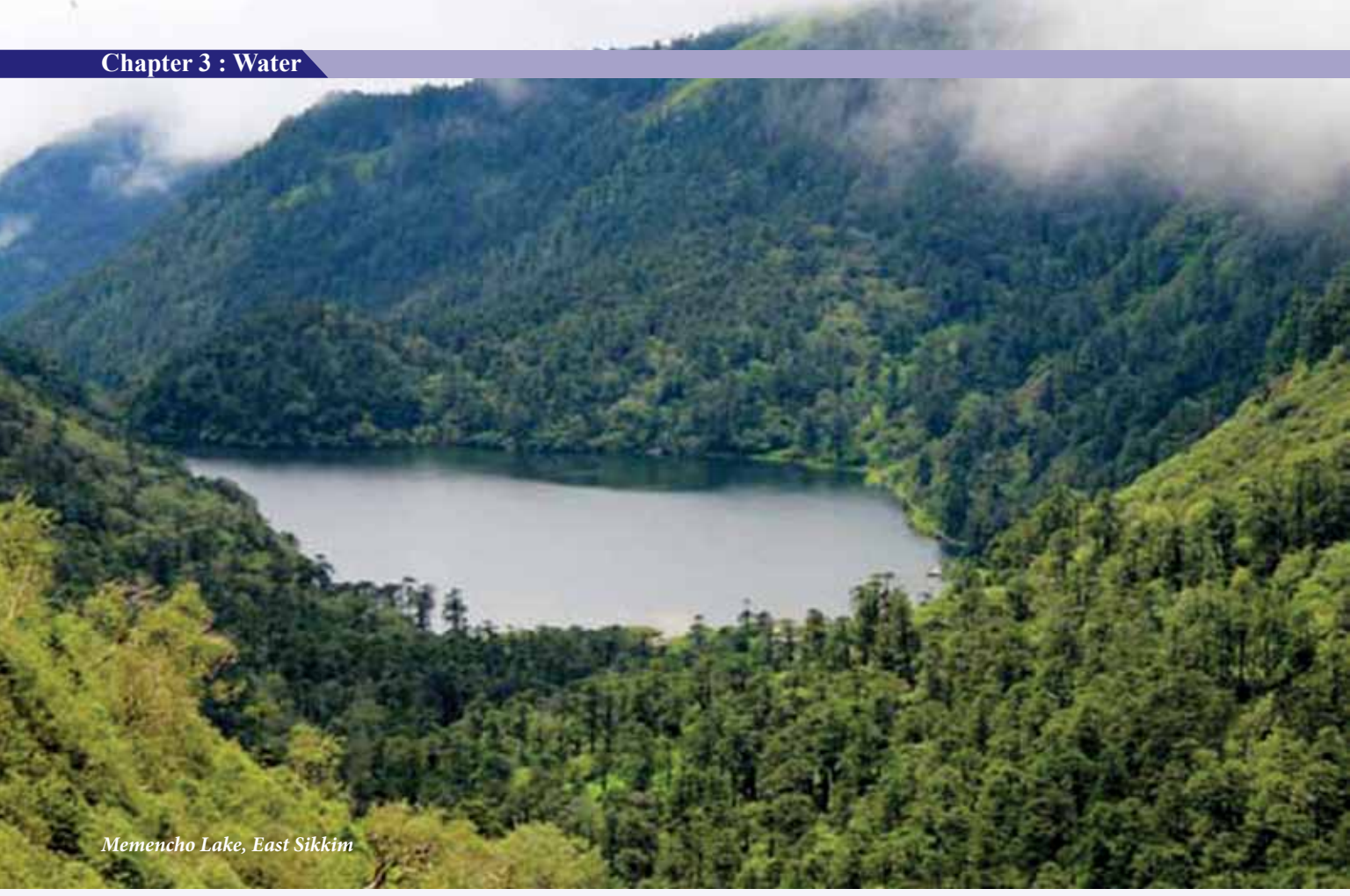
3.2.1 Pressures from Agriculture

Agriculture is the main occupation in Sikkim, and the important land use in Sikkim. Sample projections done by the irrigation department of Sikkim show that the maximum demand is for the Kharif Crop and the minimum demand is for the Rabi crop. And demands during both these seasons are increasing. It is to be noted that these tentative projections have been made without taking into consideration the climate change pressure that would inadvertently increase the water requirement.

Figure 3.1: Land Diversion for Various Purposes



Source: *FCA, FEWMD, Sikkim (Courtesy: ENVIS)*



Memencho Lake, East Sikkim

Table 3.3: Ground Water availability status and use in Hilly States of India

States	Net Ground Water Availability (bcm)	Irrigation (bcm)	Domestic and Industrial Use(bcm)	Total Annual Draft of Ground water(bcm)	Stage of Ground Water Development (%)
Sikkim	0.046	0.003	0.07	0.010	21
Mizoram	0.039	0.000	0.004	0.004	1
Nagaland	0.038	N. A	0.008	0.008	2.14
Tripura	2.74	0.09	0.07	0.16	6

Source: *Ground Water Year book India 2012- 2013, Published by Central Ground Water Commission ,and Ministry of Water Resources.*

Table 3.4: Polluted River stretch of Sikkim

Sl. No	River	Stretch Identified	Towns Identified	Approx. length of the Stretch (in Km)
1	Dikchu	Nampong to Dikchu	Dikchu	4
2	Maney Khola	Adampool to Burtuk	Adampool	2
3	Rangit	Dam Site (NHPC) to Triveni	Legship, Jorethang, Triveni	20
4	Rani chu	Namli to Singtam	Ranipool, Namli, Singtam, Gangtok	15
5	Teesta	Melli to Chungthang	Melli, Rangpo, Singtam	60

Source: *Central Pollution Control Board, 2015*

Table 3.5: Water Utilization by Different Sectors in Sikkim

Sector	Year-wise Tentative Projections (UNITS)				
	2010	2020	2030	2040	2050
Irrigation use a. Kharif b. Rabi	 1764.00 371.00	 2058.00 484.28	 2352.00 557.05	 2499.00 649.89	 2646.00 742.74
Urban Suburban Areas(PHED)	23.70	42.51	55.27	71.86	93.41
Rural Areas (RMDD)	17.00	20.72	25.28	30.79	37.53
Industries (Department of Commerce and Industries)	0.42	0.53	0.66	0.83	1.03
Maximum Requirement of Water for Kharif Season (I A+II+III+IV)	1805.12	2121.76	2433.19	2602.48	2777.97
Minimum requirement of water during Rabi season (IB+II+III+IV)	412.12	528.04	638.24	753.37	874.71

Source: *State Action Plan on Climate Change Sikkim, 2012-2030*

3.2.2 Pressures from Energy

Hydro power sector is one of the potential areas for generating revenue to improve the socio-economic conditions of the people. Actually, hydro power is considered as the green power available to mankind and the Government of Sikkim's policy has been to synchronize development imperatives with a conscious effort to attain environmental sustainability. Hydro power is considered a cleaner and greener source of energy when compared to other sources. The significance of hydropower is that:

- The cost of operation is not susceptible to market price fluctuations
- It has multipurpose benefits including power generation

The State Government has set up the Sikkim Power Development Corporation (SDPC) to tap into the State's hydropower potential, which is estimated to be around 8,000 MW. Independent Power Producers (IPPs) have approved 29 hydroelectric power (HEP) plants for development. These projects are at various stages of construction and would have an installed capacity close to 5,350 MW when completed.

However, this increasing need is also a pressure on water requirements for other purposes. It also creates land diversion in other sectors.

West District has the maximum land diversion. The land use pertaining to land diversion at the higher end is road or railways and hydel power. As per the Central Electricity Authority, 2008, the hydel power developed is 13.86% of its total capacity.

The major hydroelectric projects which cater to the energy needs of Sikkim are indicated in the tables below.

Table 3.6: Sikkim's Hydroelectric Projects

S. N.	Name	Capacity (in MW)	Location	District
1	Teesta V	510	Singtam	East
2	Rangit	60	Legship	West
3	Kalez	2	Kalez	West
4	Lower Lagyap	12	Ranipool	East
5	Jalli	2	Sangh Khola	East
6	Rimbi I	NA	NA	NA
7	Rimbi II	1	Rimbi	West
8	Rothak	0.2	Rothak	South
9	Rongnichu	2.5	Nimtar	East
10	Chatten	1	Lachen	North
11	Meyong Chu	4	Naga	North
12	URHP	6	Nimtar	East
13	Manglay	2	Manglay	South
14	Lachung	0.2	Lachung	North
15	Rabom Chu	3	Chungthang	North
16	Rongli	5	Rongli	East
17	Lachung	3	Lachung	North

Source: *Energy and Power Department, Government of Sikkim, 2015*

3.2.3 Pressures from Tourism

The high altitude areas of the state are an important tourist destination but are ecologically fragile and very important in terms of water security. But such ecologically fragile areas are subjected to large inflow of tourists which has serious environmental concerns. Besides vehicular pollution, garbage accumulation leading to water pollution is a major challenge brought about by tourism which needs to be addressed in Sikkim (Sikkim Government, n.d). There are problems in solid waste and sewage disposal in fragile mountain ecosystem, including piling up of non-biodegradable waste in natural ecosystems like rivers.

Already, Gangtok is overcrowding and competition for water resource is slowly becoming a major problem (Sikkim Government, n.d). Another impact is through consumption of water resources faster than they can be replenished (or resource depletion).

3.2.4 Pressure due to Climate change

Sikkim experienced a very dry winter in 2008 and 2009. This could be attributed as an early impact of climate change. Few of the impacts due to this are springs becoming seasonal, high volume of run offs down the hills during frequent extreme rainfall events, degradation of vegetation leading to the inadequate recharging of water bodies charged through water to mention a few. This makes climate change among the most important pressure on the water resources of Sikkim. This is further covered in the climate change chapter

3.3 Impact

3.3.1 Competition for Water and Decreased Allocation

As mentioned earlier that due to water short ages there is an increased competition of available water. This is compounded by decreased allocation due to inadequacy of the existing infrastructure to meet local demands.

3.3.2 Drying Wetlands

Retreat of the glacial stock due to unnatural melting negatively impacts the Himalayan river ecosystem as the volume of the snow-fed rivers gets affected in the long run. In the short run, it invokes numerous natural hazards like Glacial Lake Outburst Floods (GLOF), soil erosion, flash floods, river floods and



Lhonak Glacier, North Sikkim,
Date of Photo : September 6, 2016
(Photo by Karma Choden Bhutia)



Tsomgo Lake, East Sikkim
(Photo by IPR)

landslides. Such drying of wetlands has started getting noticed in the ecology of Sikkim Himalaya. Further, small streams that feed the large rivers are drying up more recently due to the combined effects of climate change and land degradation in and around the major watersheds of the region.

3.3.3 Receding Glaciers

The temperature in Gangtok has been rising at the rate of 0.2–0.3°C per decade (SAPCC, 2012). Therefore, the increase in temperature has been around 1–1.5°C since 1957. Annual rainfall is increasing at the rate of nearly 50 mm per decade, except in winter months, which have been exceptionally dry during the period 2006–2010. Comparison of long-term meteorological data available for Gangtok station (1957 to 2005) in terms of the trend over the last few years (2006–2009) reveals an acceleration of these patterns, with winters becoming increasingly warmer and drier (K. Seetharam, 2012).

A study conducted by the Department of Science and Technology on the East Rathong Glacier in West Sikkim shows that the total recession of the glacier during the last 43 years (1965–2008) is about 1.44 km and about 320 min last nine years (1997–2006), with an average rate of 35.5 m per year. The melting of glaciers and accumulation of melt water in the lakes has significantly increased the volume of water in the glacial lakes resulting in increasing the chance of Glacial Lake Outburst Flood (GLOF) events. Thinning and retreat of glaciers results in formation of new glacial lakes and enlargement of existing ones. The climatic change/ variability in recent decades have made a considerable impact on the glacier life cycle in the Sikkim Himalaya. The increase in area of glacial lakes behind unstable moraine dams poses more danger of downstream flooding. This has made the downstream regions more vulnerable (Kumar, n.d.)..

3.4 Response

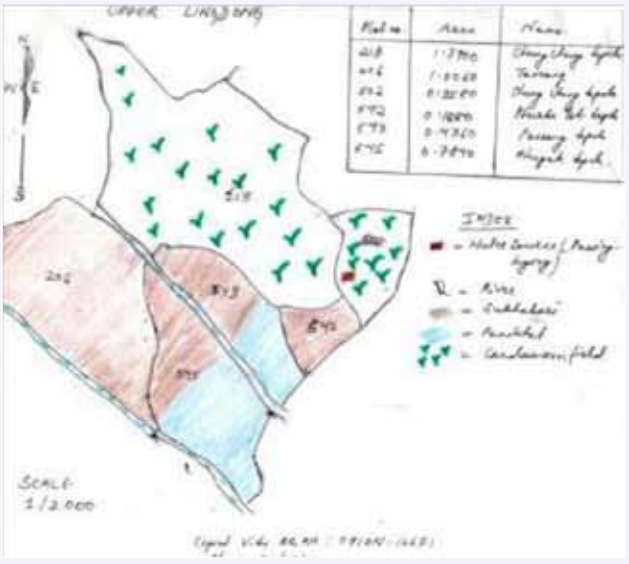
Water is an important component for the survival of mankind. In Sikkim, certain areas are affected both by floods and droughts. In order to tackle this situation, proper coordination is required between districts and state level administration. For appropriate planning and management, Government of Sikkim has adopted the State Water Policy that enables Sikkim to balance and diversify the needs a rising out of development.

3.4.1 Dhara Vikas

Dhara Vikas (meaning, spring- shed development) is an innovative programme to revive and maintain the drying springs in the State. The primary objective of Dhara Vikas is to ensure water security by breaking the cycle of abundance and scarcity of water. It, however, is also an effective climate change adaptation response as it enhances the hydrological contribution of the mountainous ecosystem. Increasing occurrence of droughts in South and West districts were the primary reason for taking up this initiative by RMDD in 2008. The streams and springs in these districts dry up every year.

As a robust climate adaptation strategy for drought-prone districts, Dhara Vikas, is helping alleviate the problem of rural water scarcity by reducing the surface run off of rainwater and allowing more water to percolated own to recharge underground aquifers, which, in turn, ensures an increased discharge from springs.

Map 3.4: Planning of Dhara Vikas in Sikkim



Source: *MGNREGA-Spring shed Development Dhara Vikas in Sikkim, Rural Management and Development Department, Government of Sikkim.*

Besides its significant impact on crop patterns and yields, the programme has also worked on developing a village spring atlas and a water source atlas for the State. Water access to the population through this initiative has also led to improved sanitation practices.

Dhara Vikas is also a highly replicable strategy to address the persistent problem of water scarcity in the region. It is ecologically sound and helps cover large areas and help ground water recharge up to 900 million liters a year.

3.4.2 Pokhari Sanrakshan Samiti (PSS) initiative

The water bodies of Sikkim are mass ecotourism destinations, with as many as 2,000 visitors per day. Tsomgo (Changu) in East Sikkim, Gurudongmar in North Sikkim and Khecheopalri in West Sikkim generate footfalls of more than 5 lakh tourists per year. To ensure the lake conservation initiative in its true perspective, the assistance of local community has been in built in to the mechanism by constitution of Lake Conservation Committee, locally termed the *Pokhari Sanrakshan Samiti* (PSS) initiative. These committees have the responsibility of preserving the lake and its catchment and maintaining the cleanliness and sanitation in lieu of collecting a nominal lake conservation fees from the tourists. Implementation of this innovative and participatory policy has resulted insignificant improvement in the conservation of the lake, its catchment, solid waste disposal, sanitation and interpretation of the values of the lake to the visitors.

3.4.3 Water Harvesting

Over the years, the local people of Sikkim have evolved efficient water harvesting systems, together with their traditional land management systems. Construction of water channels, regulation of water flow and drawing of drinking water were traditionally organized as community enterprises. Common traditional sources of drinking water are natural springs (locally called



Rural hardship due to water scarcity in Namthang block, South Sikkim
Source: Rural Management and Development Department, Government of Sikkim
(Photo Date 14/02/2012)

dharas, *pandhera* etc), and streams (locally called jhoras or kholas). The locals have traditionally evolved an ingenious method of transporting water from these sources to their houses by using bamboo poles.

3.4.4 Flood Management Programme (FMP)

The Ministry of Water Resources, Government of India had sanctioned Flood Management Programme (FMP) during 2007-08. In all, 24 schemes at the cost of Rs. 8620.94 lakhs, have been completed by 2014-2015. This programme has supplemented the State Government in terms of irrigation facility. It has also helped in generating employment for the farmers, thus helping to improve their economic conditions.

3.4.5 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 level needs to be augmented. The farmers innovatively harness the flow of springs to fill up water tanks, which are utilized for irrigating kitchen garden, green house crops and domestic uses. These water tanks (with the facility of roof-water harvesting) have provided a new lease of life to many villages with acute drinking water problem. Hundreds of such water storage tanks (having a capacity ranging from 10,000 to 40,000 litres) have been constructed with funds lever-aged from three national programmes, namely-MGNREGA, National Rural Drinking Water Programme (NRDWP) and Rashtriya Krishi Vikas Yojana (RKVY).

3.5 Conclusion and Recommendations

There are many challenges and concerns that would need to be addressed to make Sikkim a water secure state. The most important of them would be to protect the springs and various recharge zones. The three pressures in the form of climate change, agriculture and energy will have an overriding impact on the country's water resources and the government will need to focus on available water resources and the depletion of fresh-water availability and its implications to avert the negative consequences expected with the development drive.

It is also required to do an impact assessment of the already existing measures such as Dhara Vikas to measure its efficiency and develop further risk options. It is also important to relook at the existing traditional practices in the light of modern science as these have been very effective in Sikkim.

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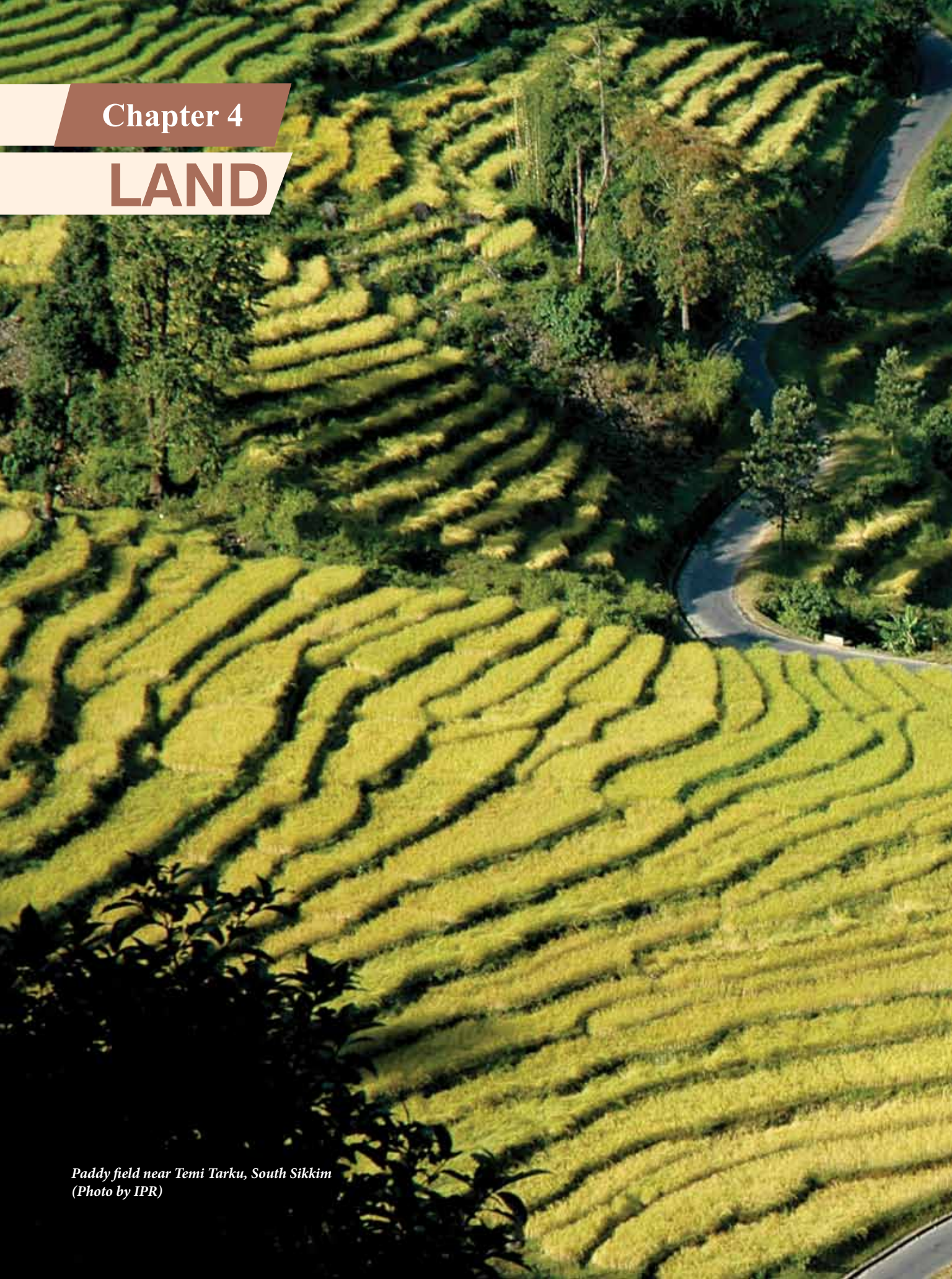
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Chapter 4

LAND



Paddy field near Temi Tarku, South Sikkim
(Photo by IPR)



Land as a resource is scarce in Sikkim due to its hilly terrain. This chapter focuses on land analyzing the various factors which act as a pressure leading to land degradation. A sustainable use of land is the only way to save Sikkim's degrading land that is highly prone to disasters like earthquakes and landslides. In future, traditional knowledge is going to play a pivotal role in managing land as Sikkim's vital natural resource.

4.1 State

Sikkim has abundant natural resources though non-renewability and higher rate of consumption than regeneration always pose risks of devastation of the native ecosystem. Land is one important natural resource that supports the entire terrestrial ecosystem on which human beings are largely dependent for survival. As human needs and population grow, the pressure on land and other natural resources continues to increase. The steepness of the terrain, tectonic instability and heavy monsoon rainfall and rapid population growth adversely affect the land resources in Sikkim, which has a total geographical area of 7,096 square kilometers. Sikkim constitutes 0.22 percent of the total land area of India. The State is highly susceptible to acute soil erosion problems due to its undulating topography and high intensity of rainfall, which on an average is 2500mm per year. The various detrimental factors that put pressures on Sikkim's land are agriculture, susceptibility to disasters, urbanization and thus sustainable land management practices need to be adopted in order to protect environment of Sikkim.

4.1.1 Land Use Pattern and Forest Cover in Sikkim

The land use of Sikkim has been explained through Table 4.1. Reportedly, 84% of the state's area is forest area, and nearly 47.8% of the total is under forest and tree cover (Forest Survey of India, 2015). The state depicts a variety of forest types owing to the wide range of altitudes across the territory. These range from sub-alpine forests in the higher altitudes (above 3600 meters) to sub-tropical forests in certain areas at altitudes of 1000-2000 meters.

4.1.2 Agricultural land

The state's economy is heavily dependent on agriculture since more than 80% of its rural population depends on agriculture and allied sectors for livelihoods. Out of the total land area, approximately 11.17% is sown (Table 4.1) with the predominant crops that include rice, maize, oilseeds and pulses. The earlier practice of rampant usage of chemical fertilizers and supplements for enhancing yield has been successfully thwarted after the launch of the Sikkim State Organic Mission from 2003.

