Khangchendzonga Landscape Conservation and Development Initiative

Feasibility Assessment Report: India

Submitted to

Ministry of Environment, Forests & Climate Change,