SIKKIM ORGANIC MISSION
100% Organic State



Farmer ploughing the field (Photo by IPR)

Sikkim was declared as an organic state in the year 2016. Constant efforts to rejuvenate the land have been implemented in the state from 2003 onwards. By the end of the year 2015, the state was able to convert 76,169.604 ha of its cultivated area in to organically certified cultivation. For capacity building, the Government trained all the farmers to make appropriate changes in the package of practices and adoption of better technologies.

The certification has been granted by engaging 6 accreditation bodies as per criteria laid down by National Programme on Organic Production (NPOP).Three livelihood schools were also established in the State and more than 800 educated and unemployed youth were trained and more than 700 of them were engaged in International Certification Services and related certification activities. Practices like for going the use of chemicals, more diversified crop rotation, use of organic manures, conservation till age, more diversified farm structure etc. are essential factors that helped enhance not only biodiversity, but strengthen natural cycles and improve environmental performance that in turn increases the sustainability of organic farms. This is an effective step in decreasing the pressure on land resources in the state where 80% of the rural population is dependent on agriculture and allied sectors for livelihood.

Table 4.1: Land Use in Sikkim

Land Use	Area in '000ha	Percentage
Total Geographical Area	710	
Reporting Area for Land Cultivation	693	100
Forests	584	84.31
Not Available for cultivation	11	1.54
Permanent Pastures and other Grazing Lands	0	0
Land under Misc. Tree crops and Groves	8	1.13
Culturable wasteland	3	0.48
Fallow Land other than Current Fallows	4	0.65
Current Fallows	5	0.72
Net Area Sown	77	11.17

Source: *Land use Statistics, Ministry of Agriculture, Government of India, 2012-13*



Temi Tea Garden, South Sikkim
(Photo by IPR)

4.2 Pressures

4.2.1 Agriculture and Allied Sectors

The agriculture systems practiced in Sikkim are integrated with nature, and farming is still at a subsistence level than commercial. Sikkim is totally a hilly state whose agro-climatic conditions range from sub-tropical to Alpine. Due to adverse geographical conditions, climatic parameters and difficult terrain conditions; extension of the area under cultivation does not seem possible. With the ever-increasing population and tourism in the hilly state, the pressure on land has continued to rise, resulting from intensification in use of land resources rather than expansion.

A declining trend is observed in the yield of most crops but the overall productivity of the agricultural systems has remained similar (Figure 4.1 and Table 4.2). Agriculture in Sikkim is witnessing an ongoing process of transformation from cereal-dominated subsistence agriculture to high-value, cash crop dominated commercial horticulture. The precise changes in cropping patterns in terms of the area under different agricultural and horticultural crops from 1975-76 to 2004-05 indicate a definite shift in cultivation towards horticultural crops. The major cash crops in the state are oranges, large cardamom, ginger, baby corn, pulses, buckwheat and turmeric, which have a huge demand in the domestic and international markets (Sikkim Organic Mission, Government of Sikkim). Certified organic cash crops from Sikkim, like ginger, have successfully penetrated European markets and the department visions a higher demand in the near future. This may center the focus on production of specific crops for higher economic benefits, exerting pressure on the land in absence of multi-cropping or crop rotation practices.

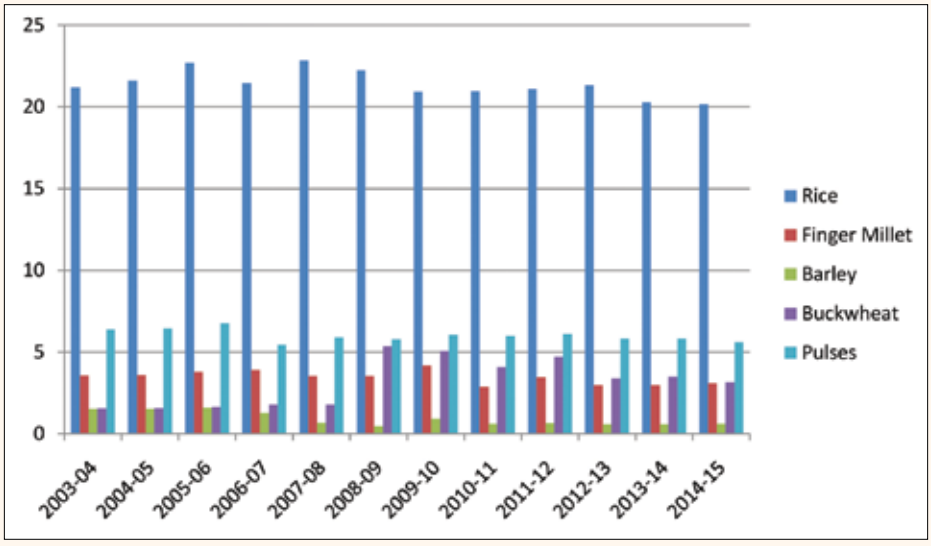
Introduction of exotic crops (high yielding varieties/ hybrids) such as kiwis, rice, pulses, etc. endanger the traditional agricultural practices and indigenous species, degrading and fragmenting their natural range on land. Also, from 2003 onwards the cropped area under rice and barley has started slightly declining (http://sikenvis.nic.in/Database/Agriculture_777.aspx).

Table 4.2: Crop Production (in metric tonnes) in Sikkim

Years Crop	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Rice	21.19	21.61	22.69	21.45	22.85	22.23	20.93	20.97	21.08	21.34	20.26	20.18
Finger Millet	3.57	3.6	3.78	3.9	3.53	3.53	4.18	2.89	3.45	2.96	2.97	3.09
Barley	1.51	1.52	1.59	1.27	0.66	0.47	0.92	0.61	0.63	0.59	0.59	0.6
Buckwheat	1.55	1.56	1.64	1.79	1.79	5.35	5.07	4.06	4.72	3.38	3.49	3.16
Pulses	6.38	6.44	6.76	5.45	5.89	5.79	6.06	5.97	6.11	5.83	5.83	5.6

Source: *Annual Reports, Food Security & Agriculture Development Department, Government of Sikkim*

Figure 4.1: Crop Production (in metric tonnes) in Sikkim



4.2.2 Disaster Risks

Owing to its geographic location on the Himalayas and geological conditions of high seismicity, Sikkim is prone to frequent natural disasters. This has further been aggravated by unplanned urbanization process and increasing tourist pressure. Therefore, the developmental activities in the state need to be structured considering the natural hazards associated with the mountain chain. As per NIDM and Vulnerability Atlas of India, Sikkim falls in seismic zone IV, a high risk are a making it highly vulnerable to earthquakes. Additionally, the highest annual rainfall in the state may even exceed 5000mm, triggering natural calamities like landslides and floods which degrade healthy land and affect the population negatively. The Sikkim State Disaster Management Authority **(SSDMA)** mentions in its report that the increase in disasters is due alterations by human activities like improper construction practices, deforestation and removal of vegetation cover.

1. Landslides

Heavy or prolonged rainfall, snow-melt, frequent water-level changes and seismicity are the major causes of landslides in Sikkim, which result in considerable loss of life, property and damage to communication networks, human settlements, agricultural and forest land. 642 landslide events have been recorded in Sikkim from 1957-2005, depicted in the table below.

Table 4.3: Number of Landslides

Districts	Number of landslides
North	32
South	368
East	153
West	89

Source: *Sikkim State Disaster Management Authority, 2006*

North Sikkim has an annual average of two landslides per sq. km, resulting into a mean land loss of 120 meters per km and a soil loss of 2500 tonnes per sq.km. The maximum number of landslides is observed in South Sikkim due to complex geological setting combined with contemporary crustal movements, varying slopes, heavy rainfall and increasing anthropogenic activities in the ecosystem. (M.S Rawat, 2012).

Acceleration in construction activities, especially with respect to road development that exposes the inner rock structures further weakened by rains, are attributed as a major factor affecting frequency of rain- induced landslides (SSDMA).

Case Study on Landslide Treatment done in West Sikkim



Regeneration in process at Pelling-Naku Tadong, West Sikkim (Photo by Sandhya Pradhan)

Many studies have been done by the State Departments to conduct and study landslide treatment after occurrence of such events. In this case, the main focus by the authorities has been to reduce casualties in the landslide areas. This is done by stabilizing the slip area-keeping in mind the topography of the area, causes of erosion, and the types of landslides that occur: ranging from rockslide, rock falls, rock toppling, debris slide, and rock-cum-debris slide.

In this study, the areas affected by landslides were so huge that no proper demarcation of the slide could be drawn. After carrying out the recommended measures, the landslides in all the areas under study have shown a colossal growth in terms of their flora. The bio-engineering works and soil moisture conservation works have helped to stabilize the soil in the area.

Recommendations of the study

To ensure complete stabilization of eroded areas, the study recommended for the following measures to be taken:

- Construction of extensive drainage system, laying of sub-surfaced rain age pipes, perforated pipes are some of the solutions to counter excessive leaching of soil, which may requires additional investments.
- Since during monsoon season, there arise seasonal springs that flow unsystematically in the hilly terrain carrying with them rich soil nutrients, further decreasing the capacity of the soil to retain excess water; Pollarding may be the solution to reduce the pressure of soil erosion and landslides and also provide adequate supply to fulfil the daily requirement of fuelwood, timber and fodder.

Source: *Impact of Landslide and Erosion Control Treatment, A study in West Sikkim in Schemes and Policies Implemented from 1995-96 till 2010-11, Forests, Environment & Wildlife Management Department, Government of Sikkim.*

2. Earthquakes

Sikkim is prone to high frequency earthquakes and urbanization further increases the vulnerability due to earthquake- induced landslides. One such earth quake was recorded in 2011, with a magnitude of 6.8 on the Richter scale. The high intensity tremors triggered various types of natural calamities in the form of landslides, road blocks, falling boulders, lake bursts, flash floods, uprooting of trees, and caused severe damage to life and property. (*Land Revenue and Disaster Management Department, 2012*).

Sikkim-Nepal Earthquake 2011 and induced landslides

A strong earthquake with magnitude 6.8 on Richter scale shook the region on 18th September 2011. The epicenter of the tremors was near the Sikkim-Nepal border. This event triggered many 'new' and 'reactivated' landslides across the state, the extent of which is proportional to the steepness of the slope. Studies have reported 210 landslide events on 12 motorable road stretches on the Sikkim-Darjeeling Himalayas, which caused huge damage to infrastructure and the environment.

This example clearly implies how one disaster can give rise to another, cumulatively causing huge negative impacts on the environment, which in cases are aggravated by anthropogenic reasons.

Table 4.4: Earthquake in Numbers and Magnitude

Year	Numbers	Magnitude
2005	2	4.1-5.1
2006	2	5.3-5.7
2007	5	3.3-5.0
2008	2	4.2-4.4
2009	1	3.2
2010	--	--
2011	12	2.9-6.8
2012	9	3.3-4.9
2013	2	3.0-5.0
2014	2	3.9
2015	4	4.0-7.9

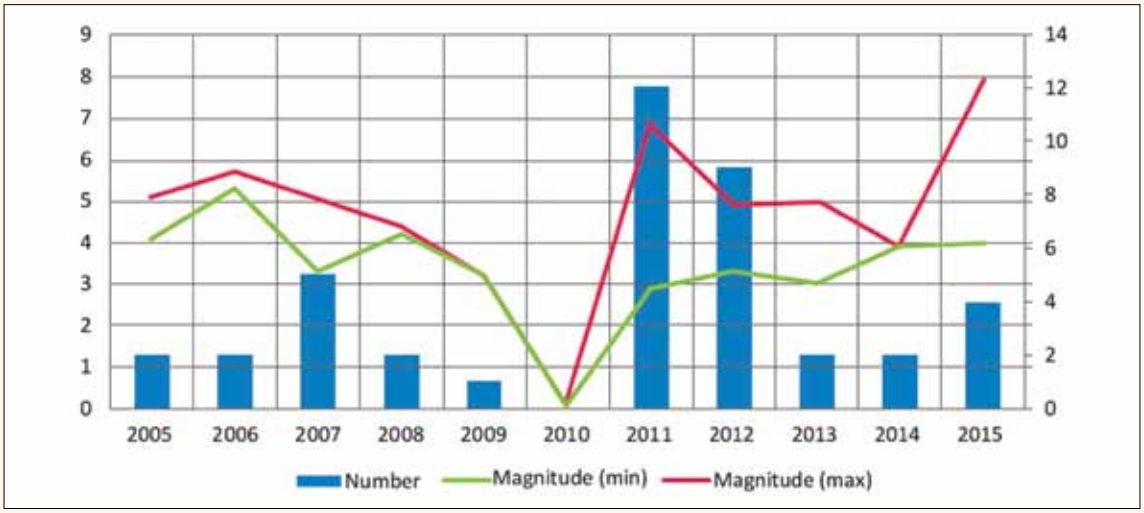
Source: *SSDMA*

Maximum number of earthquakes was recorded in the year 2011 with the magnitude ranging from 2.9-6.8. Though the number reduced in 2015, the upper limit of the range increased from 6.8 to 7.9. (Table 4.4).



A Private Building at Baluwakhani, Gangtok collapses after the major earthquake on September 18, 2011 (Photo by Santosh Sharma)

Fig 4.2: Earthquake in Numbers and Magnitude in Sikkim



3. Forest Fires

Fires are the biggest hazards to forests and are a grave threat to the entire ecosystem of the region. Forest fires start mostly due to natural causes such as lightning and high atmospheric temperatures, coupled with low humidity. But, there are also man-made causes for forest fires that range from electric sparks or ignition material. Besides the loss of precious flora and fauna, forest fire severely affects the regeneration of plants, soil moisture regime and the nutrient balance. At the same time, it also renders the trees highly prone to insect and fungal attack. The damage depends upon the frequency, intensity of fire, type of forest, availability of fuel and local climatic factors. The number of cases of forest fires has increased since 2005 as depicted in the table below. This could be attributed to overall rise in temperature and the increased proximity of human settlements to forest areas. Sikkim experienced a very dry winter in 2008 and 2009 period during which 157 forest fire cases was recorded damaging 1668.50 ha area consisting of bushes, bamboo, sal, teak, rhododendron, juniper and mixed species and other plantations.



Forest fire at Mangshila North Sikkim

Table 4.5: Forest Fires

YEAR	No. of Forest Fire	Area Damaged in HA	Forest Fire Months during the year
2005	31	225	Feb, March, April, May & December
2006	56	475.5	Jan, Feb, March & April
2007	18	64.5	Jan, Feb, March & April
2008	46	348.5	Jan, March, April, November & December
2009	**157**	**1668.5**	Jan, March & April
2010	34	136.5	Jan, Feb & March
2011	62	530.1	Jan, Feb, March & April
2012	34	253.51	Feb, March, April & November
2013	38	274	Jan, Feb & March
2014	62	634	Jan, Feb, March & April
2015	91	644	Jan, Feb, March, July, Aug & September
2016	49	259.6	Feb, March, April, July Aug, Oct, Nov & December

Source: *http://sikenvis.nic.in/Database/ForestFireCases_4087.aspx*

4.2.3 Urbanization and development

Urbanization has been a rapid phenomenon across the state, though concentrated in a few centers like Gangtok, Namchi, Rangpo etc. The state has 9 urban centers whilst the share of population living in urban areas has gone up from 11.07 to 24.97 percent over the last decade (Census of India, 2011).Consequently, there has been a rise in demand for developmental infrastructure, extension of road network, housing, economic opportunities and transportation facilities, creating huge requirements for land that needed to be diverted for varied uses. Nearly 9 lakh tourists visited the state in 2011-12, whilst the numbers have risen over the years as the state gains recognition on a global platform (Tourism Survey Report for the State of Sikkim 2011-12, Ministry of Tourism, Government of India). The floating population also exerts immense pressure on the land in terms of infrastructure, and food requirements.

4.3 Impact

The natural and anthropogenic pressures discussed in the section above have multiple impacts on the land resources in the state, and across the country in general. Some of the major threats to land are discussed in the section below.

4.3.1 Degraded Land

In Sikkim, land degradation is a major environmental concern. The total degraded land of Sikkim constitutes 17.32% of the total geographical area (*Soil and Land Use Survey of India, Ministry of Agriculture and Cooperation, Government of India 2012).* The causes of land degradation in Sikkim range from rocky wastes to severe water erosion as depicted in Table 4.6. While South Sikkim suffers from severe water erosion, East and West districts are affected both by water erosion and rocky waste. North District witnesses the maximum land degradation due to rocky wastes and glacial erosion since a significant portion of the land is under perpetual snow cover (*Report on Inventory of Degraded Lands of East, West, North and South Districts of Sikkim using Remote Sensing Techniques* Government of Sikkim, 2007).

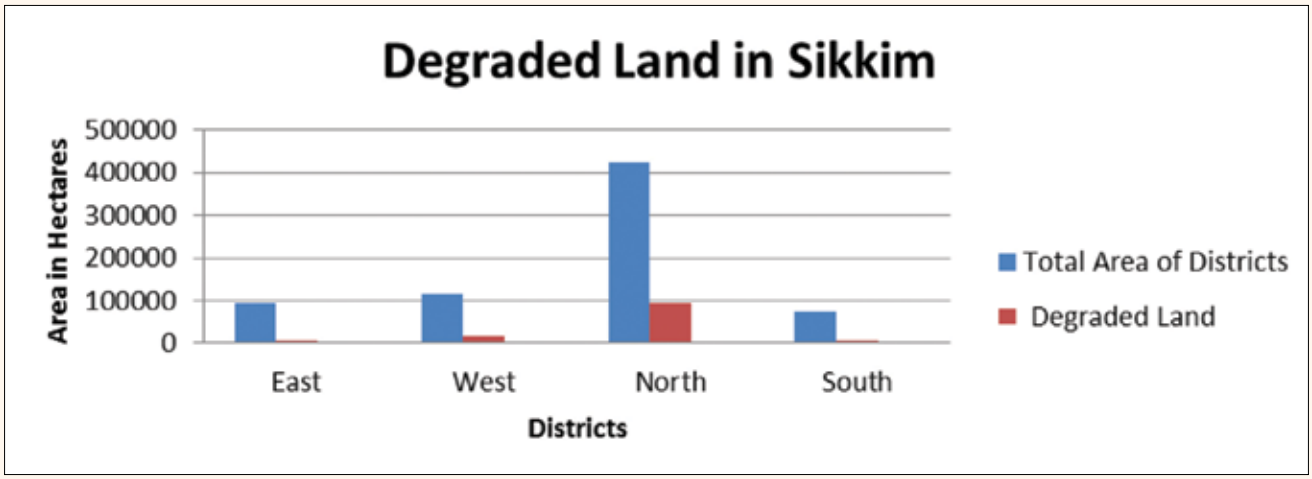
There has been a significant increase in wastelands in the category of snow covered/glacial areas and land with open scrubs. With over a total of 23 wasteland classes, Sikkim has shown a decline of almost seven percent in wasteland area from 2005 to 2009. (Table 4.6)

Table 4.6: Category-wise Distribution and Change in Wastelands (Area in Sq. Km.)

District Name	Land with Open Scrub			Underutilized/degraded forest (Scrub domain)			Barren Rocky / Stony Waste			Snow Covered / Glacial Area		
	2005-2006	2008-2009	Change	2005-2006	2008-2009	Change	2005-2006	2008-2009	Change	2005-2006	2008-2009	Change
East	1.03	10.57	9.54	4.51	4.21	-0.30	111.67	104.15	-7.52	5.12	2.52	-2.60
North	2.54	7.43	4.89	24.45	24.93	0.48	351.15	145.17	-205.98	2474.07	2662.62	188.55
South	2.26	1.68	-0.58	15.05	14.95	-0.11	5.09	3.66	-1.43	29.19	29.54	0.35
West	0.53	0.55	0.02	16.94	17.10	0.16	111.99	109.24	-2.75	125.28	134.83	9.55
Total	**6.37**	**20.23**	**13.87**	**60.96**	**61.18**	**0.23**	**579.90**	**362.22**	**-217.67**	**2633.66**	**2829.51**	**195.85**

Source: *Wasteland Atlas of India 2011*

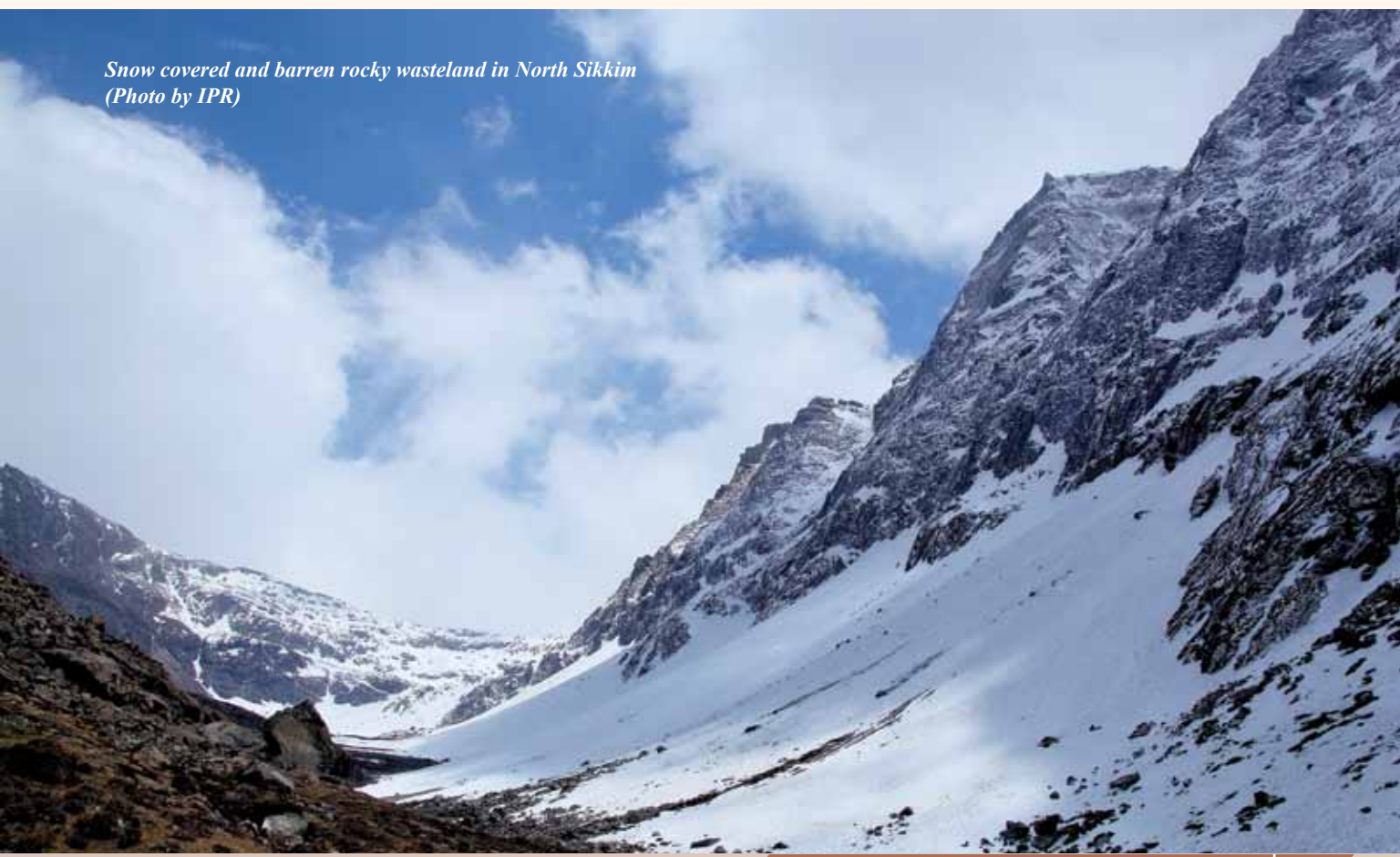
Figure 4.3: Degraded Land in Sikkim



Source: *Soil and Land Use Survey of India, Ministry of Agriculture and Cooperation 2012, Government of India.*

In all, 46.12% of the total land area falls under the wasteland category. North Sikkim District recorded a maximum change of 188.55 sq. km. of its area under snow covered/glacial wastelands, while East Sikkim District recorded a negative change of -2.60 sq. km. Land with open scrub area is the minor wasteland category, accounting for an area of 20.23 sq. km. (2008-09). East Sikkim District recorded a maximum change of 9.54 sq. km. under the land with open scrub, while South Sikkim District recorded a negative change of 0.58 sq. km. in same category. (*Wasteland Atlas of India 2011*)

Quantitative loss of land is also a phenomenon where land is lost to natural disasters like landslides and earthquakes. Exposed rocky surfaces are eroded by wind and water, rendering the land unusable.



Snow covered and barren rocky wasteland in North Sikkim (Photo by IPR)

4.3.2 Loss of Biodiversity

From 1980-2016, since the Forest (Conservation) Act was introduced, 2482.87 hectares of forest land has been diverted for various uses across the state (Sikkim ENVIS 2015). Though compensatory afforestation measures by the Forest Department are reportedly successful, it is not absolutely effective in preserving the indigenous biodiversity of the area. Land use change and agriculture intensification are one of the major reasons for biodiversity loss with pesticide use, synthetic nitrogen fertilizers, land consolidation, drainage and the use of heavy machinery being major factors (Sikkim Organic Mission, 2015 , Government of Sikkim). The state houses 72% of the Indian species of Rhododendrons, 26% of all Indian flowering plants and 1681 species of medicinal plants. With such a huge bio diversity treasure within its boundaries, Sikkim needs to direct efforts to preserve biodiversity in its natural habitat (Sikkim Action Plan on Climate Change).

4.3.3 Loss of human life and property

Sikkim lies in the Himalayan region and under seismic zone IV, thus becoming vulnerable to great ecological damage in the instance of a high impact earthquake. Landslides are also a common occurrence in the state owing to its unique topography.

The major earthquake in 2011 claimed 60 lives, in addition to injuring 719 people. The damage caused by the earthquake was intensified by seasonal heavy monsoon rains that caused landslides, mudslides and floods destroying thousands of homes, buildings, trees and infrastructure. The earthquake induced more than 300 landslides all over the state, ruining green patches of land and, disturbing the road connectivity to major towns like Mangan, Chungthang, and Lachung. Even NH31A, the main route connecting Sikkim and West Bengal was badly affected, leading to road blocks, falling boulders, lake bursts and flash floods with incessant rain, which continued for over a week after the earthquake (India Disaster Report, 2012)

4.3.4 Land Pollution

Sikkim has a population of approximately 6 lakhs with six dedicated waste disposal sites for municipal solid waste. Unscientific dump sites are major contributors to land pollution since they do not have identified systems for collection of leachates, thus leaking chemical pollutants into the ground. At the site in Lower Martam, 50 metric tons of unsegregated solid waste collected from the city of Gangtok is dumped



Landfill site at Martam, East Sikkim

daily (Gangtok Municipal Corporation). The situation aggravates in the tourist season when the state hosts a floating population of nearly 9 lakh tourists, adding to the quantum of waste being dumped. The government has taken initiatives to ban the use of styrofoam products like cups, plates etc and also prohibited the use of package drinking water bottles in government functions and meetings since they hugely add to the volume of waste dumped on land.

The other dump sites at Sipchu, 32nd Mile, Chandey and Martam have historically been unscientific dump sites wherein contamination from synthetic products is also a major contributor to land pollution. The process to build a scientific landfill in Gangtok is in progress under an ADB funded project, and more such projects are expected to be initiated in the state.

4.4 Response

- Sikkim has been declared a 100% organic State in the year 2016. January 18 has been declared as Organic farming day in Sikkim. The state covers nearly 75,000 ha of land under organic farming.
- The State has a designated Disaster Management Authority responsible for its State Disaster Management Plan (SDMP). The disaster management plan includes community participation, structural and non-structural measures like relooking at disaster management programmes, amendment of laws and legislations to focus on creating resilience, creating regulations for better land use and safety, etc. Additionally, A State Disaster Relief Fund was earmarked according to the Disaster Management Act, 2005, which aims to support such plans.
- The forest fire management program is implemented during the fire season. Fire lines are cleared and fire camps set up for tackling fires. The JFMCs are equipped with firefighting equipment, training and awareness programs.
- The state has also been proactive in approving and checking compensatory afforestation for the forest land diverted to other purposes. From 1980-2016, 2482.87 ha of forest land have been

diverted for various purposes, to compensate for which 4990.10 ha of non-forest and forest land has been stipulated for afforestation (ENVIS Sikkim, 2016).

- Land degradation treatment by Environment and Soil Conservation divisions including landslide treatment, check dams, gully plugging and protective walls.

4.5 Recommendations

- There is a need to enhance the involvement of local communities in the management and governance of land and forests and also to invest in awareness creation on the ecological and economic value of these natural resources to effectively reduce the impact of anthropogenic factors that interrupt natural ecosystems.
- Better waste disposal facilities to reduce contamination of land due to leachates leaking into the ground, thereby polluting land and ground water resources.
- Augmentation of capacities of the local communities to reduce disaster risks by interventions from the SDMA will be greatly beneficial.

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Water Resources

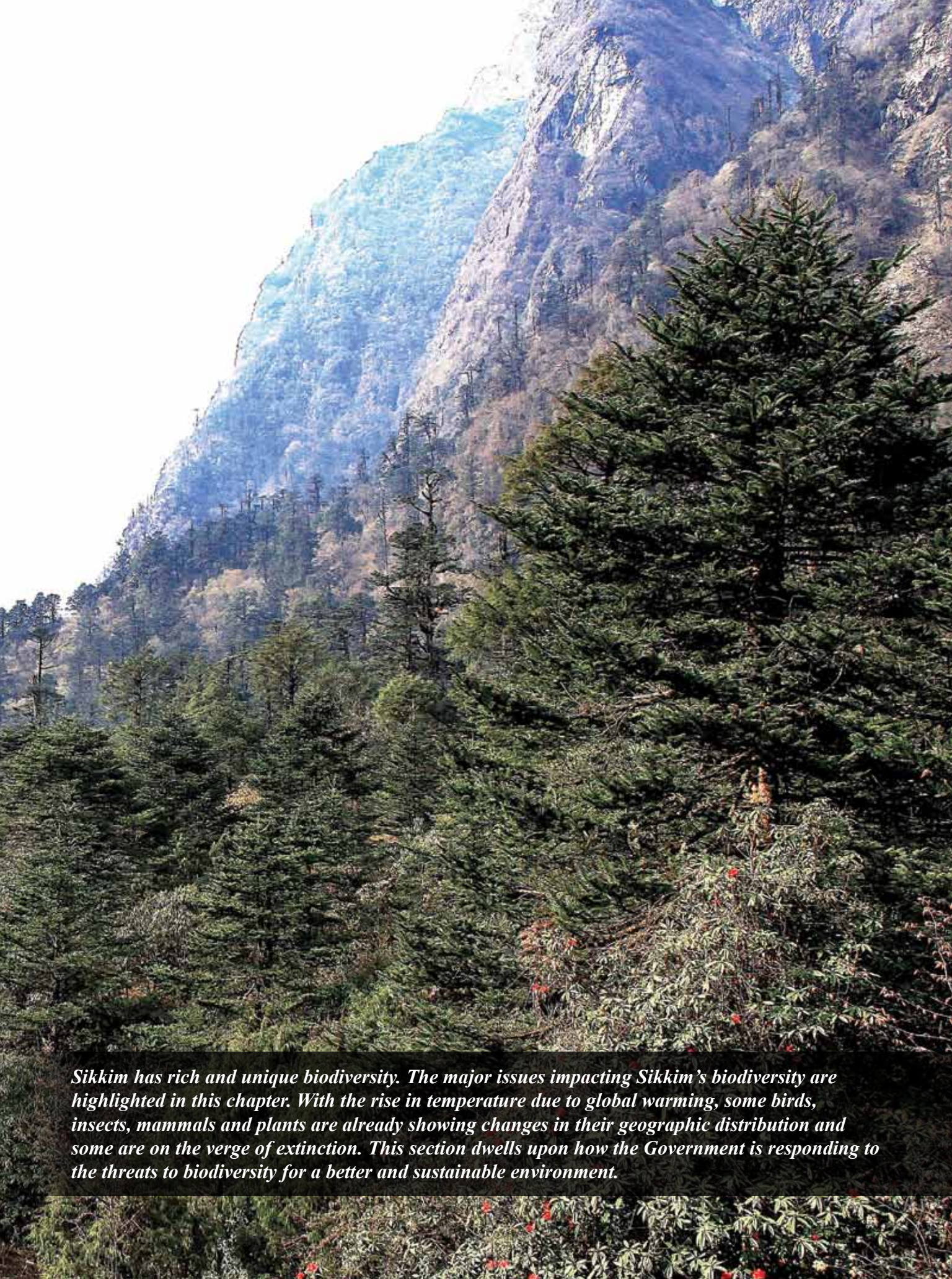
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Chapter 5

FORESTS AND BIODIVERSITY



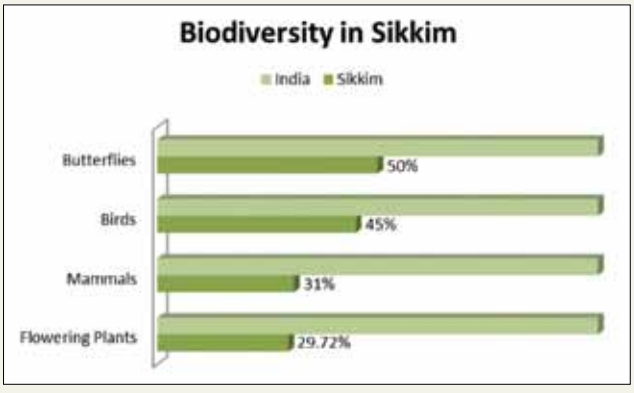
On the way to Yumthang, North Sikkim
(Photo by IPR)



Sikkim has rich and unique biodiversity. The major issues impacting Sikkim's biodiversity are highlighted in this chapter. With the rise in temperature due to global warming, some birds, insects, mammals and plants are already showing changes in their geographic distribution and some are on the verge of extinction. This section dwells upon how the Government is responding to the threats to biodiversity for a better and sustainable environment.

Sikkim is located in the Eastern Himalaya and is globally renowned for its rich biological diversity. The unique terrain, climate and biogeography of the state have resulted in the sustenance of varied eco-zones in close proximity. In addition, the harmonious presence of several ethnic groups, with distinct identities and traditional livelihoods, adds to the treasure house of knowledge on biodiversity. It is a land of vast variation in altitude from around 300 meters to 8586 meters above the sea level. The State houses 29.72 percent of India's flowering plants. Rhododendrons, Primulas and Orchids constitute 33.88, 42.96 and 42.55 percent of India's total diversity respectively. The state is also home to 52.28 percent of the total butterfly species and 43.68 per cent of the bird species of India. Globally, Sikkim is one of the richest habitats for birds. Sikkim has been a treasure for botanists and explorers and the state has the highest number of vascular plants named after any Indian state (Sikkim Himalaya: Unique Features of Biogeography and Ecology, G.S. Rawat and Sandeep Tambe)

Figure 5.1: Biodiversity in Sikkim



Sikkim has habitats ranging from sub-tropical to cold deserts and has India's smallest bio-geographic province-Tso Lhamo Plateau. It is famous for the most extensive zone of krummholz (stunted forests) in the Himalayan zone.

Being an agrarian State, a large variety of agricultural crops is grown in Sikkim. Over 175 cultivars of 69 crop species are cultivated, with rice having the highest number of cultivars (43), followed by maize (26).

Elevation plays a prime role in fashioning the eco-regions of the State. This is evident from the presence of Sal forests in the Rangit Valley in the south to the temperate fir forests in the north, beyond which lie the trans-Himalayas and the cold desert of the Tibetan plateau.

Forests are extremely important for ensuring environmental functions. They facilitate climate regulation, soil and biodiversity conservation, and also ensure water security. Forests are a home to a wide variety of plants and animals and provide a range of ecosystem services and sustainable livelihood opportunities for local communities.

Sikkim represents five major types of forest systems: tropical, sub-tropical, temperate, sub-alpine and alpine forests. These forest systems harbor some of the unique and endemic species of flora and fauna.

The tropical forests are dry deciduous found in the valleys of Teesta and Rangit. *Dillenia pentagyna, Dysoxylum floribundum, Albizia procera*, and *Alnus nepalensis* are few of the common species found in this area. Temperate forests in the Himalayan region are predominated by coniferous trees that have broad leaved trees and aren't very tall. In Yanthang and Lachung, the major tree species are fir, juniper, deodar, chilgoza, oak and ash. The Alpine forests are found in Chopta Changu areas in Sikkim. These are low scrub, dense ever green forest, consisting mainly of rhododendron and birch. It can with stand heavy snow fall and mosses and ferns cover the ground during summer and spring. Above Yanthang in Sikkim we have the sub alpine forests. The common tree species are red fir, black juniper, birch, and larch. Rhododendron is also a common species. Due to heavy rainfall and humidity in this area, the timberline is also high.



Tibetan Red Sand Fox, *Vulpes ferrilata*
(Photo by Karma Choden Bhutia)



Himalayan Blue Sheep at KNP
(Photo by Sangay G. Bhutia)



Snow Leopard (Panthera uncia)
camera trapped from KNP, West Sikkim

5.1 Status

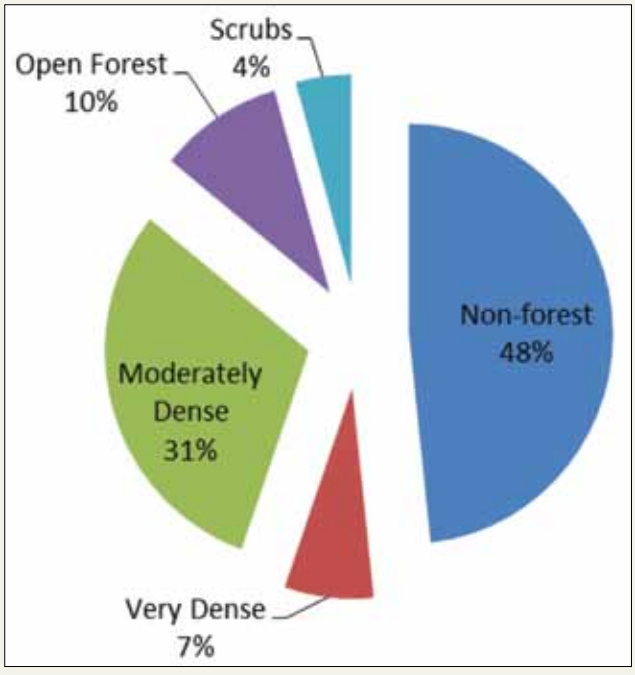
5.1.1 Forests

Forests are a major land use in the state, occupying 3392 sq. km. of the total geographical area of Sikkim. Legally, these forests are classified into Reserved Forests (76.83 percent) and Protected Forests (5.48 percent). Sikkim's total forest cover is higher than 33%, at 47.80 percent to fit total geographical area under forest and tree cover (0.43 percent of India's forest and tree cover). 7.05% of this area is under Very Dense Forests, 30.44% under Moderately Dense Forests and 9.82% under Open Forests. Outside the Green Wash, the State has 1,392 sq. km under forest cover, which accounts for 19.62% of the total geographical area (India State of Forest Report, 2015).

The forest cover has been religiously maintained since 2009 despite several developmental activities in the State. The slight decline in the total forest cover in 2013 as compared to 2011 is attributed to earthquake-induced landslides in Sikkim in 2011 (India State of Forest Report, 2013). Similarly, there has been a minor decline in the total forest cover from 2013 to 2015 due to natural as well as anthropogenic disturbances such as landslides, road construction and shifting cultivation. (India State of Forest Report, 2015,FSI)

The South District boasts of the highest percentage of forest cover, followed by the East District. This green cover is intact due to the strict implementation of the existing forest policies in the State as well as the sensitivity of the Government and the citizens.

Figure 5.2: Forest Density in Sikkim



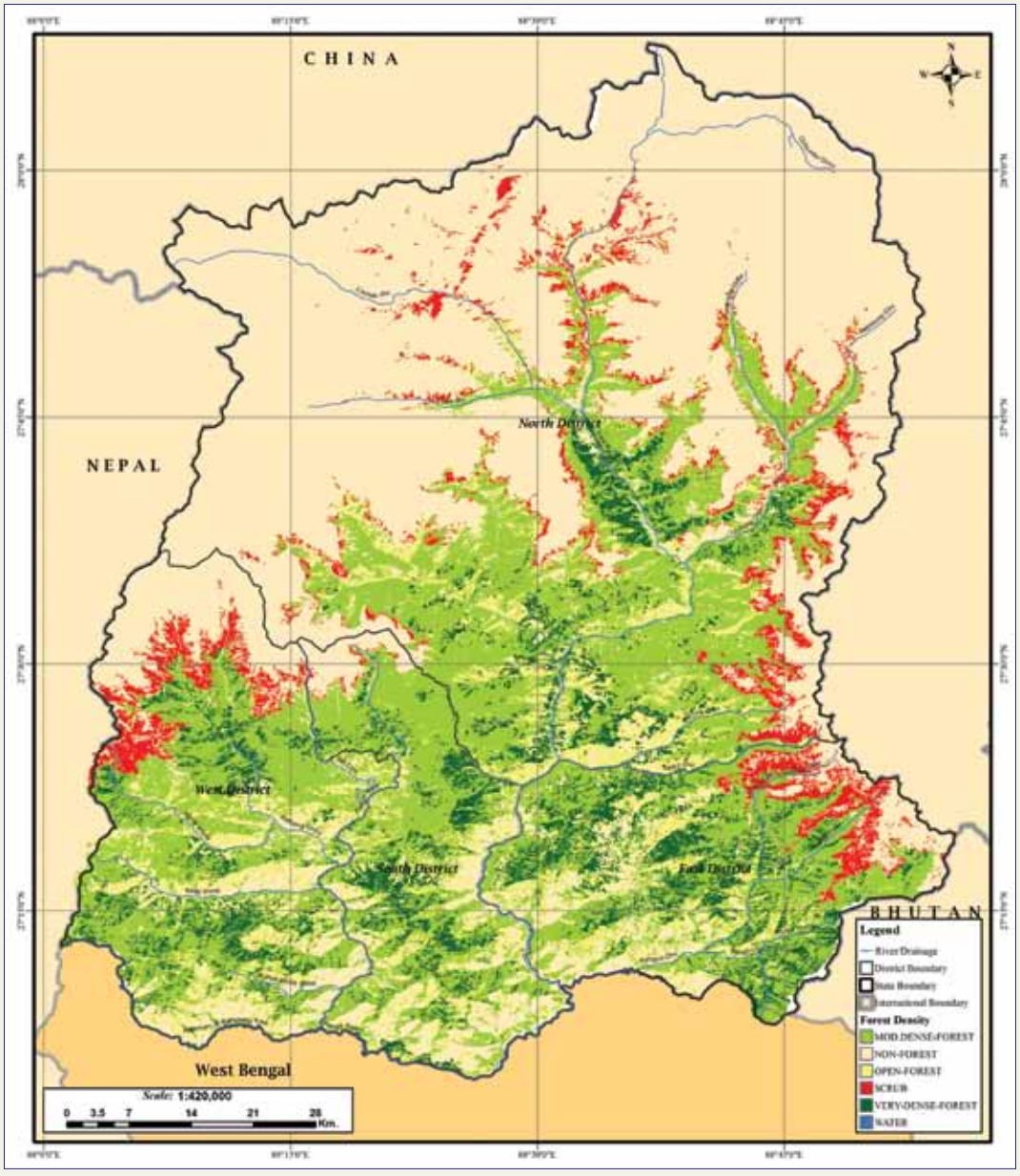
Source: *India State of Forest Report 2015, FSI*

Table 5.1: Forest Cover of Sikkim

Forest Cover within Green Wash	Area in sq. km
Very Dense Forests	390
Moderately Dense Forests	1,323
Open Forests	252
Sub-total	1,965
Forest Cover outside Green Wash	
Very Dense Forests	110
Moderately Dense Forests	837
Open Forests	445
Sub-total	1,392
Total Forest Cover	3,357
Tree Cover	35
Total Forest and Tree Cover	3,392
%age of State's Geographical Area	47.80%
%age of India's Forest and Tree Cover	0.43%

Source*: India State of Forest Report 2015, FSI*

Map 5.1: Forest Cover of Sikkim



Source: *Forest Survey of India Report 2015*

Table 5.2: Sikkim's Forest Cover in 2007, 2011, 2015

Districts	Total Area	2007		2011		2015	
		Total Forest (sq. km)	Percentage of Geographical Area	Total Forest (sq. km)	Percentage of Geographical Area	Total Forest (sq. km)	Percentage of Geographical Area
East	954	699	73.27	699	73.27	699	73.27
North	4,226	1,315	31.12	1,317	31.14	1,315	31.12
South	750	571	76.13	571	76.13	571	76.13
West	1,166	772	66.21	772	66.21	772	66.21
Grand Total	**7,096**	**3,357**	**47.31**	**3,359**	**47.34**	**3,357**	**47.31**

Source: *Indian State of Forest Report, 2007, 2011, 2015*

5.1.2 Human-biodiversity interactions

In a state that has nearly 47% of its area under forest, is 100% organic agriculturally and derives major economic benefits from nature tourism, biodiversity is indispensable from human life. People living in and around forests are dependent on them for livelihoods, whilst many others seek indirect benefits from the nature's bounty in the state.

Sikkim also has a rich base of medicinal plants that significantly contribute to the economy and generate employment. A strong traditional system of medicine based on 424 species of medicinal plants is prevalent in the state (SoER Sikkim, 2007). These plants are mostly found in forests, like 90% of the medicinal plants in India. *Abelmoschus manihot*(L.), Medikus Curcuma *longa* and *Datura stramonium* are some of the popular medicinal plants in Sikkim and have wide applications in treatment of epilepsy, leprosy, paralysis, hemorrhages during childbirth and cholera. They are an important part of local tradition in Sikkim and are of importance in the rural sector. The state harbors potential to commercialize sale of Yartsa Gunbu, which has a high demand in the international market owing to its use in traditional Chinese and Tibetan medicinal systems.

5.1.3 Protected Areas

A significant part of the state's total geographical area, at 30.77%, is under the Protected Area (PA) network with seven Wildlife Sanctuaries, one National Park and one Conservation Reserve (Table 5.3). Sikkim has the highest State-wise percentage of Pas in the country. The Khangchendzonga National Park is spread in North, South and West Sikkim with in the altitudinal range of 1400m asl-8598m asl. It has also been designated as a UNESCO World Heritage Site for its natural and cultural significance, bringing Sikkim on the global map. The Khangchendzonga National Park is surrounded by 835.92 sq km of buffer zone and 311.20 sq km as transition zone collectively forming a Khangchendzonga Biosphere Reserve (KBR) with 2931.12 sq km. Including the KBR, Sikkim has 46.93% of its geographical area under the protected area network.

Sikkim's diverse faunal base includes more than 125 species of mammals of which many species viz., Red Panda, Snow Leopard, Clouded Leopard, Musk Deer, Tibetan Wolf, Red Fox, Indian Wild Dog, Hog Badger, Tibetan Sheep or Argali, Tibetan gazelle, Serow, Goral, Tibetan Wild Ass, etc. are included in the Indian Red Data Book. Some of the endangered mammalian species of Sikkim are Bharal, Fishing Cat, Golden Cat, Leopard Cat, Marbled Cat, Himalayan Tahr, Pangolin, Spotted Lingsang, Tibetan Fox, etc. are also found in Sikkim. (Sikkim Human development Report, 2014)

Similarly, few of the bird species of conservation concern in Sikkim are Black Necked Crane (Migratory), Blood Pheasant Lammergeyer, LargeFalcon, Monal Pheasant, Peafowl, Tibetan Show Cock, Satyr Tragopan, Snow Partridge, etc. (Biodiversity of Sikkim, ENVIS Sikkim2015).



Khangchendzonga National Park inscribed as UNESCO's World Heritage Site

KNP is India's first World Heritage Site listed in 'mixed' criteria

The 40th World Heritage Committee on 17th of July, 2016 at Istanbul, Turkey inscribed Khangchendzonga National Park of Sikkim, India as a UNESCO's World Heritage Site on 'Mixed' criteria recognizing the outstanding universal values for its both natural and cultural significance.



Charmaney at Dzongri, Khangchendzonga National Park, West Sikkim

Table 5.3: Protected Area Network in Sikkim

S.No.	Name of Protected Area	District	Area (Sq. km)
1.	Fambong Lho Wildlife Sanctuary	East Sikkim	51.76
2.	Kyongnosla Alpine Sanctuary	East Sikkim	31.00
3.	Pangolakha Wildlife Sanctuary	East Sikkim	128.00
4.	Maenam Wildlife Sanctuary	South Sikkim	35.34
5.	Kitam Bird Sanctuary	South Sikkim	6.00
6.	Barsey Rhododendron Sanctuary	West Sikkim	104.00
7.	Shingba Rhododendron Sanctuary	North Sikkim	43.00
8.	Khangchendzonga National Park (KNP)	West/North/South	1,784.00
9.	Sling Dong Faireanum Orchid Conservation Reserve	South Sikkim	0.06
A.	**Total Area of PAs**		**2,183.16 (30.77% of State's TGA)**
B.	**KNP Buffer Zone**	West/North/South	**835.92**
C.	**KNP Transition Zone**	West/North/South	**311.20**
Khangchendzonga Biosphere Reserve (KNP+ Buffer zone + Transition zone)		West/North/South	2931.12
		Total PA network (A+B+C)	**3330.28 (46.93 % of State's TGA)**

Source: http://www.sikkimforest.gov.in/Wildlife.htm

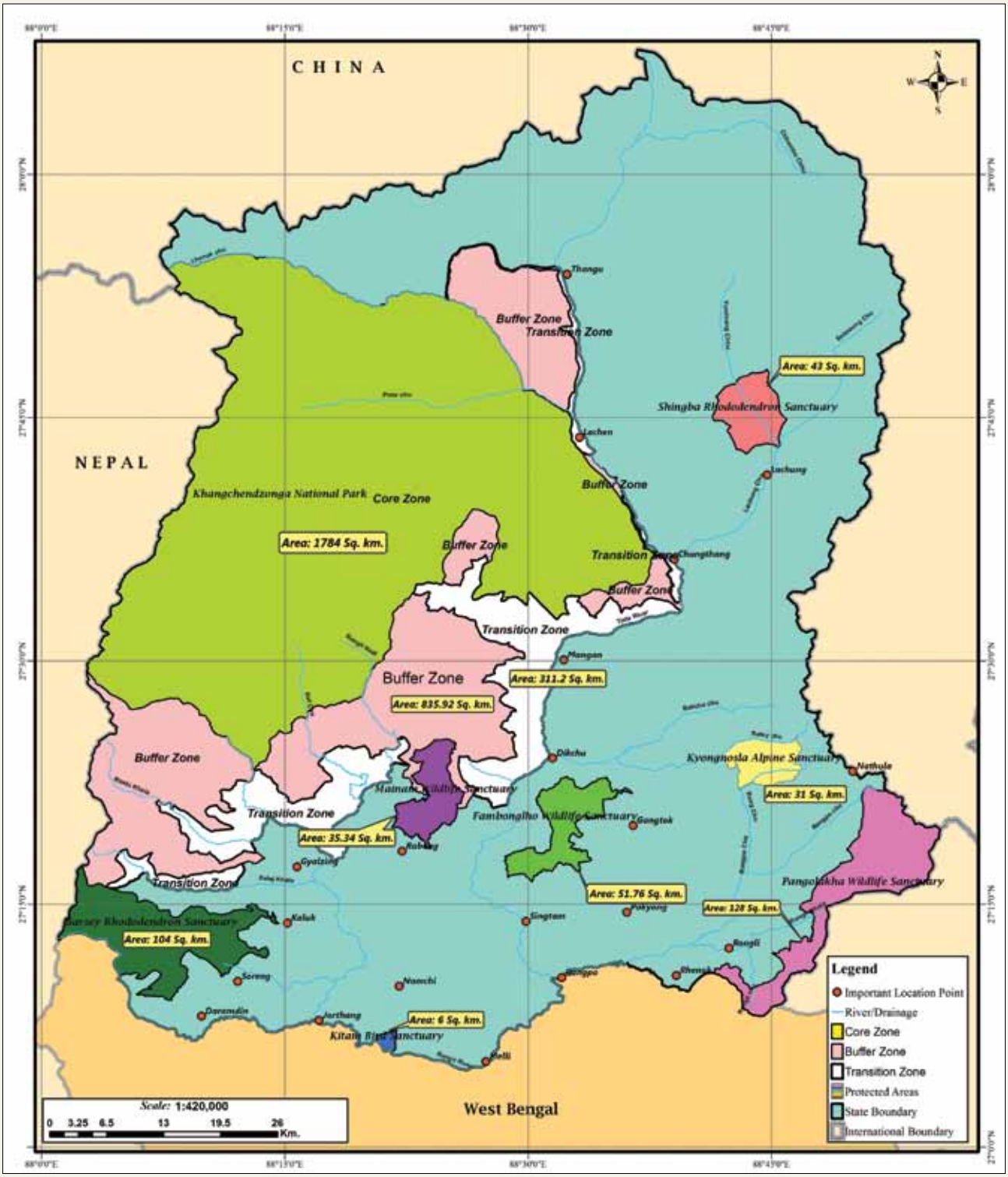
Sikkim's biodiversity richness: Rhododendrons of Dzongu Valley

The majority of rhododendrons explored in the Sikkim Himalaya are entirely new to rhododendron world. A major part of Dzongu, especially the upper reaches, falls inside the Khangchendzonga National park declared as a UNESCO World Heritage Site.

Unique species found in the valley are *R. Maddenni* and *R. Niveium.*



Map 5.2: Protected Area Map of Sikkim



Source: *Remote Sensing Cell, FEWMD*

5.1.4 Wetlands

Wetlands are amongst the most productive ecosystems on Earth (A. Ghermandi, 2010). They exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics (Space Applications Centre, 2011).

High altitude lakes account for 40.79 per cent of the total wetland area, the major ones being Chhangu (Tsomgo), Khecheopalri, Gurudongmar, Cholamu, Memencho, Lampokhari, Samiti etc. The Tsomgo lake is an important tourist site.

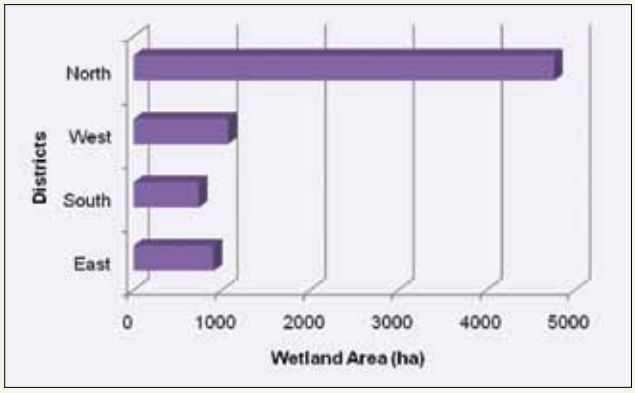
Such wetland ecosystems form an ideal habitat for Red Panda, Rhododendrons and various species of birds. Gurudongmar is located at an altitude of 5,183 meters above sea level and it is the largest glacial lake located in the northern district of Sikkim. It is the source of the stream Chhombo Chhu, which ultimately meets another stream flowing from Tsho Lhamo and together form the Teesta River.

Tsomgo is located at an altitude of 3,700 meters above the sea level, being one of the 11 sacred high- altitude lakes in Sikkim, notified by the Sikkim Government in 2001 as 'a religious place more than 100 years old'.

Besides teeming with a variety of floral and faunal species, the wetland receives flocks of waterfowl (about 10-15 at one time) which use this site for halting and transit.

The North district of Sikkim has the maximum percentage of geographical area under wetlands (Figure 5.3 and Table 5.4), constituting 63% of the state's total wetlands.

Figure 5.3: Wetland Area in Sikkim




Gurudongmar Lake, North Sikkim

Table 5.4: Distribution of Wetlands in Sikkim

S. N.	District	*Geographic area* (ha)	*Wetland area (ha)*	*% of total wetland area*	*% of district geographic area*
1	**North**	**422600**	**4764**	**63.72**	**1.13**
2	**West**	**116600**	**1069**	**14.30**	**0.92**
3	**South**	**75000**	**739**	**9.88**	**0.99**
4	**East**	**95400**	**905**	**12.10**	**0.95**
	Total	**709600**	**7477**	**100.00**	**1.05**

Source: *National Wetlands of Sikkim-2010, Published by Space Application Centre, Indian Space Research Organization, Ahmedabad*

5.2 Pressures

Biodiversity of the state faces a number of threats like soil erosion, deforestation, air pollution, waste management, habitat fragmentation etc. These environmental threats stem from natural and anthropogenic factors, majorly from disasters and developmental activities in the region.

5.2.1 Introduction of alien/exotic species

International Union for Conservation of Nature and Natural Resources defines Alien Invasive Species as a species which become established in natural or semi-natural ecosystems or habitats, act as an agent of change, and threaten native biological diversity. An exotic species from South China namely *Cercaris nigricornis* has also recently invaded north-east India including Sikkim. (Insect Diversity of Sikkim, Kailash Chandra, ZSI and Sikkim forest.gov.in)

5.2.2 Waste Management

Poor and unscientific waste management is an environmental hazard. Gurudongmar and Tsomgo wetlands face problems due to garbage accumulation from religious offerings and inadequate infrastructure for functional public

toilets (WWF, 2015), posing a threat to the biodiversity due to improper management of solid waste (Department of Forest, 2011). Being pre dominant tourist destinations, many sites in the state suffer from improper garbage handling and consequent accumulation of plastic water bottles and a variety of packaging material.

5.2.3 Man-animal conflict

Man animal conflicts in Sikkim can be grouped into four categories: crop raiding by animals, attacks on humans and livestock, and animals occupying human habitations. Increasing overlap between human and animal habitations, and subsequent loss of livestock to wild animals exacerbates the conflict. High altitudes have more incidences of yak/ cow kill by attack of wild dogs and Himalayan Black Bear. Herders from high altitudes also inform about cattle lifting by snow leopards in some parts. Himalayan black bears actively feed on maize in the agricultural fields before the onset of winter. This poses a threat to them from impending public outrage (ENVIS Sikkim Quarterly Newsletter, Vol.9).

5.2.4 Climate Change

Climate induced changes have directly or indirectly impacted the habitat and distribution limits and the food availability for wild animals. Due to the shortage of food, wild animals wander around human habitations in search of food. For example, one of the probable reasons for random movement of Himalayan Black Bearing villages and towns in recent years could be climate change. This species eats a corns and nuts of the previous year, and if the productivity of such nuts decreases due to unusual weather events, they wander around for other foods (Chimalaya, 2012). Increase in temperatures and low humidity over Sikkim have also caused an increase in forest fires causing loss of flora and fauna.

5.3 Impact

Across the globe, increasing anthropogenic pressure and diminishing forests have adverse effects on biodiversity. Introduction of exotic (non-native) species into an area, either by accident or on purpose is also a major threat to the native species. Alien species in an area do not have their natural predators to control their populations and consequently can rapidly affect native species and invade large tracts of land and water. For example, Titebati (*Artemesia milagirica*) and Banmara (*Eupatorium adenophorum*) are spreading uncontrollably in parts of Sikkim. They suppress regeneration of the natural flora, and can cause reduced yields and increased harvesting costs on agricultural land. Some invasive species (e.g. Parthenium) also can cause animal health problems.

As an evident consequence of climate change, the tree lines have been known to shift upward. Tree species from the low altitude tree are gradually shifting towards high altitude zones as the climate is more suitable for survival. *Alnus nepalensis* found around Gangtok is a species that usually is found in warmer regions (Climate Himalaya, 2011).

5.4 Response

The government of Sikkim invests hugely in biodiversity conservation and preservation programs. The state has protected nearly 25% (178,400 hectares) of its geographical area inside the boundaries of the Khangchendzonga National Park, which is a major step towards biodiversity protection in the state. It has been declared as a World Heritage Site in July 2016 based on both cultural and natural criteria. The park is home

to the Red Panda, Snow Leopard and an abundance of butterflies. 22 endemic, rare and threatened species of plants are also found with in the park and its adjacent reserve forests.(Environmental Initiatives of the State Government; Forest, Environment and Wildlife Management Department, GoS,2016)

The Sikkim Government has built up a repository and dissemination center in Environmental Science and Engineering to support e-governance. Modern technologies of information acquisition, processing, storage, retrieval and dissemination of environmental information have been geared up and the Indian State-level Basic Environment Information Database (ISBEID) has also been extended in the state.

1. Conservation and monitoring of alpine areas

The state has also launched an innovative and unique programme for the participatory conservation of the alpine areas by enrolling local community level resource persons as Himal Rakshaks or Honorary Mountain Guardians. These Himal Rakshaks have been trained on participatory monitoring of the alpine areas. The practice of grazing is totally banned in these forests.

2. Conservation of high altitude lakes

The Government of Sikkim has constituted the Sikkim State Wetland Authority for conservation and management of wetlands in the State.

For the conservation of high altitude lakes impacted by tourism, the local community has been empowered and involved in lake management through the Pokhri Sanrakshan Samiti initiative.

A comprehensive plan for development of the lakes as eco-tourism destinations is also under the process of being attempted by the authorities. Restoration measures like desilting, providing silt detention structures, weed control, abatement of pollution, awareness etc. are being adopted. There are also discussion on attempts to include Khecheopalri (West Sikkim), Tsomgo (East Sikkim) and Gurudongmar (North Sikkim) wetland complexes, in Ramsar Sites.

3. Conservation of rivers and checking river pollution

A State Level River Conservation Authority is proposed to be set up with the objective to keep the rivers pollution free and to maintain a healthy aquatic ecosystem, protecting aquatic biodiversity. The concept of Eco-protection of river/ rivulets and the mechanism for 'Pay when you litter' against any dumping garbage and waste materials being developed. All the villages / residential areas adjacent to main streams and rivers shall be actively involved in the management and conservation of rivers by formation of River Conservation Protection Force.

4. Plantation under State's flagship programmes

The Government of Sikkim has launched several unique flagship programmes such as State Green Mission, Ten Minutes to Earth, Paryavaran Mahotsav and Smritivan (memorial forest) with a view to raise avenue plantation and beautification of all vacant and waste lands. The major objectives of the programme are to create a green belt and avenues for meeting aesthetic recreational needs of the people and beautify the areas for tourist attraction. Other initiatives to conserve the State's green cover include declaration of Heritage Trees and Mith Trees which are unique initiatives practiced in Sikkim.



Roadside plantation

5. Under Integrated Watershed Development Program (IWDP) for Non-forest areas through the Zilla Parishad, there's an emphasis on fuel wood and fodder plantation in order to reduce pressure on natural forests and to enhance the productivity of land.

6. The Government of Sikkim has imposed a five-year ban on collection of all medicinal plants and non-timber forest produce for commercial purposes.

7. Protection of Eco-Sensitive Zones

The notification on eco-sensitive zones relates to areas surrounding the Protected Areas as eco-sensitive zones. Development activities, including mining, quarrying or setting up new 'major' hydro-electric projects, will not be allowed in these areas.

The purpose of an eco-sensitive zone is to create areas that can act as shock absorbers around the identified stretch to protect environment and wildlife. The extent of eco-sensitive zone, under the notification, varies from 25 meters to 200 meters from the existing boundary of the national parks and sanctuaries, depending on the topography of the region and its proximity to international boundaries with Nepal and China.

Recommendations

- There is thus a need to strengthen the role of van-panchayats and the formation of forest user groups, and extend the implementation of these models to wider geography.
- In the context of poverty, as well as large and expanding human and livestock populations putting increasing pressure on the forests of India and leading to consequences of over-grazing and severe degradation of land and forest resources, it will be important to promotion an integrated grazing and livestock management policy that aims to reduce the pressures acting on forests while also in parallel promoting the generation of alternative livelihood options for communities that have been traditionally forest dependent or that live in adjoining areas.

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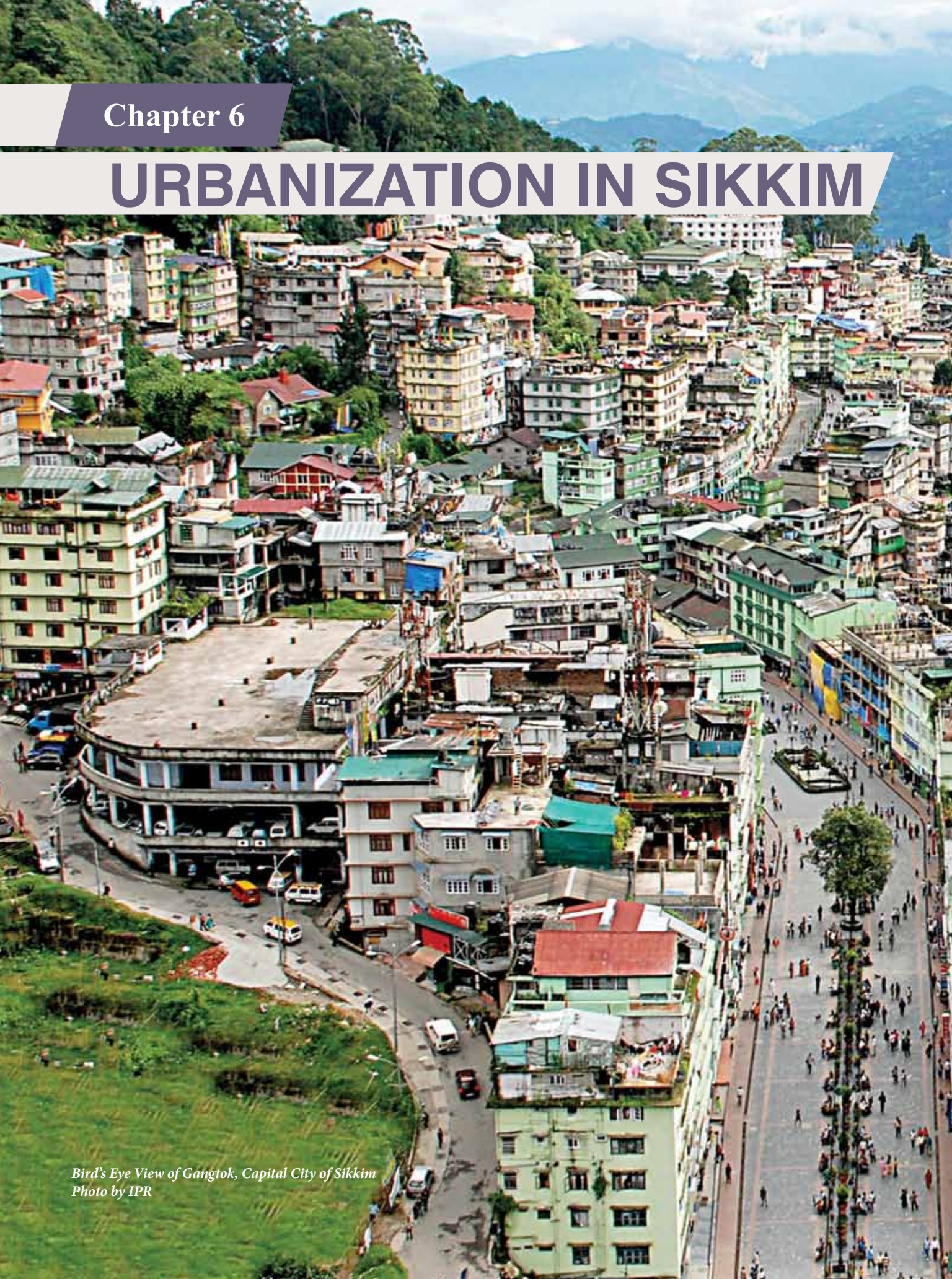
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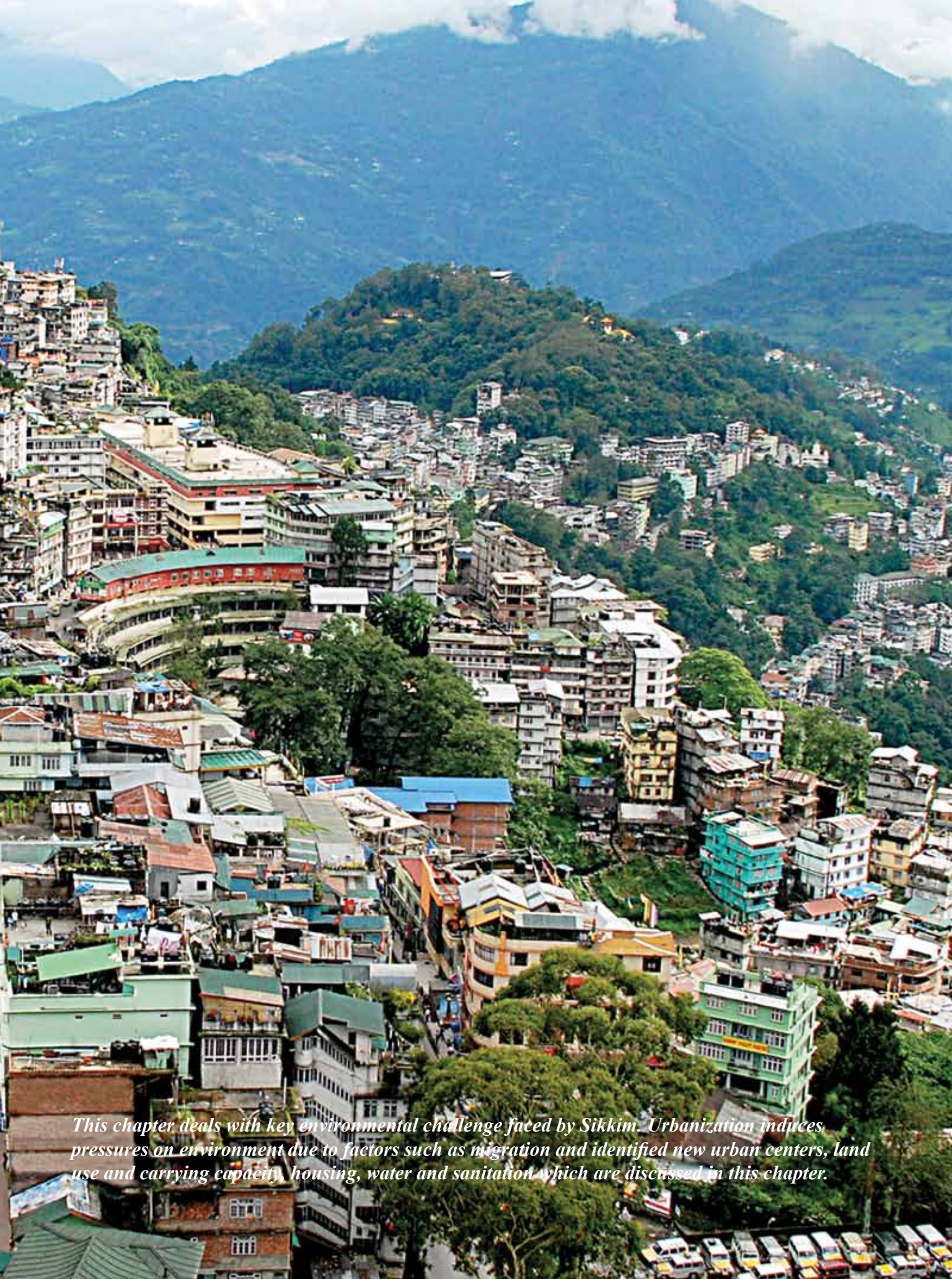
SoER Sikkim, 2007

Chapter 6

URBANIZATION IN SIKKIM



Bird's Eye View of Gangtok, Capital City of Sikkim
Photo by IPR



This chapter deals with key environmental challenge faced by Sikkim. Urbanization induces pressures on environment due to factors such as migration and identified new urban centers, land use and carrying capacity, housing, water and sanitation which are discussed in this chapter.



Uttarey Village, West Sikkim

6.1 Introduction

Sikkim is a State with pre dominantly rural population. Urban population accounts for nearly 25 percent (1, 53,578) of the total population (6, 10,577). The urban population as percentage of total population has increased from 11.07 % in 2001 to 25.15% in 2011.The capital city Gangtok alone has a share of 65% of the total urban population of Sikkim (Urban Development and Housing Department, Government of Sikkim, 2016).

The four districts of the State have nine urban centers in total. The East district is the most urbanized and accounts for nearly eighty percent of the total urban population. The primary reason for this may be the existence of National Highway-10 (NH-10) which runs through the district and connects the country with Nathula pass, which is not only one of the major trade route but also an area with tourist attraction. Owing to this road connect; the east district has witnessed tremendous urban development.

6.2 Status and Trends

The table 6.1 details the area, population and households in all urban centers of Sikkim. Sikkim has only one Class-I city, that is Gangtok with population of size more than 1,00,000. Rangpo and Namchi are Class-IV cities whose population lies in between 10,000 and 19,000. Singtam, Rhenock and Jorethang are Class-V cities with population size in between 5,000 and 9,000. The others–Gyalshing, Naya Bazaar and Mangan are Class-VI, with population size of less than 5,000.

The process of urbanization in the State has been slow, except for the explosive growth of State Capital, Gangtok. Urbanization in Sikkim has been driven by the growth of administrative and commercial activity. The urban population in Sikkim is concentrated primarily in the East District especially in the capital city of Gangtok. The quality of life, the pace of development and availability of basic infrastructure and employment prospects have been the major reasons for migration from rural tour ban locations. The urban services are subjected to lot of pressure due to the rapid increase of population in a limited area with land constraints and their floating nature due to tourism. The strain in the system is evident in the form of traffic and transportation challenges, industrial and commercial development prospects, housing shortage, garbage collection issues etc.

Since 1994, the Urban Development & Housing Department has come a long way in improving the living standards of the urban masses by putting in place the requisite urban infrastructures and bringing about progressive reforms in Urban Governance.

6.3 Pressures on Environment

Urbanization induces pressures on environment due to the following four identified factors: migration and identified new urban centers; land use and carrying capacity; housing; water and sanitation. The degree of pressure in the following factor follows:

Table 6.1: Urban Statistics -Sikkim

District	Area (km^2)	Town/City	Area (km^2)	Class	Urban Population (Town/city wise)	Urban Population (District wise)	Total Population	% Urban Population	Urban Body	Number of wards	Number of Households
EAST	**954**	Gangtok	19.2	Class I	100286	122487	283583	43	Municipal Corporation	15	23773
		Singtam	0.18	Class V	5868				Nagar Panchayat	5	1144
		Rangpo	1.79	Class IV	10450				Nagar Panchayat	5	2505
		Rhenock	4	Class V	5883				Census Town		1269
WEST	**1166**	Gyalshing *	3.6	Class VI	4013	5248	136435	4	Nagar Panchayat *	5	881
		Naya Bazaar**	0.12	Class VI	1235				Notified Bazaar Area **		252
NORTH	**4226**	Mangan	1.76	Class VI	4644	4644	43709	11	Nagar Panchayat	5	1054
SOUTH	**750**	Jorethang **	0.45	Class V	9009	21199	146850	14	Nagar Panchayat **	5	2107
		Namchi	7.15	Class IV	12190				Municipal Council	7	2733
TOTAL	**7096**		**38.25**		**153578**	**153578**	**610577**	**25**			**35718**

***Data Source**: Census 2011*

**Gyalshing Nagar Panchayat has been upgraded to Gyalshing Municipal Council in 2015*

***The Jorethang Nagar Panchayat and Naya bazaar Notified Town Area have been combined to form the Nayabazaar-Jorethang Municipal Council in 2015*

Table 6.2: Different types of Land Use categories of Gangtak Town, 1975-2011

SL. No.	Land Use Categories	Percentage of Total Land Area				
		1975	1985	1995	2006	2011
1	Residential	65.5	54.8	49.6	43.0	36.0
2	Commercial	6.9	6.4	4.6	4.0	3.5
3	Public & Semi Public	0.6	1.7	4.2	15.0	21.4
4	Transportation	13.4	12.2	10.6	19.0	20.1
5	Recreational	12.6	17.7	22.0	13.5	14.1
6	Industrial	1.1	7.3	9.0	5.5	4.9

Source: DST, Gangtok-Sikkim

6.3.1 Migration and New Urban Center's:

According to NSS 64th Round Report, Migration in India, 2007; 70% of the migration in Sikkim is rural to rural migration where as 12.5% of the total migration is from rural to urban setup and urban to urban migration is 9.2%. There is also an evidence of reverse migration from urban to rural of approximately 8.3%. 21.7% of the total migration is induced due to employment related reasons. Marriage is the reason for approximately 45% of the migration and 6% of the migrants were for the purpose of higher studies. (www.rural.nic.in)

The State of Sikkim had 9 towns according to Census 2001. The number of towns remains the same in 2011. However, Gangtok moved from Class III City (Population – 29,534) in 2001 to Class I City (Population–1,00,286) whereas two other cities moved from Class VI to Class IV– Namchi and Rangpo. Urban population in Sikkim in total has increased by 156% from 59,870 in 2001 to 1,53,578 in 2011. This increase in population in urban centres impact the usage of natural resources in this region, which is evident from the patterns of land use, increased use of water and other resources and waste generation from urban activities.

6.3.2 Land Use and Carrying Capacity

There have been no studies undertaken on the changing land-use patterns for any urban centres, except for Gangtok. The land use pattern of Gangtok town has been categorized in six categories i.e. residential, commercial, public and semi-public, transportation, industrial and recreational. In the post-merger period (merging of Sikkim with India), public and semi-public area had also been expanded from 0.6 percent in 1975 to 21.4% in 2011. Residential area has declined from 65.5% (1975) to 36.0 percent in 2011. There has been 7 percent and 1.7 percent increase in the transport and recreational sectors respectively from 1975 to 2011. However, the land use pattern of industry drastically declined compared to situations before 2006. (Paul, et al.,2016) Since no studies have yet been under taken on the carrying capacity of the city and towns of Sikkim, it is difficult to draw any concrete conclusions on whether the rate and extent of urbanization is feasible within the ecological boundaries of the regions of urbanization and the state in general.

6.3.3 Housing

Sikkim has a housing shortage of 10,000 households. (Ministry of Housing and Urban Poverty Alleviation, 2013) Estimated slum population of Sikkim in 2001 was 9,609, approximately 16% of the total slum population. Projected slum population in 2017 is 15,729 (Ministry of Housing and Urban Poverty Alleviation, 2013). Increase in urban population due to migration and estimates of housing shortage will require additional units of houses to be constructed. It entails increasing consumption of natural resources like land, water, energy and building materials to meet the rising need for construction along with contributing to CO_2 emissions immensely. Case in point is the fact that buildings use 40% of energy, 30% of raw materials, and 20% of land and water each, whilst accounting for 40% of CO_2 emission, 30% of solid waste generation and 20% of water effluents (Roy Chowdhury, 2011).

6.3.4 Water and Sanitation:

98.2% of the urban households in Sikkim have access to improved sources of drinking water. (Department of Economics, Statistics, Monitoring and Evaluation, 2013)

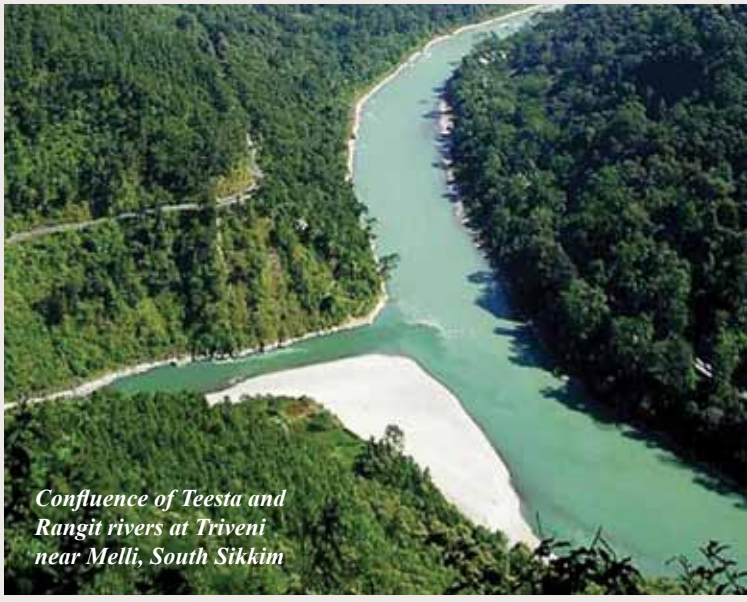
The water quality in Sikkim varies from excellent to very poor depending on the seasons. Further, the

Table 6.3: Projections of water utilisation by sector in Sikkim

Sl. No.	Sector	Year wise tentative projections				
		2010	2020	2030	2040	2050
I.	Irrigation use					
	a. Kharif	1764.00	2058.00	2352.00	2499.00	2646.00
	b. Rabi	371.00	464.28	557.05	649.89	742.74
II.	Urban Suburban Areas (PHED)	23.70	42.51	55.27	71.86	93.41
III.	Rural areas (RMDD)	17.00	20.72	25.26	30.79	37.53
IV.	Industries (Department of Commerce and Industries)	0.42	0.53	0.66	0.83	1.03
V.	Maxium requirement of water for Kharif season (IA+II+III+IV)	1805.12	2121.76	2433.19	2602.48	2777.97
VI.	Minimum requirement of water during Rabu season (IB+II+III+IV)	412.12.	528.04	638.24	753.37	874.71

Source: *Irrigation Department*

frequent landslides and flash floods cause water contamination in the supply lines. This causes massive disruption in the water supply to households in addition to inviting the threat of several water-borne diseases. Water quality checks were also performed in Gangtok and its neighbourhood, viz. Singtam, Tadong, Deorali, Sichey, Selep, Ranipool and Rumtek. The average pH value was found to be 8.4±0.1. Except for the chlorinated water at the Selep water treatment plant, the water samples were found to have microbial presence. In Selep, chlorination is primarily used for disinfection of the collected water. However, it is known that drinking chlorinated water on a long term may lead to cancer, mutations and other adverse health hazards. The table below summarizes the pH value and microbial content data in 6 cities of Sikkim.



Confluence of Teesta and Rangit rivers at Triveni near Melli, South Sikkim

Table 6.4: PH value and Microbial activities in water of Urban Centres

City	Source of Water	pH Value	Microbial Activity
Namchi, South Sikkim	PHE raw PHE treated 7.9 Tinjhir Dhara	7.8 7.9 7.7	Present Present Present
Solophok, Namchi, South Sikkim	Chardham storage tank Chardham storage tank at Shiva monument	8.5 9.5	Present Absent
Singtam, East Sikkim	Rolep Dhara	8.2	Present
Ranipool, Gangtok, East Sikkim	Ranikhola Sewerage water after treatment	8.4 8.2	Present Present
WTP, Selep, Gangtok, East Sikkim	Inlet water Chiorinated water Final staged water	8.1 10.6 8.1	Present Absent Present
Rumtek, Gangtok, East Sikkim	Simsar Natural source, Sirwaw	8.5 8.0	Present Present

Source: *Water quality and quantity analysis in Sikkim, North Eastern Himalaya: Archana Tiwari*

6.3.5 Electricity Consumption

The State has achieved 100% village level electrification. At the household level, 92.5% of the Households are electrified in Sikkim. As per the latest estimates 14,225 rural and 2,845 urban households are to be electrified by Financial Year 2019 (Government of Sikkim and Deloitte, 2015). Following table 6.5 gives the trends of electricity consumption in the Sikkim from 2008 to 2016.



Teesta valley power transmission

Table 6.5: Electricity Consumption (in Kwh per annum)

Category	2008-09	2009-10	2010-11	2011-12	2012-2013	2013-14	2014-15	2015-16
Agriculture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Domestic	56.20	58.40	57.97	82.77	78.98	83.98	78.93	74.96
Commercial	28.90	29.30	29.23	29.72	38.26	35.43	35.33	37.43
Public Lighting	2.60	2.60	2.60	2.30	0.43	0.35	0.29	0.15
Temporary Supply	0.10	0.10	0.15	0.30	0.09	1.61	1.36	1.16
HT Industrial consumers	57.50	59.20	58.39	71.63	91.76	97.11	110.49	126.30
LT Industrial consumers	1.20	1.90	1.31	8.63	1.15	1.15	1.37	1.34
Bulk Supply	13.50	14.50	13.35	13.21	16.23	17.74	20.98	23.37
Outside State	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	160.00	166.00	163.00	208.56	226.90	237.37	248.75	264.71

Source: *Tariff Order for FY 2017-18, (March 2017 Report); Sikkim State Electricity Regulatory Commission, Gangtok, Sikkim; Energy and Power Department, Government of Sikkim*

6.3.6 Tourism

Sikkim, with its beautiful landscape, varied biodiversity, rich heritage and cultural marvels attract tourists from all over the world and India thus making tourism as one of it's major contributors in the State's economy. The year 2010 was declared as 'the year of tourism'. Sikkim has also been declared as the best region to visit in 2014 by Lonely Planet-a leading global travel guide. Sikkim's Tourism Mission 2015 seeks to make tourism the main livelihood of the people of Sikkim and transform each and every household and individual into a skilled force for the tourism Industry.

Sikkim attracted a record 700,011 tourists in 2010—which had been declared as 'the year of tourism'. The number of tourists dipped in 2011 due to a massive earthquake, but witnessed an increase in the very next year. The inflow of international tourists has been ever increasing since 2005, which increased by 197% from 2005 to 2014 whereas the inflow of domestic tourists has increased by 61.77% during the same time. In fact, tourist arrivals have exceeded the total population of the State. (Figure 6.1)

Tourism is estimated to contribute to around 8 percent of the state GDP. Close to 2.9 million tourists visited Sikkim during the Eleventh Plan period in between 2007 and 2012. This number is expected to rise to 5 million tourists during the Twelfth Plan period, between 2012 and 2017 (Tourism and Civil Aviation Department, 2014). Sikkim has been making a conscious effort to promote a variety of eco- tourism activities. These include (i) activities in mountains such as trekking, bird and wildlife watching, hiking, photography, mountaineering, etc.; (ii) activities in rivers and lakes such as angling, rafting, etc.; and, (iii) participating in cultural and traditional events such as agro-tourism, handicraft making, fairs, festivals.

Sikkim Ecotourism policy has also been framed in 2011. The vision of the policy is to establish Sikkim as an ultimate and unique eco-tourism destination, offering memorable and high quality learning experience to the visitors, which in turn will contribute to poverty alleviation as well as promoting natural conservation.

Khangchendzonga National Park

The park has been awarded the status of a mixed world heritage site on July 17, 2016 as it fulfils UNESCO's criteria for both cultural and natural heritage. It is also the first site in India to be granted this prestigious honor.

The park, situated in the North and West districts of Sikkim covers 25% of the state's total area. It is named after the world's third highest peak, Mt. Khangchendzonga at 8,586m asl. A number of lakes and glaciers grace the high altitude landscape in the park which supports a plethora of flora and fauna, many of which are endemic. The largest Himalayan predator, Snow Leopard, the flagship species of KNP, which has been given immense protection under India's national Wildlife (Protection) Act, is found here.

Fig 6.1: Tourist Flow in Sikkim

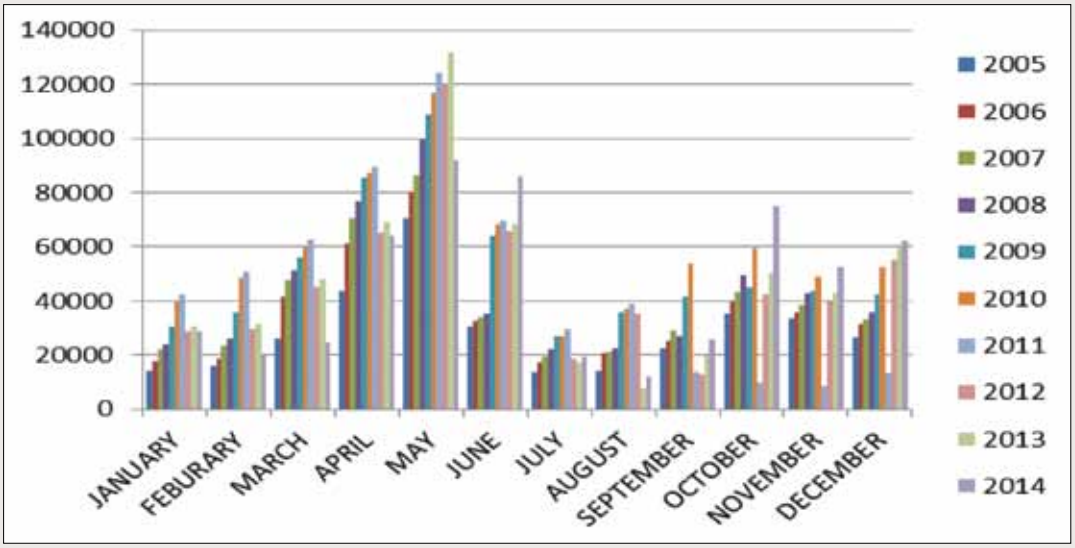


Table 6.6: Important Tourist Spots

East	West	North	South
Rumtek Monastery	Pelling	Kabi Lungchok	Namchi
Enchey Monastery	Singhshore Bridge	Phodong Monastery	Tedong Hill
Cottage Industry	Khecheopalri Lake	Lachung	Temi Tea Garden
Flower Show	Yuksom (Yuksom)	Yumthang	Maenam hill
Tibetology	Pamayangtse Monastery	Phensong Monastery	PhurTsa Chu
Chorten	Sanga Cho ling Monastery	Chungthang	Rabongla
Saramsa garden	Dubdi Monastery	Singik	Jorethang
Hanuman Tok	Barsey	Lachen	Sadam-Tarey Bhir
Ganesh Tok	Rabdenste Palace Ruins	Gurudongmar	Bhleydungpa Yangang
Tashi view Point	Dzongri		Samdruptse
Tsomgo Lake	Uttarey		Chardham Solophok
Nathula			Kitam
Zaluk, Aritar			
Ranka Tourist Village			

Source: *ENVIS Sikkim, 2016*

Table 6.7: Tourists Flow in Sikkim

SN.	MONTH	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	JANUARY	14245	17887	22286	24035	30395	40160	42314	28560	30292	28824
2	FEBURARY	16100	18550	23465	26098	35883	48420	50652	29642	31278	19830
3	MARCH	26100	41593	47465	51018	55965	60560	62438	45231	48102	24597
4	APRIL	43702	61084	70684	76539	85669	87172	89238	65341	69054	63730
5	MAY	70744	80052	86448	99625	108778	116641	124323	120212	131804	92199
6	JUNE	30480	32912	34025	35172	63905	68236	69784	65673	68205	85763
7	JULY	13760	17268	19462	22010	26992	27021	29540	18628	17161	19472
8	AUGUST	14382	20628	21428	22628	35826	37180	38964	35294	7713	11875
9	SEPTEMBER	22738	25028	25295	26910	41285	53624	13943	12678	20115	25478
10	OCTOBER	35396	39834	43218	49456	44865	59582	9682	42390	50461	75025
11	NOVEMBER	33480	35899	38215	43018	43720	48764	8326	39602	42836	53275
12	DECEMBER	26523	31208	33213	35864	42345	52651	13249	55287	59728	62350
	TOTAL	**347650**	**421943**	**465204**	**512373**	**615628**	**700011**	**552453**	**558538**	**576749**	**562418**

Source: *Tourism and Civil Aviation Department Sikkim, 2015.*

6.4 Impact on Environment

With growing urbanization, increased need of housing and sanitation and increased tourism activities not only pushed up the demand of water but also resulted in higher degrees of waste generation, pollution and deforestation – the common impacts of urbanization on environment. Some of the impacts mapped are as follows:

6.4.1 Land and Water Degradation

Waste is one of the primary causes of land and water degradation. Major municipal solid waste generating sources relevant to urban areas include households and commercial centres. Sikkim being one of the popular tourist destinations in India, hotels and commercial centres are major sources of solid waste. Statistics for the waste as per category can be seen in the given table (Centre for Science and Environment, 2016).

Cities in Sikkim have uneven topography – no flat area more than a few hundred square meters exists in continuity. This makes management of Municipal Solid Waste very challenging especially in terms of collection of waste from the households. Urban centres in Sikkim are treating only 40% of its total municipal solid waste appropriately (Swachch Bharat Mission, 2016).

Households and commercials centres are also major contributors of waste water. Currently only 42% of the households in Sikkim are connected through sewage lines for safe disposal of waste water to Sewage treatment plants (Sulabh ENVIS, 2016).

Industries are also source of hazardous waste and industrial waste water. There are more than 20 Pharmaceutical Industries in Sikkim. The Industries are mandated to treat their waste water in Effluent Treatment Plants before disposing off to the river systems. Hazardous solid waste produced by the industries are collected and sent to Haldia in West Bengal for treatment. Incineration and Hydro-clave technologies are used for safe disposal of Bio- medical waste. Sikkim disposes 97% of its bio medical waste safely. (Public Information Bureau, 2011) Gangtok is the only Municipality in Sikkim that has taken initiative to collect e- waste at their office on voluntary basis and sends it to West Bengal for further disposal (Sikkim Express, 2015). Any formal initiative on Construction and Demolition Waste are yet to be undertaken by Sikkim.

Table 6.8: Municipal Solid Waste of Gangtok, Sikkim - Category wise (2016)

Category	Total Waste (MT/day)	Total Waste (%)
Food waste	14.85	34.69
Paper waste	7.65	17.87
Plastic waste	7.65	17.87
Metal waste	2.00	4.67
Glass waste	1.03	2.41
Textiles waste	0.18	0.42
Inorganic waste	9.45	22.07
TOTAL MSW	**42.81**	**100**

Source: CSE, 2016

6.4.2 Municipal Solid Waste Management

A total of 74 Metric Tonnes/ day of Municipal Solid Waste is generated in the 9 urban centres in Sikkim, with Gangtok alone contributing 50 Metric Tonnes/ day[1]. The percapita waste generation in Gangtok is high compared to other hilly capitals – Shillong (0.38 MT/day) and Shimla (0.30 MT/day) (Gangtok Municipal Corporation, 2016). According to one of the reports (Centre for Science and Environment, 2016), 33% of Gangtok's waste is food waste out of which 46% is recyclable and 21% is other inert/ inorganic material. Irresponsible dumping in *jhoras* (river streams) from moving vehicles and down hillsides are some of major concern of improper disposal.

Sikkim is building its first composting unit in Gangtok. Recyclable materials are currently recovered from the waste through informal channels and the rest of the waste adds to the landfill site. There are trucks with 2 compartments for segregated waste collection owned by Gangtok municipality but current practices at HH and commercial centres are not enough for segregated collection. The fifth landfill in Sikkim is a sanitary landfill with advanced technologies for waste disposal and includes a compacter, shredder, leachate collection system and a treatment plant. The historical waste poses a major issue for proper disposal treatment as it is right beside theriver.

Innovative community segregation and collection models are tested in Arithang ward of Gangtok Municipality, Sikkim. Various initiatives have also been taken in popular tourist sites to prevent waste generation. For instance, Lachen, a village in North Sikkim, has banned use and sale of plastic bottled drinking water in their area.

The current study is largely based on broad extrapolation of estimated values from small scale studies on generation and treatment values of the waste because of the absence of adequate data.



Daily pickup of MSW

6.4.3 Municipal Waste Water Management

Only 42% of the state's households are connected to the sewerage network services, implying that roughly 58% of the households discharge their sewage through open drains/channels and rely on rudimentary technologies like Septic tanks for biological treatment of sewage water (UDHD, 2015). Sikkim generates 24 Million Liters per Day (MLD) of wastewater daily (Sulabh ENVIS, 2016). Currently, Sikkim is treating 11–13 MLD of waste water. The state has a documented sewage treatment capacity of 31.88 MLD out of which 8 MLD is currently in operation. Waste water treatment plant is running on higher than its designed capacity. (Sulabh ENVIS,2016). One treatment plant is non-operational whereas nine are under construction (potential capacity- 18.88 MLD) (Sulabh ENVIS,2016).

6.4.4 Biomedical Waste Management

Sikkim generates 821 kg of bio medical waste per day, which includes anatomical, plastic, cytotoxic and sharps waste, out of which 798 kgs /day gets treated (Public Information Bureau, 2011). Sir Thutob Namgyal Memorial Hospital and Sikkim Manipal Hospital are two large health care facilities in Sikkim.

6.4.5 Hazardous Waste Management

Sikkim generates 487.8MT of hazardous waste per day from 19 Industrial units in the state, majority of which are pharmaceutical industries. The SPCB is responsible for monitoring the hazardous waste and waste water generation in these units.

The state has no centralized hazardous waste treatment facility. The entire quantum of waste generated by these units is transported to the Central Pollution Control Board authorized waste management facility at Haldia, West Bengal. The cost of transportation and treatment is borne by the industrial units and a manifest receipt system is in place to ensure that the waste is received at the facility, copies of which are circulated across all concerned departments like State Pollution Control Board, Sikkim.

[1] Swachch Bharat Plan 2016 prepared by Gangtok Municipality (GMC) states 50 MT/day as the total waste generation in Gangtok. Not in my Backyard Report, 2016 (CSE) states 45 MT/day in same reference. This report uses official GMC data.

6.4.6 Air Pollution and Carbon Emissions

The Sikkim State Pollution Control Board (SPCB) has a regular Ambient Air and Water Quality Monitoring Programme to assess the status of pollution. These monitoring programmes are funded by the Central Pollution Control Board, Ministry of Environment & Forests, Government of India.

Sikkim has seven air quality stations out of which two are function according to the report by CPCB in 2014 (ENVIS, 2014). However, SPCB Sikkim shows data from 7 stations in the month of October 2016.

According to the data by SPCB, the PM10 levels, SO2 and NO2 levels are all under the prescribed national standards. The table below summarizes the peak and low values of air quality in the month of October 2016 at 7 stations (table 6.9).

Table 6.9: Air Quality Data from 7 stations for the month of October 2016

Air quality stations	PM 10 levels (Standard – 100 µg/m3)		SO2 levels (Standard – 80 µg/m3)		NO2 levels (Standard – 80 µg/m3)	
	Peak value	Low value	Peak value	Low value	Peak value	Low value
Rangpo	64.46	15.68	4.21	BDL	5.51	BDL
Singtam	42.50	31.80	7.20	BDL	1.20	BDL
Mangan	44.76	19.58	2.05	BDL	1.10	BDL
Pelling	17.70	10.50	2.60	BDL	5.90	0.70
Chungtang	39.70	14.60	BDL	BDL	BDL	BDL
Ravangla	20.52	16.30	3.90	2.00	1.40	BDL
Namchi	30.48	22.71	2.70	BDL	0.39	BDL

BDL – Below detectable limit; Source: SPCB Sikkim, October 2016)

Figure 6.2: Trend of Vehicles Registration



Source: *data.gov.in*



Vehicles are one of the key contributors to air pollution. Statistics reveal that there has been a 90 percent increase in registration of new vehicles from 2008-09 to 2009-10. However, a sudden dip in vehicular registration has been witnessed from year 2010 onwards due to revision of taxes for purchase of new vehicles (data.gov.in).

The air quality data in and around industrial areas are available for various months of 2015 and 2016. The data revealed that the degree of polluting gases in most of the industrial areas is well-below the prescribed national standards whereas in some cases they are close to standard limits. The red coloured figure depict data above the annual NAAQ (given in Table 2.4). A summary of the same follows in the table below:

Table 6.10: Air Quality Data from 9 industries in the year 2015 and 2016

SN	Name of Industry	Location	District	2015				2016			
				SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$	SO_2 $\mu g/m^3$	NO_2 $\mu g/m^3$	PM_{10} $\mu g/m^3$	$PM_{2.5}$ $\mu g/m^3$
1.	Golden Cross Pharmaceutical Pvt. Ltd.	Mulukhey	East	18	**56**	**73**	34	5.7	11.1	**61.4**	31.9
2.	Alkem Laboratories Ltd.	Kumrek	East	14	**51**	**61**	39	7.55	27.85	54	20.9
3.	Cipla Pharmaceutical Ltd.	Kumrek	East	14	34	58	21	9.5	**47.5**	58.5	26.5
4.	Torrent Pharmaceutical Ltd.	32 No. Middle Camp	East	27.17	31.17	**90.17**	**52.33**	28	33	**82.5**	**47.5**
5.	Zydus Wellness Sikkim	Mamring	South	BDL	11.6	53.5	25.5	10	26.3	**72.4**	29
6.	Zydus Healthcare	Bagey Khola	East	BDL	BDL	34.9	21	5.9	10.7	**63**	31.85
7.	Sun Pharma Laboratories Ltd.	Setipool	East	BDL	10	43.66	27.6	10	28	51	17
8.	Denzong Albrew Pvt. Ltd.	Mulukhey	East	7.6	32.55	45	10	4	27	40	14
9.	Godrej Consumer Products Ltd.	Mamring	South	6	23	41	16	12.5	39	43.5	17.5

Source: *State Pollution Control Board, Sikkim*

6.5 Response

Sikkim Government has constituted the City Development Plan and the Mobility Plan (2010) to strategies urban development towards sustainability and efficiency. Some of the specific programmes/ schemes currently undertaken by the Urban Department that impact the environmental ecosystem in the urban centres are following:

6.5.1 Smart Cities (UDHD,2014)

The Smart Cities Mission has an objective to promote cities that provide core infrastructures and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a role model to other aspiring cities.

The core infrastructure elements in a smart city would include:

i. adequate water supply,

ii. assured electricity supply,

iii. sanitation, including solid waste management,

iv. efficient urban mobility and public transport,

v. affordable housing, especially for the poor,

vi. robust IT connectivity and digitalization,

vii. good governance, especially e-Governance and citizen participation,

viii. sustainable environment,

ix. safety and security of citizens, particularly women, children and the elderly, and

x. health and education

Sanitation, solid waste management, efficient urban mobility and sustainable environment are environmental components of the city that are included in the smart city plan.

Namchi and Gangtok (in June 2017) have been selected for developing into smart cities so far.

6.5.2 Swachh Bharat Mission (Urban) Mission (UDHD,2014)

Weak sanitation has significant health costs and untreated sewage from cities is the single biggest source of water resource pollution in India. This indicates both the scale of the challenge ahead of the Indian cities and the huge costs incurred for not addressing them. The Swachh Bharat Mission (SBM) emanates from the vision of the Government to ensure hygiene, waste management and sanitation across the nation. Objectives under the mission are following:

i. Elimination of open defecation

ii. Eradication of Manual Scavenging

iii. Modern and Scientific Municipal Solid Waste Management

iv. To effect behavioural changere garding healthy sanitation practices. Generatea wareness about sanitation and its linkage with public health

v. Capacity Augmentation for ULB's

vi. To create an enabling environment for private sector participation in Capex (capital expenditure) and Opex (operation and maintenance)

A State Mission Directorate has been setup along with State High Powered Steering Committee vide notification no.17/Home/2015 dated 18.4.15 along with the District Level Review and Monitoring Committee. Project Management Unit (PMU) under the Mission Directorate has also been setup in Sikkim. DPRs under solid waste management are being prepared for all the ULBs

6.5.3 Atal Mission for Rejuvenation and Urban Transformation (AMRUT) (UDHD, 2014)

AMRUT mission aims to provide basic services (e.g. water supply, sewerage, urban transport) to household sand build amenities in cities which will improve the quality of life for all. The objectives of the programme are

i. Ensure that every household has access to a tap with assured supply of water and a sewerage connection;

ii. increase the amenity value of cities by developing greenery and well maintained opens paces (e.g. parks);and

iii. reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling).

The Mission will focus on the following Thrust Areas:

i. Water Supply,

ii. Sewerage facilities and septage management,

iii. Storm Water drains to reduce flooding,

iv. Pedestrian, non-motorized and public transport facilities, parking spaces, and

v. Enhancing amenity value of cities by creating and upgrading green spaces, parks and recreation centers, especially for children.

Gangtok, being a city having 1 lakh plus population which is one of the criteria for selection under AMRUT, has been selected under this mission. Accordingly the State Government has prepared the Service Level Improvements Plans (SLIPs).

6.5.4 Town Planning Activities (UDHD,2014)

The Town Planning Activity, has undertaken:-

a. Drafting of the revised building regulations. The revised building regulation has been made ready after including the matters that are of relevance to the State. The bylaws are intended to cover the entire State and shall not be limited to the urban areas alone. (i.e. it shall be applicable in both the urban and rural areas). Water harvesting has been made compulsory for building having size of 5000 sq ft or more. The final draft copy has been submitted to the Land Revenue & Disaster Management.

b. Revised City Development Plan for Gangtok. The revised CDP for Gangtok is being under taken under the Capacity Building for Urban Development supported by the World Bank and is being prepared by CRISIL Infrastructure Advisory in consultation with UD & HD. Their vision is being undertaken to assist the Urban Development& Housing Department in identifying the gaps in service delivery and to help better manage urban spaces. It is proposed to access, revise and update the existing city development plans which form the baseline for any planning exercise post JNNURM. This will help in ensuring that the plans are grounded with current situations and participatory in nature and address the current legal and systematic constraints.



Central Park, Namchi, South Sikkim

6.5.5 Asian Development Bank (ADB) assisted North Eastern Region Capital Cities Development & Investment Programme (NERCCDIP). (UDHD,2014)

The UD&HD with the financial assistance of the Asian Development Bank is implementing the North Eastern Region Capital Cities Development & Investment Programme which has been designed to improve the urban infrastructure and promote reforms for sustainable, efficient and responsive urban service delivery in the capital city of Gangtok. The physical investments include the improvement in present system of drinking water supply lines by de-bunching the secondary distribution system and extending water supply to peripheral areas with allied works in two tranches with a total cost of Rs. 47.00 crore whereas investment for sanitation & solid waste Management would be to the tune of Rs.17.00 crore.

Under the Gangtok Water Supply Scheme, the ADB has approved and sanctioned installation of 14000 household consumer water meters with an objective of preventing wastages and ensuring equitable distribution of drinking water to the consumers.

One of the significant components of Solid Waste management project is the construction of a new Scientific Sanitary landfill site and refurbishment of existing redundant mechanical compost plant at Martam, east Sikkim.

6.6 Conclusion and Recommendation

The process of urbanization in the State has been slow, except for the explosive growth of State Capital, Gangtok. The population of Gangtok has increased by more than 200% in between 2001 and 2011 and is 65% of the total urban population of Sikkim *(Urban Development and Housing Department, 2016).* With growing population, rises the demands for land, water use and so does the quantum of waste generated in the region. Urbanization comes within creased demand for mobility and transport systems which are also carbon intensive and eject pollutants into the air.

Water and sanitation system, waste management

systems and transport systems will bear the pressure of urbanization and the state will have to ensure effective and efficient systems for environment sustainability of urban development in Sikkim.

Some of the strategic and operational recommendations for ensuring sustainability of urban development in Sikkim are:

i. *Complete Sanitation:*

- Sikkim should aim for 100% sewage network coverage to all households. In this way, all waste water will be appropriately treated before joining the river or streams.
- Sikkim should aim to have rainwater harvesting systems in households, community building and commercial centers to reduce rainwater entering into drainage for treatment.

ii. *Total Waste management*

- Sikkim should aim to become a Zero-Waste state that is not just green and clean on the streets but also manages its complete waste value chain in a responsible and efficient manner. This should include reduction of total waste generation through responsible consumption and incentivizing resource efficient production and packaging systems; segregation of all waste at source; recycle all recyclables and complete decomposition of wet compostable waste, preferably at household and community level.
- Sikkim should also ensure that all inhabitants are protected from any public health hazard that may arise due to unsafe disposal of contaminated biomedical waste or health impacts of its treatment in incinerators.
- A more comprehensive data on industrial waste water and consistency in data of air quality from cities and industries need to be measured.

iii. *Sustainable transport systems*

- Limitation in data for indicators on quality (especially on Percentage of people within 0.5km of public transit running at least every 20 minutes) and affordability (Average rate/ km in different modes) are key for sustainable mobility management and should therefore be considered to be evaluated after considering appropriate methodology.
- Greenhouse emissions profile of transport sector is not available.

iv. *Eco-Tourism*

- Sikkim must aim to achieve its vision to establish Sikkim as an ultimate and unique eco- tourism destination, offering memorable and high quality learning experience to the visitors and contributing to poverty alleviation as well as promoting natural conservation. For the same, the State should continue to promote ecotourism assets natural and cultural features that attract visitors—such as landscapes, endemic or rare flora and fauna, local agricultural products, local culture and festivals, local folktales, history, historical monuments and heritage sites.

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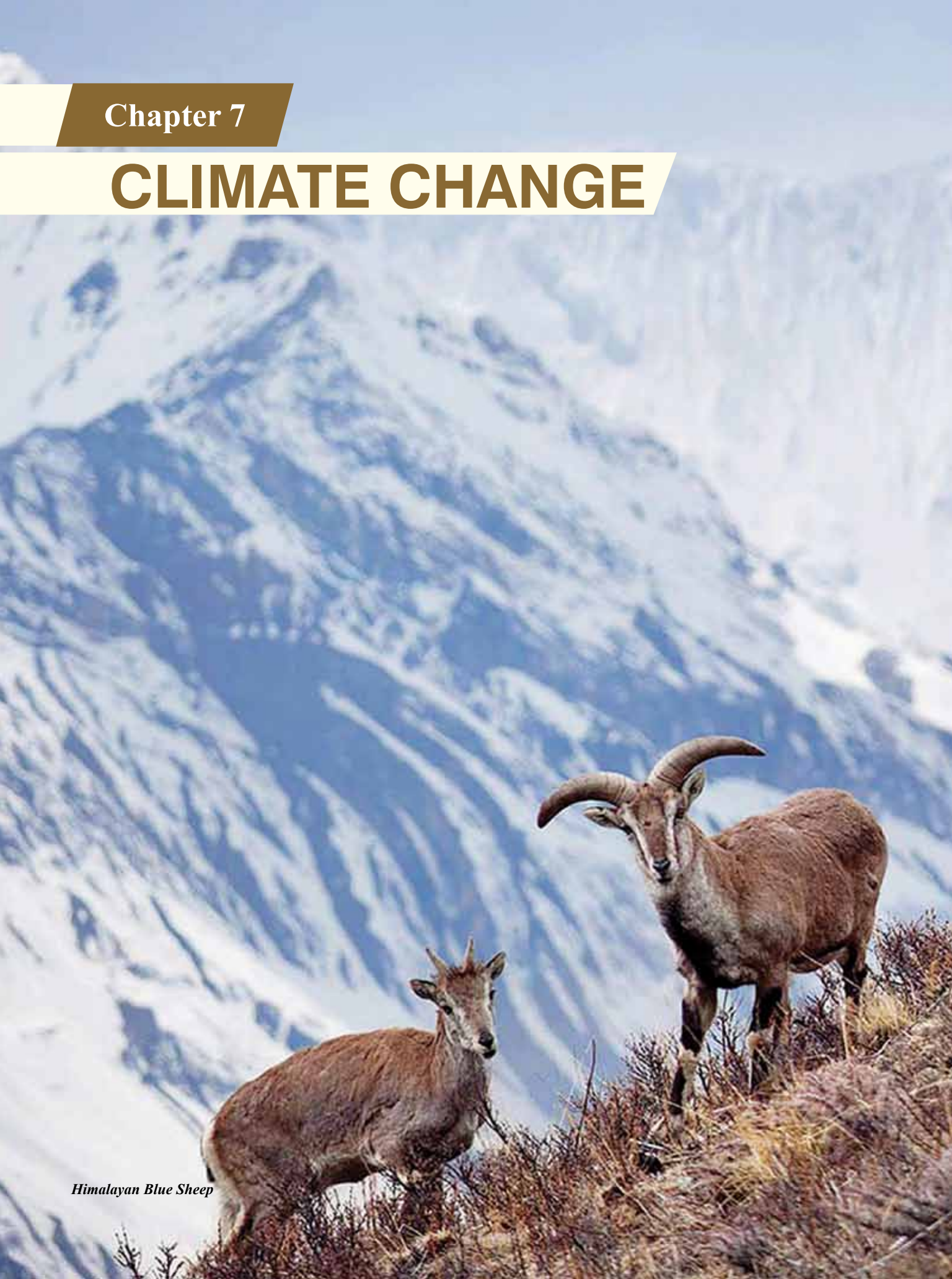
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Chapter 7

CLIMATE CHANGE



Himalayan Blue Sheep



This chapter focuses on cross sectoral impact of Climate Change in Sikkim. Climate change has shown significant impact on agriculture, forests, biodiversity and glaciers.

7.1 Introduction

Climate Change impact at the global level has become a major concern today and Sikkim is no exception. In the regional context, Climate Change has contributed to the unpredictable or erratic rainfall pattern; drying up of local springs and streams; migration of species to higher elevations; shifting of sowing and harvesting period of crops; emergence of invasive species and incidence of diseases/pests in crops as well as in fodder species. However, studies have shown that the Himalayas are warming faster than the global average (Shrestha, Gautam and Bawa, 2012). Building resilience in both human and ecological systems to an optimum level is the best possible way to adapt to climatic variation, though not much is known about the vulnerability of mountain ecosystem to climate change (Rai G. S. in Arrawatia & Tambe,2012).

Additionally, increasing climate variability is experienced in the mountain ecosystem by challenges in water supply management, flow fore casting adding to the impacts of scarcity on food, water and energy needs of the growing population of Sikkim. However, communities in Sikkim have awareness of climate change and have started to adapt to the impacts (Bawa and Ingty,2012)

7.1.1 Climate Monitoring Stations

Due to the varied geography, the weather ranges from sub-tropical temperature conditions in the southern lower parts to tropical, temperate, alpine and cold desert climatic conditions in the snowy north. High mountains, within this small area of 7,096 KM^2, act as a barrier for the monsoon winds and creates heavy precipitation as snow on the mountain tops. Another feature of Sikkim's climate is a dry weather on the lee ward side of the mountain. Detailed data regarding climate and rain is also available from two stations - Gangtok and Tadong. There are observatories in Mazitar (East Sikkim), Mangan (North Sikkim), Namthang (South Sikkim) and Gyalshing (West Sikkim) but they are recent and do not provide continuous data series for analysis and assessment. Therefore, this chapter keeps the data and analysis limited to Gangtok and Tadong, this is extrapolated and reported at Sikkim level for analysis.

7.2 Status &Trends

7.2.1 Precipitation and Temperature

The winter, extending from November to March, is extremely cold and the minimum temperature in some places, particularly in north, falls below the freezing point. Gangtok, the capital of the State, witnesses a higher range of temperature in winter. Gyalshing, which represents the west, is little bit warmer than Gangtok. On the contrary, summer is short, mild and pleasant and lasts from April to May but the heat is quite oppressive in deep valleys during this period.



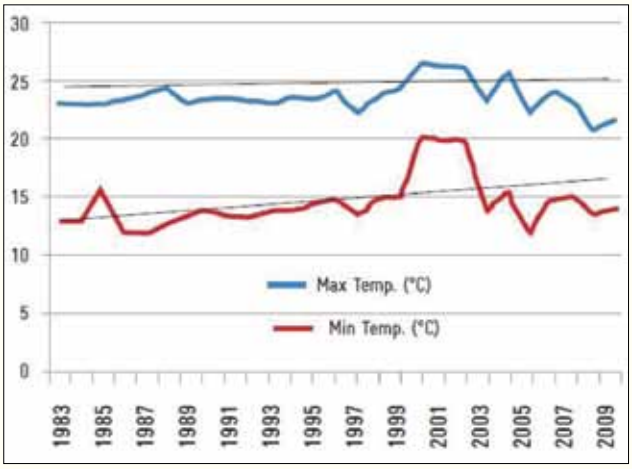
Children walking in the rain in Sikkim
(Photo by Marina Shakleina)
Source: http://indiaclimatedialogue.net/2016/05/16/[illegible]-hope-ample-rainfall-revive-growth/

Variations are also observed in the pattern of rainfall. The state experiences monsoon from June to October, when it rains heavily. March witnesses the onset of thunder storms and its frequency increases till the rainy season sets in around June.

During the time period of 1983 to 2015, Sikkim has been observing a declining trend in rainfall (IMD, 2015). Total rainfall has decreased by around 250 mm between the periods of 1983 to 2015. In these recent years, rainfall patterns have become erratic; monsoons are usually late. Torrential rainfall has replaced the monsoon drizzle. This has resulted in high surface run off and dry period during winters (SAPCC, 2012).

The India Meteorological Department (IMD) records reveal that there were slight changes in the climate of Gangtok from 1983 to 2015. Analysis of annual average maximum-minimum temperature indicates that though there is no change in the maximum temperature, but the minimum temperature has increased.

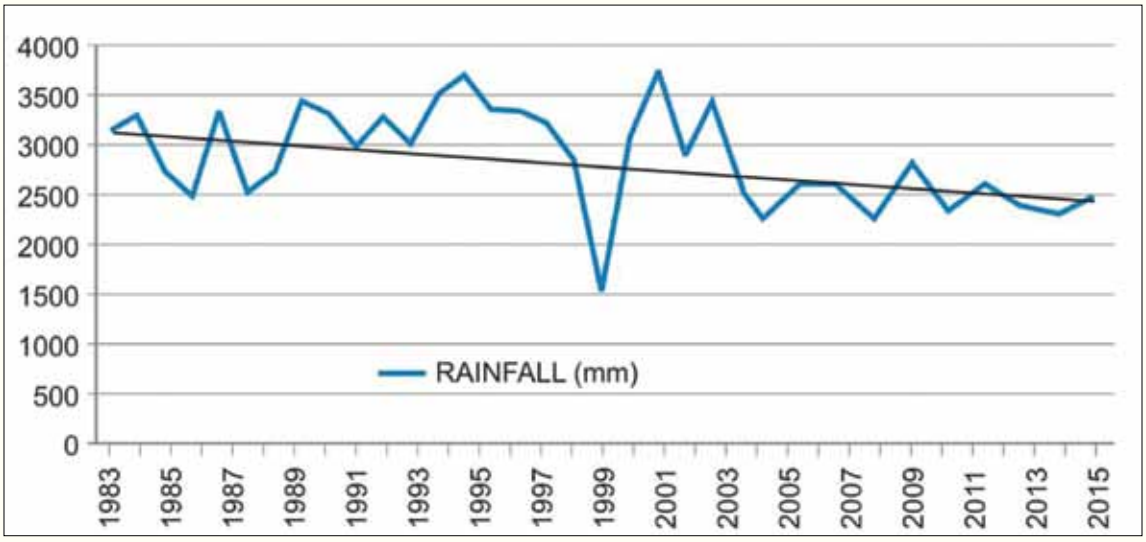
Figure 7.2: Temperature Pattern in Sikkim



7.2.2 Future Projections of Climate Change in Sikkim

According to Meteorological Department, Government of India, Sikkim Division, each year has been warmer year than the previous for the State. Across India, the highest increase in annual mean minimum temperature from 1951 to 2010 was observed for Sikkim (+0.07°C/ year) (IMD, 2013). As per the Quantifying Uncertainty in Model Predictions (QUMP), Sikkim's southern part is likely to experience a negative change i.e. the seasonal rainfall is likely to reduce by about 25% (SAPCC, 2012). Additionally, summer rainfall is indicating a marked improvement, but the higher altitudes are likely to face lower precipitation. Further, the temperature is likely to rise in between 1.6 to 6.4°C by 2030s with respect to 1970s (SAPCC, 2012).

Figure 7.1: Rainfall Pattern in Sikkim



7.3 Drivers

7.3.1 Anthropogenic Emissions of Greenhouse Gases from Sikkim

For Sikkim, climate change should be viewed as largely driven by global level activities but is affecting all sectors of the state. The emission of Greenhouse gases from Sikkim is largely negligible in comparison with national level and in fact Sikkim's forests absorb more CO_2 than total GHG emissions.

There is not much of an industry presence in Sikkim for GHG and the transport sector is usually the major source of Greenhouse Gases (GHG) emission. One could estimate that the transportation sector accounts for the largest share of Sikkim's GHG emissions. The growth rate of vehicles between 2005 and 2010 averaged to 13% per annum with a total of 70% increase in the number of registered vehicles in 2010 as compared to 2005. Most of these vehicles are four wheelers and are privately owned and more specifically belong to the category of Sport Utility Vehicles and Multi-Utility Vehicles (SAPCC, 2012).

There has been a rapid increase in energy consumption if we observe its consumption pattern from the year 2010 to 2015. But this is not much of an issue with regards to GHG emissions as out of the total installed capacity of 57.11 MW (small power project) only 5 MW is from a diesel thermal power plant and rest is from renewable energy sources (MOSPI, 2015).

Relation between GDP and GHG emission intensity

$$CO_2 \text{ Emissions} = GDP\$ \times \frac{\text{Energy Use}}{GDP\$} \times \frac{CO_2 \text{ Emissions}}{\text{Energy Use}}$$

Formula Credits: Dave Cohen, 2012

Multiple studies have confirmed that basic industrialization clearly implies higher emissions. Further, there is significant quantitative heterogeneity in the strength of the relationship between emissions and GDP both during periods of growth and decline (Doda, 2013). It is important as a study for climate change policy because it determines in part the future emissions paths associated with projected GDP paths.



5 MW Diesel Power House at Gangtok

Table 7.1: Energy Consumption in Sikkim

S.N	Year	Energy Consumption(MU)		Population		Per Capita Consumption (in kWh)	
		Rural	Urban	Rural	Urban	Rural	Urban
1	2010-2011	130.54	69.17	480981	59870	271.41	1155.4
2	2011-2012	136.89	71.37	456999	153578	299.54	464.73
3	2012-2013	126.68	79.49	456999	153578	277.19	517.61
4	2013-2014	135.1	78.06	456999	153578	295.62	508.29
5	2014-2015	119.88	74.12	456999	153578	262.33	482.63

Source: *Per Capita Energy Consumption, Energy and Power Department, Government of Sikkim, 2014-15.*

7.3.2 Land Use, Land-Use Change and Forestry

As per IPCC, forests act as carbon sinks and contribute to climate change mitigation by increasing in carbon density of existing forests at both stand and landscape scales and reducing emissions from deforestation and degradation. The carbon sequestration of forests of Sikkim is very significant in India (Ravindranath et al, in Arrawatia & Tambe, 2012). As per the Forest Survey of India (2011), *Carbon Stock in India's Forests* report the carbon stock of Sikkim's forests is around 39,731 tons. The state is a net sink of greenhouse gases for India. There has been a steady increase in forest area since the past decade, while agricultural land is decreasing. The total forest cover for different zones in Sikkim is as follows:



Himalayan Silver Fir Forest at North Sikkim

Table 7.2: Forest Cover Change Matrix (2005-2015)

State	Districts	Forest Cover in 2005			Forest Cover in 2015			Change (2005-2015)		
		VDF	MDF	OF	VDF	MDF	OF	VDF	MDF	OF
Sikkim	East Sikkim	162	396	121	162	411	126	0	15	5
	North Sikkim	132	755	439	135	889	291	3	134	-148
	South Sikkim	95	311	123	93	371	107	-2	60	-16
	West Sikkim	109	450	169	110	489	173	1	39	4

VDF -Very Dense Forest, MDF - Medium Dense Forest, OF -Open Forest

Table 7.3: Increase in Land cover change in Sikkim during 2006 and 2009

Description	2006 (January 06th) Area in sq. km	2009 (February 09th) Area in sq. kms
Agriculture land	699.36	593.36
Build up	18.09	24.51
Forest	2778.11	2868
Grass land, grazing land/ Alpine	718.58	635.38
Snow	1824.23	2054.88
Wasteland	1004.69	858.3
Waterbody	52.94	61.57

Source: *Sikkim State Remote Sensing Application Centre, Department of Science and Technology and Climate Change, Gangtok.*

7.4 Direct and Indirect Impacts of the Changing Climate

There isn't much research available on the vulnerability of mountain ecosystems to climate change especially for the Himalayas. This is due to unavailability of enough data on two most critical climatic variables: temperature and rainfall (Shrestha, Gautam and Bawa, 2012). However, few impacts can be attributed to climate change in Sikkim. These range from the water sector to agriculture and biodiversity to human settlements.

7.4.1 Water

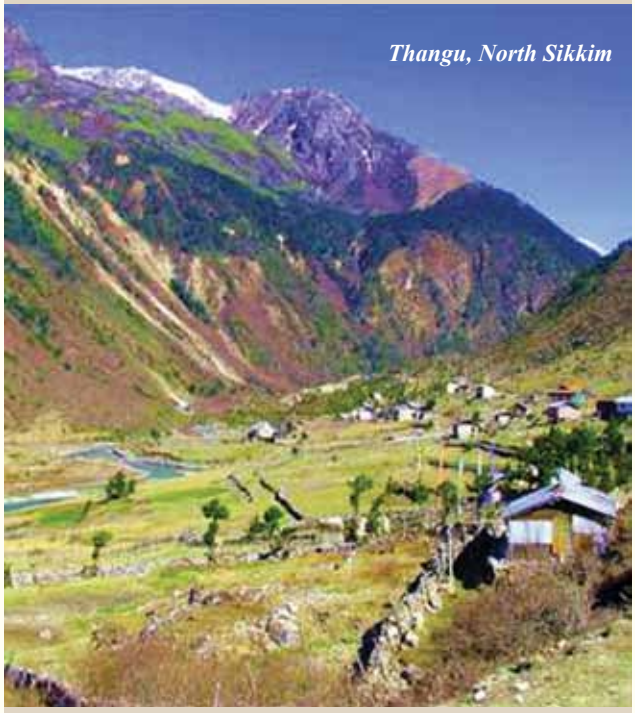
Sikkim has 231 lakes located at an average altitude of 4700m (SAPCC, 2012). River Teesta and its tributaries are the only drainage system present in Sikkim. Although these may sound a lot, Sikkim solely depends upon "*springs and streams*" to meet its water demand. This also makes the water supply sector vulnerable to climate change. While on the other hand quality of the water sector is mainly hindered by pollution, degradation of environment, and climate. Few of the major impacts are as follows:

Melting of Glaciers: With varied climatic conditions, glaciers adjust their size and flow in order to maintain synergy with the changing climate. The field observations prove that Sikkim's lakes have been growing in size and volume from 1965 onwards. Sometimes, the phenomena of development of new lakes have also been observed. These lakes develop due to glacier retreat and melting. There have been past events of GLOF (Glacial Lake Outburst Flood) in the Sebu Chu Valley of North Sikkim.

Glacier thinning and retreat in the Sikkim Himalayas has resulted in the formation of new glacial lakes and the enlargement of existing ones due to the accumulation of melt-water behind loosely consolidated end-moraine dams. Such lakes are inherently unstable and subject to catastrophic drainage; and, they are potential sources of danger to people and property in the valleys below them (ICIMOD2011).Local communities living in the region are dependent upon the lakes for their livelihood, regardless of whether they are settled or nomadic.

A collaborative project with CDAC Pune and Sikkim State Remote Sensing Application Centre, Department of Science and technology and Climate Change shows that many glacial lakes in Sikkim Himalayan region have expanded over the years. This is an impact of climate change on glacial lakes and therefore an important hazard. Statistics reveal that the cold desert of North Sikkim is highly sensitive to climatic variation.

GLOF at a glance in Sikkim


Thangu, North Sikkim

Lakes that are formed due to glacial meltwater are usually unstable. Sudden catastrophic release of water from such lakes is called a glacial lake outburst flood (GLOF). In June 2007, the river Lachen Chu experienced a GLOF event. This was partly due to the receding glaciers. This event washed away Seabuckthorn which is an important component of soil fertility.

Another lake in Sikkim that is at risk is the Shako Cho Lake. Its impact could directly affect Thangu, a village of about 100 homes immediately below the lake. The flood could also demolish houses in Lachen. Part of this lake led to flooding of a habitation of farmers along the river belt.

The situation developing in Sikkim is similar to GLOF at Dig Tsho, a moraine-dammed glacial lake in the Khumbu area of eastern Nepal. Dig Tsho as many of the lakes in Sikkim, was not a large glacial lake rather a small' clean- ice' glacial lake. Most affected areas were close to the origin of the outbreak.

The GLOF at Dig Tsho is an example that even small lakes may cause serious damage, especially if there are populated areas and infrastructure located near the hazard source.

Table 7.4: Increase in area of glacial and high altitude lakes in Sikkim between 1976-2010 *Area in sq.km*

Name of the lake	1976	1989	2000	2010
Gurudongmar Chho	1.048	1.099	1.104	1.134
Chho Lhamu	0.963	1.031	1.031	1.031
Khangchung Chho	1.261	1.605	1.661	1.734
KhoraKhang Chho	0.217	0.269	0.302	0.351
South Lhonak Chho	0.171	0.41	0.691	1.028
Lhonak Chho	0.282	0.418	0.494	0.656
Bhale Pokhari	0.104	0.108	0.114	0.114
Glacial lake feeding river Shako Chho	0.409	0.561	0.561	0.561
Glacial lake feeding river Tikip Chho	0.108	0.214	0.308	0.311

Source: *Collaborative project with CDAC Pune and Sikkim State Remote Sensing Application Centre, Department of Science and technology and Climate Change, Gangtok.*

7.4.2 Agriculture

Like most of India, in Sikkim too, agriculture is a major economic activity with 65% of the population remains engaged in it (Census 2011). With only 12% of total land area of Sikkim being cultivable, agriculture is practiced on terraced field that has been laboriously created from steep hillsides. While largest area under cultivation in Sikkim is used for producing cardamom, Sharma and Rai (2012) point out that in the last 10 years farmers in Sikkim have lost the comparative advantage of large cardamom. This is partly due to facing numerous unpredictable scenarios related to global warming and climate change for the mountain farmers (Sharma and Rai in Arrawatia & Tambe, 2012). Cardamom industry is mostly hit by dry spells and emergence of viral diseases leading to decline in yield 3.5 times lesser when compared to the yield 10 years ago (Sharma and Rai in Arrawatia & Tambe, 2012). Sharma and Rai (2012) describe a number of changes at low, medium and high altitudes, primarily in response to reduced pasture lands, warming and decrease in precipitation. Pastoralists at high altitudes move around less and have become sedentary in nature. Productivity of several crops has decreased while crop diversification has increased (Arrawatia & Tambe, 2012).In the sub-tropical zone (less than 1,000 m), the production of important cash crops like ginger, orange, and other fruits has declined due to prolonged droughts and outbreak of pests, diseases and weeds. This zone was earlier a productive area with multiple cropping.

Studies report that farmers have observed that the colonization of invasive species causing problems as well as reduction in fodder production (Rai G.S. in Arrawatia & Tambe, 2012). With the colonization of invasive species, the common fodder species such as *Digitaria sanguinalis (Ghogey Banso), Paspalum conjugatum (ChitreBanso), Panicum repens (Phurkey), Thysanolaena agrostis (Amliso)* are declining (Rai G. S. in Arrawatia &Tambe, 2012). The fodder production is witnessing disturbed phenology due to the erratic rain caused by the changing climate.

7.4.3 Biodiversity

Sikkim boasts of a rich and diverse flora and fauna supported by unique climate created by topography of the Himalaya. However, climate change and changes in annual weather patterns may be affecting the numbers and distribution of native and invasive species in Sikkim.

A change in climate can have far-reaching consequences on diverse species, their distribution and ecology on the whole. A study has shown that the suitable bio-climatic envelope for rhododendrons, one of the most important floras of the state, would shrink considerably under the climate change scenario. The threats to Tibetan gazelle (*Procapra picticaudata*) and southern kiang (*Equus kiang polydon*) in northern Sikkim are higher due to increasing trends in temperature (Climate Change and its impact upon the forests of Sikkim; Ravindranath et al., 2012) With flowering and fruiting being affected by the changing climate, availability of food inside the forests for wildlife has changed over time. This has a direct correlation to more incidences of wildlife straying into villages, leading to increased human- wildlife conflict.

Forests can play an important role in mitigating the impacts of climate change by functioning as a carbon

sink, water tower and also in checking natural disasters. Erratic rainfall, extensive dry spells during winters, early summers and decrease in annual rainfall in recent past due to climate change has increased the incidence of forest fires in Sikkim (R.K. Sharmaetal.,2012). With warming of the climate, forest fires are ascending upwards and impacting the temperate oak and sub-alpine conifer forests which are not habituated to this new threat. High calorific value, aggressive middle storey vegetation and slow growing nature of these old growth forests make them especially vulnerable to this new threat fueled by a warming climate. Regarding Sikkim, a detailed study on patterns of forest fires due to climate change is certainly lacking (R.K. Sharma et al., 2012). Increased fire frequency can affect the viability of some plant species by damaging or destroying them before they reproduce. The minimum period between fires required to allow species with in the area to reach reproductive maturity is being disturbed. Further, these species are adversely affected when fires are too frequent. A report ranks Sikkim as the second most vulnerable state addressing the impacts of climate change within the Kangchenjunga landscape. (Chettri et al.,n.d.)

7.4.4 Urban and Rural Settlements

The increase in the intensity of extreme climate events is expected to have significant implications for the Urban and Rural Settlements and livelihoods in Sikkim. In relation to urban settlements, IPCC (2007) states that "*climate change is almost certain to affect human settlements, large and small, in a variety of significant ways*". Climate change is likely to exacerbate many of the risks faced by low-income urban residents as per IPCC. Additionally, climate change will impact the rural community dependent on climate sensitive rain-fed agriculture.

Rural communities are most vulnerable to Climate Change due to lesser adaptive capacity and fewer mechanisms to cope with the climate risks. A study by Tambe et al. (2012) found that South district was found to be the most vulnerable followed by West. East and North districts were found to be relatively resilient to climate related change. However, areas like Karzi- Mangnam and Sakyong- Pentong villages, which were not highly exposed, were found to be highly vulnerable due to their high sensitivity and low adaptive capacity (Tambe et al., 2012). Rain-fed agriculture and reliance on local water supplies make rural households very climate-sensitive. They are also dependent on natural resources such as fuel wood and wild herbs which are also climate sensitive. Climate change can reduce the availability of these local natural resources, limiting the options for rural households.

In the Himalayan region, shifts in climate will impact the rural or poorest households as they are least able to adjust to new conditions. Decline in productive agricultural land may also cause forced migration for work (Hunter, n.d.). In the urban settlements space, transportation is at risk due to climate change. Increase in accidents is expected caused by broken roads because of landslides, and extreme precipitation. Permafrost at higher altitudes might also affect the international border roads (SAPCC, 2012).

7.4.5 Energy Sources

Sikkim's total installed capacity of power is 57.11 MW of which 5 MW is from diesel thermal plant and rest is from hydropower and other renewable energy sources (MOSPI, 2015). Climate Change will directly impact the hydro power projects. The change in hydrology could cause changes in the available discharge of a river influencing the economic and financial viability of the project. An expected increase in climate variability may trigger extreme climate events, and sudden increase in volume of water could lead to floods or decrease in water leading to droughts. Changing hydrology and extreme climate events create the risk of higher degree of sedimentation. Turbine erosion due to increase in sediment content could lower efficiency and costs of the hydropower project. There would also be a decline in energy generated (SAPCC,2012).



Dam site of 60 MW Rangit HEP

7.5 Sikkim's Climate Change Response Strategy

Spring sheds: A novel way to revive critical springs and adapt to climate change.

In Sikkim, mountain springs, i.e. Dhara in local parlance, have been traditionally playing a vital role in providing water security to nearly 80% rural households. Development of these spring sources under the banner of Dhara Vikas or Spring-shed Development is being taken up across the villages to revive and maintain drying springs under the MNREGA scheme. The mountain springs are the natural discharges of groundwater from various aquifers, in most cases unconfined. These are very important as the state of Sikkim solely depends upon "springs and streams" to meet its water demand (Sikkim SAPCC, 2011). As per RMDD, the leading governmental department leading the Dhara Vikas, the success of the programme is reflected through its revival of five lakes and 50 springs, it has further generated more demand from villages that suffer from similar water scarcity.

The spring shed development is a modification of the spring sanctuary approach (Negi and Joshi 2002) in using geo hydrology to identify there charge area. It is different from watershed development (which adopts the catchment approach) in terms of scale, costs, duration, treatment methods as well as success indicators. The spring discharge can be increased when required during lean periods resulting in enhanced rural water security of the local community in the dry season, thereby building resilience against climate change impacts (Tambe et al.,2012).

7.5.1 Water

As water is among the most impacted resource due to climate change, the government of Sikkim has taken adaptive measures in the form of rural water storage infrastructures. This would help in artificial recharge in upper catchments to revive the dry season discharge of streams. This has been specifically done in Rolu, Seti, Reshi and Rohtak in south and West Sikkim (Arrawatia & Tambe, 2012). The government has also helped in reviving dried up lakes by improving their catchment, de-silting to enhance their water holding capacity and piping water from a perennial source. This is an important climate adaptive response as lakes play an important role in naturally recharging groundwater.

Besides the the Pokhari Sanrakshan Samiti and Dhara Vikas Programme, which have been covered in the Water Chapter, some of the adaptive measures that the Government of Sikkim have taken in the water sector are:

- Strengthening the rural water storage infrastructure
- Rejuvenating dried up lakes
- Enhancing the dry period base-flow of streams by developing their hill top catchments
- Torrent Training Initiatives for Flood Control
- Increasing efficiency of water use - drip irrigation system



The cascading Seven Sister Waterfall, North Sikkim

7.5.2 Agriculture

Farming practices supplemented with traditional knowledge have come up as a response to climate change in Sikkim.

Communities now store seeds underground or mix it with kerosene, ash, camphor etc. to protect it from dry winter. Seed banks have also been enlarged in case crops get damaged by hailstorm. Additionally, farmers are also participating in green initiatives taken by the government. *Terminalia myriocarpa* (panisaj) and *Alnus nepalensis* (uttis) are two indigenous trees that are being planted by farmers for the State Green Mission.

The national flagship programme, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) has become an important source of climate- proof cash income in the rural areas. Rural folk have started supplementing farming livelihoods with non-farm activities like MGNREGA, tourism, trade, non-farm labour and in extreme cases even migration.

Few of the agriculture specific responses to climate change, the Government of Sikkim have taken are as follows:

- Sikkim Organic Mission
- State Green Mission to help REDD+ aimed at mitigating climate change
- Expanding the Network of Minor Irrigation Channels
- High value contract farming in floriculture sector with assured marketing linkages
- Conserves oil and moisture by means of mechanical measures– bench terracing of sloping lands
- Promoting climate resilient livelihoods in drought prone zone though poultry farming
- Promoting climate resilient, high value farming of baby corn
- Re-introduction of traditional buckwheat crop to help farmers adapt to longer winter droughts

7.5.3 Biodiversity

A good way to protect biodiversity hot spots is to increase the coverage of protected area in the form of sanctuaries and national parks. Sikkim currently has the highest at 31% of the total geographical area compared to the national average of 5%. The creation of Sikkim Ecology Fund has also been notified, for assessing the growing stock and amount of carbon present in the forests of Sikkim. A vegetation carbon pool assessment is being carried out under ISRO's Biosphere Geosphere Programme. The Department of Space, Government of India has agreed to install an 'Eddy Covariance CO2 and other trace gasses flux tower' in Sikkim for detailed study of the net carbon absorbed by forests and vegetation pool which will be linked with prospective earning of carbon credits as per UNFCCC guidelines. 'Ten Minutes to Earth' is an annual plantation programme that was started in 2009 and the Forest Department plants saplings all over the state, this activity of plantation lasting 10 minutes helps sequester 1400 tons of carbon dioxide annually.

The Government of Sikkim initiated the State Green Mission in order to raise avenue plantation and beautification of all vacant lands by the local population. This concept makes Sikkim a unique state among others in the country for taking green measures. Due to such moves, Sikkim's forest and tree cover has increased by about 4% from 43.95% in 1993 to 47.80% in 2015 of state's geographical area (State of Forest Report, Forest Survey of India). The preference is given to fruit bearing tree species and ornamental flowering species. As tree plantation was done on one hand, on the other the government banned felling of trees in forests. This was done to protect the existing natural forests and to bring the degraded forests and agricultural fallows under afforestation drives. The forests act as huge carbon sinks and help in sequestration of CO2 and also conserve soil and water for economic gain in the long run.

Besides, many other measures have been taken to protect the biodiversity from climate change, which have been covered in the Biodiversity chapter as well, and few are mentioned as follows:

- State policy of banning green felling in forests
- Ban on Grazing
- Participatory conservation of high altitudes – Himal Rakshaks
- Converting Barren Sloping Lands to Productive Terraced Fields
- Establishing plantations of fast-growing indigenous tree species

7.5.4 Urban and Rural Settlements

The first step for climate change adaptation related developmental intervention is to undertake a vulnerability assessment at the lowest level to understand the needs and then design policy and programmes accordingly. Sikkim is the first state in the country to under take a "Climate Change Related Vulnerability Assessment of the Rural Communities at the Gram Panchayat Level". It helps enhance resilience of rural settlements based on strong science. Further, to enhance mitigation in Sikkim, the government is piloting energy efficient buildings in all Government buildings in Gangtok. This will later extend to other urban spaces as well.

The Rural Housing Mission has been initiated to achieve a "katcha (temporary) house free status, "This is important as extreme weather events, due to climate change, destroy weak households. This will ensure that the poor in remote mountain areas will have access to improved and safe housing.

As transportation is a sector responsible for major GHGE missions the state as per its action on climate change, has proposed to create a vehicle taxation policy that would reduce private usage of vehicles on the one hand while formulating a public transport policy that would promote clean and user friendly public transport services.



Daramdin Village, West Sikkim

7.5.5 Clean Energy

Sikkim has made a strong step forward in creating awareness and usage of renewable energy through its Sikkim Renewable Energy Development Agency (SREDA). The availability of streams flowing down the Himalayas has facilitated the state to utilize Hydro Electric Power. As the state is growing, so are its energy needs, and the State in parallel speeding such projects up as well as taking up rural electrification.

Sikkim is committed to expand the capacity of clean, renewable sources of energy especially hydro and solar power to meet electricity demand growth and reduce GHG emissions. Total hydro power potential in the state so far is around 266.64 MW with 88 potential power plants possible and the projects are at different stages of implementation (MOSPI, 2015). Sikkim also has one state level energy park. Further energy efficiency and conservation is closely looked at by Energy & Power Department in Sikkim to take voluntary initiatives to promote energy conservation which will contribute in reducing GHG emissions.

7.5.6 Resource Mobilization: Education, Finance and Research

India as a country also requires a lot of resources to address its needs to adapt and mitigate climate change. These are basically in the form of education, finance and research on climate change. Sikkim has been on the fore front of such research on climate change impacts. Sikkim carried out bas in wise glacier inventory way back in 1999 in collaboration with the Space Application Centre, Department of Space, Government of India. This was even before the IPCC reports were released. The inventory of glaciers of Sikkim was carried out using satellite data.

The state has also prepared the State Action Plan on Climate Change, based on the spirit of the NAPCC. The State Action Plan on Climate Change has been formulated by Government of Sikkim to help communities adapt to the changing climate. The State Action Plan on Climate Change (SAPCC) advocates a strategy to meet the challenge of climate change and improvement in the ecological sustainability of Sikkim's developmental path.

The National Mission for Sustaining Himalayan Ecosystem (NMSHE) supported Sikkim State Climate Change Cell (SCCC) was established in October 2014 under the aegis of Sikkim State Council of Science and Technology, an autonomous organization of Department of Science and Technology, Government of Sikkim. The State Climate Change Cell has the mandate to focus and address various issues related with climate change to fulfil the objectives of NMSHE and State Action Plan on Climate Change (SAPCC).

The Government of Sikkim is promoting Natural Resource Management based Climate Change Adaptation Programme. Sikkim has also taken up the initiative in setting up of Village Resource Centres with the support of the Department of Space at the Block level. More than 15 village resource Centres are already in operation for skill development, generating scientific awareness and use of remote sensing and GIS technology and for Natural Resource Management at the village level. Government of Sikkim has also put an 'environmental cess' on various non-bio-degradable materials.

In order to improve the educational aspect of climate change, Sikkim has started the Green School Programme to sensitise and improve environmental education and has established livelihood schools for building the capacity of the rural youth in the service sector and ensure their placement thereby generating climate change resistant livelihoods for the rural youth (Arrawatia & Tambe,2012).

7.6 Conclusion and Recommendations

Sikkim Government is an environmentally conscious state. Even people of Sikkim are very conscious of changing the environs around them. However, the impacts of climate change are already being seen in Himalayan Ecosystem, and are projected to intensify over the coming decades. Sikkim is also predicted to see long term change in rainfall land temperature patterns. In response, a multi-pronged strategy is required at the state and up to the local panchayat level. A number of gaps are needed to be filled in order to effectively adapt to the potential impacts of climate change. These gaps mostly lie in the realm of data of Himalayan ecosystems, education and research. This will help in developing effective policy that will develop resilience in the long run.

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Chapter 8

CONCLUSION AND WAY FORWARD



The Winding Road at Zuluk, East Sikkim



This chapter presents the various policy and institutional options to cater the emerging challenges of Sikkim. The suggested options could be effectively utilized to address the key environmental challenges as it is essential to focus on diverse alternatives to discover the probable solutions.

Sikkim, the crown of eastern Himalayas with Mt. Khangchendzonga as its jewel, is one of the greenest State in India today. Nature has poured all its goodness in abundance to this tiny Himalayan state. Lush green forests with largely endemic species, two mighty glacier fed Himalayan rivers, magnificent natural lakes, lofty snow clad mountains, sparkling streams, a varied fauna and rich cultural heritage have made Sikkim not less than a paradise on earth. Sikkim covering just 0.2% of the geographical area of the country has 26% of the country's total biodiversity and has been identified as one of the hot spots in the Eastern Himalayas (ENVIS CENTRE:SIKKIM).

Air

The extensive green cover, absence of highly polluting industries, high precipitation, a vigilant state towards its environment and aware citizens have helped the state in maintaining clean air and environment so far. The air and noise pollution in Sikkim has remained well within the prescribed national standards. However, challenges do exist.

Sikkim being one of the most sought after tourist destination both nationally and internationally, the increasing plying of vehicles throw serious challenge in keeping the vehicular emissions in check. Another challenging area is to control the quality of indoor air, especially in the rural areas where biomass burning and usage of fuel wood are preferred means fuel for cooking.

The state has taken many initiatives in order to not only maintain its identity as a state with clean air but also to strive to better the air quality. The most praiseworthy step among them is to make all citizens of the state `environment conscious' under the state green mission. The other important steps taken by the state government include monitoring of ambient air and water quality on a regular basis by State Pollution Control Board; formulating Public Transport policy; banning of firecrackers; banning of burning agricultural wastes; promoting dynamic fuel policy and undertaking programmes to promote usage of clean cooking fuel.

The state should further strengthen the monitoring of air quality and take course correction measures on a regular basis; take stringent measures to curb vehicular pollution and synergize its own initiatives with Pradhan Mantri Ujjwala Yojana for promoting clean cooking fuel.

Water

Sikkim enjoys enormous water resources in the form of two major rivers, glaciers, lakes and natural springs. The state receives bountiful rainfall recharging its water table and feeding the springs, streams and rivers.



Streams meandering through a valley at North Sikkim

The state has 2 major river systems, 81 glaciers, 521 lakes and numerous springs besides getting heavy rainfall, which reveals the magnitude of the water resources – the state enjoys.

The state, however, faces challenges from a number of quarters. The increasing demand of water with the increase of population and demand from agricultural sector are two big challenges the state is facing today. A part from that the water resources of Sikkim are vulnerable to climatic variations when the dry spells shrink the resource base, tourist pressure and pollution.

The government of Sikkim has adopted the State Water policy for managing the water resources effectively and to enable the state maintain an equilibrium in between increasing demand and erratic resource base, `Dhara Vikas' or spring shed development being the most conspicuous. It is one of the most successful initiatives in making Sikkim 'water secure'. The success stories of `Dhara Vikas' are needed to be told to the entire nation especially to other mountain states for replication.

Land

Sikkim with total geographical area of 7096 square kilometers is highly susceptible to soil erosion due to undulating topography, frequent seismic activities and heavy precipitation that lead to natural disasters resulting in loss of human lives property and biodiversity. With 80% of the rural population depending on agriculture and allied sectors for livelihood, soil erosion poses a strong challenge to the planners. The state has successfully addressed the problem by several interventions at multiple levels and spheres. The environment and science divisions carries out regular land degradation treatment which are not only response oriented like landslide treatment but also preventive in nature by initiating building of check dams, gully plugging and erecting protective walls.

Afforestation initiative of Sikkim is an example to follow by the entire nation. The proactive nature of the state in encouraging compensatory afforestation is revealed from the fact that 4990.10 ha of non- forest and forest land has been stipulated for afforestation to compensate 2482.87 ha of forest land, which has been diverted for other purposes in between 1980 -2016 (ENVIS Sikkim, 2016). The state has successfully empowered the grass root levels take holders by developing strong and effective Joint Forest Management Committees (JFMCs) for effective management of rich forest resources and tackling forest fires.

The existence of a well-organized State Disaster Management Authority is another example of the proactive approach of the state to respond and mitigate natural disasters on time. Although the state regularly carries out awareness generation programmes on various issues for the local communities under multiple schemes, the planners would be needed to devise ways for making capacity development programmes an ongoing process with increased penetrability.

Forests And Biodiversity

Sikkim is the greenest state of India. 47.80% (ISFR, 2015) of the total geographical area of the state is under forest and tree cover and is home rich and diverse flora and fauna. The biodiversity is so rich that it has been identified as a hot spot– one of the two in India and one of the 36 biodiversity hot spots globally. The State is home to more than 5000 flowering plants, more than 1500 Medicinal plants species, hundreds of mammals, birds and fish varieties making the state one of the richest biodiversity among the country. Sikkim also has 28 Mountains/Peaks, more than 80 Glaciers, 534 high altitude lake, hundreds of wetlands and over 104 rivers and streams (ENVIS Centre: Sikkim). This reveals the magnificent biodiversity the state enjoys.

Sikkim's record in keeping this biodiversity intact and burgeoning is an example to follow by the whole nation. In the last one and half decades, the State has judiciously undertaken several conservation efforts, which have paid enormous dividend. Some notable measures undertaken by Sikkim include banning of felling of trees in the forest, banning on grazing in reserve forest areas, usage of plastics and non-biodegradable materials, lighting of firecrackers and scaling of sacred peaks besides defiling sacred water bodies, rocks and caves. This has been done in conjunction with the launching of Green Mission, conserving lakes, rivers and springs and most importantly empowering its citizens to protect the nature.

Urbanisation

The majority of the people in Sikkim reside in rural areas. Although the percentage of urban population to total population of the state has increased from

11.07% in 2001 to 25.15% in 2011, Sikkim has only one Class I category city with population of more than 1,00,000 people, which happens to be the state capital Gangtok. The other urban centers are Class IV, V and VI categories with far lesser population. It can thus be said that the rate of urbanization is slow in Sikkim. However, trends show that the process is skewed where the maximum pressure is concentrated within the state capital Gangtok, which witnessed the maximum growth of population in comparison with other urban clusters. This has not only stressed the civic services in the face of exponential growth in demand but also has serious implications on the environment, given the fragile ecosystem in which it is cocooned.

Urbanization demand a host of services that include affordable housing, access to clean water and sanitation, electricity, health care facilities, transport, waste management and many more such benefits. The carrying capacities of the urban centers in Sikkim are yet to be determined, which makes it difficult to determine whether the urbanization rate is not affecting the environment drastically.

Sikkim is one of the most beautiful states of India. The abundant natural beauty, clean environment, rich cultural heritage and friendly people have attracted large number of national and international tourists annually and the sector is burgeoning with time. But this has a cost. The existing urban infrastructure feels the pressure along with many challenges. Increase in demand of places to stay, water, sanitation facilities, waste generation and more have a detrimental effect on environment.

The state's response to address these challenges is commendable. Sikkim is synergizing several central government missions like Smart Cities, Swachh Bharat Mission and AMRUT with the State's own efforts like City Development Plan and Mobility Plan. The idea is to develop cities without disturbing the ecological balance. This is no doubt a Herculean task since multiple agencies would be involved with numerous interventions at different levels. The state should seriously consider promoting ecotourism with levying taxes and fees on the services used; try to be a 'zero waste' state, have a robust policy to curb vehicular pollution and cover the entire state with sewage network. The state, maintaining it's fabulous record in having clean and green environment, should set an example for other states where development does not happen at the cost of environment.

Addressing Climate Change

Climate Change is perhaps the gravest environmental challenge - the Earth is facing today. The changing climate has in fact affected every imaginable aspects of the living world and has thrown the cyclicity of our existence into disarray leading to complete chaos. No matter how committed a state is towards taking care of its environment, climate change is bound to affect it and Sikkim is no exception. The best way forward, therefore, is to formulate strategies to mitigate its' effects and prepare Man and environment to cope with the changing climatic parameters.

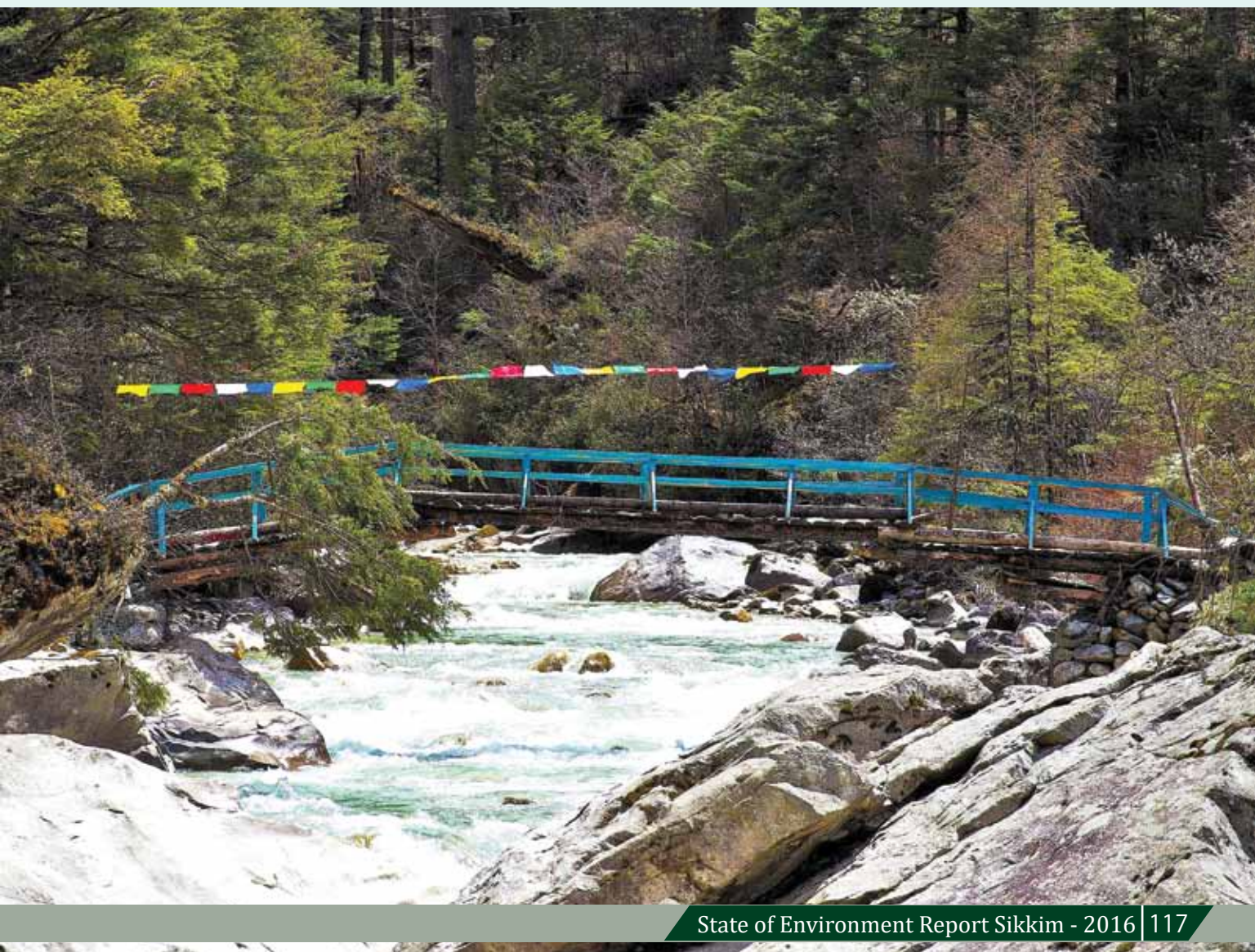
Sikkim has experienced gradual reduction in the annual rainfall, late monsoon, erratic pattern of rainfall and dry winter spells. Sikkim experienced 2015 as the warmest year in the century as per the Meteorological department. Several geographical changes have been recorded in the last few years which include shrinking of glaciers, increase in the number of wetlands and their volume of water resulting in glacial lake outburst flood. These shows the changing nature of climatic conditions due to largely external reasons since Sikkim has attached great importance in preserving and enhancing it's rich biodiversity and forest cover. This has been evidenced by the gradual decadal growth in the forest areas, which act as a net carbon sink. The emission of greenhouse gasses is minimal in Sikkim where the vehicular pollution is the largest contributor of such gasses. The state generates electricity from non-renewable sources and do not have many highly polluting industries.

Sikkim has responded in mitigating the effects of climate change in are mark able manner. A few of the important steps taken are launching the state Green Mission, Dhara Vikas under MNREGA, transforming into 100% organic state, banning of fire crackers, creating and empowering JFMCs, sensitizing common citizens for preserving the forest and biodiversity, formulating Action Plan on Climate Change, promoting climate change adaptation programmes, setting up of village resource centres and using GIS and remote sensing technologies in monitoring.

Although Sikkim, as a state and its people are environmentally aware, the catastrophic effect of climate change will pose future challenges. An unhindered watch through scientific studies of the changing parameters of climatic elements and researches on their effects on the environment and living kingdom are the only keys for sustenance. The vigilance should never be diminished.

WAY FORWARD

Sikkim has formulated some commendable policies and translated them into action very judiciously for the last several decades, which is evident by gradual increase in green cover, although the entire northern areas remain perpetually under snow and is devoid of any vegetation, maintaining good air and water quality, keeping under check noise, air and water pollution and trying to mitigate climate change effects. This has been achieved without compromising the economic development of the state. In fact, the Gross State Domestic Product (GSDP) at constant prices recorded a growth rate of 7.62 % 2012-2013. During the same period, the per capita income of the state has also increased and the poverty ratio decreased (Medium term Fiscal Plan for Sikkim 2014-15 to 2016-2017, Govt. of Sikkim, Finance, Revenue and Expenditure Dept.). All these indicate that state is in ecologically sound growth trajectory. The mission needs to be continued to achieve the Sustainable Development Goals.



Photos of Inception Workshop



Forest Minister Tshering Wangdi Lepcha giving inaugural speech









Active Stakeholder Participation

Stakeholder Consultation Participation



Inception workshop held on July 24, 2015



Consultation workshop held on April 20, 2017

List of Participants

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Impact of Climate Change Glacial Lake outbrust Floods (GLoFS)

Area in sq.km

Lake Name/Year	1965	1976	1989	1997	2000	2005	2010
Gurudongmar Chho A	1.048	1.099	1.099	1.099	1.104	1.115	1.134
Gurudongmar Chho B	0.249	0.322	0.925	1.046	1.046	1.073	1.076
Gurudongmar Chho C	0.48	0.687	0.718	0.728	0.732	0.745	0.745
Chho Lhamo	0.649	0.963	1.031	1.031	1.031	1.031	1.031
Khangchung Chho	1.178	1.261	1.605	1630	1661	1.661	1734
Lachen Khangse Chho	0.36	0.37	0.516	0.523	0.586	0.613	0.613
Glacial Lake feeding river Shako Chhu	0.273	0.409	0.561	0.561	0.561	0.561	0.561
Khora Khang Chho	0.166	0.217	0.269	0.296	0.302	0.342	0.351
South Lhonak Chho	0.242	0.251	0.41	0.633	0.691	0.794	1.028
Lhonak Chho	0.231	0.282	0.418	0.46	0.494	0.652	0.656
Bhale Pokhari	0.09	0.104	0.108	0.114	0.114	0.114	0.114
Glacial Lake feeding river Tikip Chhu	0.069	0.108	0.214	0.257	0.308	0.311	0.311

Source: *Collaborative project with CDAC Pune and Sikkim State Remote Sensing Application Centre, Department of Science and technology and Climate Change, Gangtok.*

Working Population

Category	Persons	Census 2001	Census 2011	% Change
Total Cultivators	Males	1,31,258	1,17,401	-11%
	Females	70,107	63,327	
	Persons	61,151	54,074	
Total Agricultural Labourers	Males	17,000	25,986	53%
	Females	8,762	12,883	
	Persons	8,238	13,103	
Total Household Industry	Males	4,219	5,143	22%
	Females	2,849	2,947	
	Persons	1,370	2,196	
Total Others	Persons	1,10,566	1,59,608	44%
	Males	83,998	1,15,201	
	Females	26,568	44,407	

Source*: Human Development Report Sikkim, 2014.*

Annexure III

Mountains in Sikkim

Sl. No.	Name of Peak	Height (m)	Height (ft)	Location			
				East	West	North	South
1.	Khangchendzonga	8474	27803			+	
2.	Mt. Sivo	7468	24500		+		
3.	Jongsong	7462	24482		+		
4.	Tent Peak	7366	24165		+		
5.	Pyramid peak	7129	23390		+		
6.	Pauhungri	7128	23385			+	
7.	Nepal Peak	7100	23294		+		
8.	Siniolchu	6927	22725			+	
9.	Mt. KhangchenGyao	6889	22600			+	
10.	KhangchenGyao	6858	22500			+	
11.	ChomuYumo	6854	22485			+	
12.	Langpo Peak	6852	22480			+	
13.	Domo	6792	22284		+		
14.	Gurudongmar	6736	22100			+	
15.	Mt. Kabru	6707	22005		+		
16.	Rathong Peak	6679	21911		+		
17.	Pandim	6675	21900		+		
18.	Kabru Dome	6639	21780		+		
19.	Sanglaphu Peak	6224	20420			+	
20.	Khnagpu Khangse	6157	20200			+	
21.	Lama Angden	6116	20064			+	
22.	Phulang	6041	19820				
23.	Sanglaphu	6041	19820				
24.	Chummakhang East	6035	19800		+		
25.	Mt. Thingchinkhang	6010	19718		+		
26.	Singkamo	5852	19200			+	
27.	Lakho Khangse	5822	19100			+	
28.	Burum Khangse	5811	19064			+	
29.	Kokthang	5796	19016		+		
30.	Khnagpup Khangse	5761	18900			+	
31.	Jhopuno	5351	17556			+	
32.	Narsingh	5127	16821		+		
33.	Arralang	4524	14842		+		
34.	NamprikPhuk	4223	13855			+	
35.	Dzongri Top	4130	13549		+		
36.	Chameringu	4066	13341	+			
37.	Dzongri	4030	13221		+		
38.	Pemikhangchhen	3982	13065				
39.	Dhond	3683	12082		+		
40.	JaureDanra	3631	11911		+		
41.	Singalila	3399	11152		+		
42.	Phalut	3086	10123		+		
43.	Tal Danda	3035	9956				+
44.	Labi	3018	9902				+
45.	Kephyaklo	2954	9691	+			

Impacts of Air Pollution

Pollutant	Effect on Human Health
Carbon Monoxide	Affects the cardio vascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect foetuses, sick, anaemic and young children, affects nervous system impairing physical coordination, vision and judgments, creating nausea and headaches, reducing productivity and increasing personal discomfort.
Nitrogen Oxide	Increased susceptibility to infections, pulmonary diseases, impairment of lung function and eye, nose and throat irritations.
Sulphur Dioxide	Affect lung function adversely.
Particulate Matter and Respirable Particulate Matter (SPM and RPM)	Fine particulate matter may be toxic in itself or may carry toxic(including carcinogenic)tracesubstance,andcanaltertheimmunesystem.Fineparticulates penetratedeepintotherespiratorysystemirritatinglungtissueandcausinglong- term disorders.
Lead	Impairs liver and kidney, causes brain damage in children resulting in lower I.Q., hyperactivity and reduced ability to concentrate.
Benzene	Both toxic and carcinogenic. Excessive incidence of leukaemia (blood cancer) in high exposure areas.
Hydrocarbons	Potential to cause cancer

National Ambient Air Quality Standards

Sl. No	Pollutant	Time Weighted Average	Industrial, Residential, Rural and Other Area	Ecologically Sensitive Area (Notified by Central Government)
1	Sulphur dioxide	Annual	50	20
		24 hours	80	80
2	Nitrogen Dioxide	Annual	40	30
		24 hours	80	80
3	Particulate Matter(size less than 10um)or PM10 ug/m3	Annual	60	60
		24 hours	100	100
4	Particulate Matter(size less than 2.5um)or PM2.5 ug/m3	Annual	40	40
		24 hours	60	60
5	Ozone(O3) ug/m3	Annual	100	100
		24 hours	180	180
6	Lead(Pb) ug/m3	Annual	0.50	0.50
		24 hours	1.0	1.0
7	Carbon Monooxide(CO)mg/m3	Annual	02	02
		24 hours	04	04
8	Ammonia(NH3)ug/m3	Annual	100	100
		24 hours	400	400

Annexure V

Biodiversity at a Glance

Flowering Plants	5500
Orchids	557
Rhododendrons	38
Conifers	16
Bamboos	28
Ferns and Ferns allies	362
Tree Ferns	9
Primulas	30
Oaks	11
Medicinal Plants	1681
Lichens	506
Magnolia	12
Trees and Tall Bamboos	717
Small Grasses	257
Bushes	112
Mammals	>144
Bees	30
Beetles	994
Birds	568
Butterflies	689
Moths	7000
Insects	5892
Fishes	48
Frogs	16
Lizards and Snakes	92
Reptiles	33
Amphibians	50

Eco-System at a Glance

Mountain & Peaks	28
Glaciers	84
Lakes and Wetlands	534
Rivers and Streams	>104

Source: *http://sikenvis.nic.in/Database/Biodiversity_776.aspx*

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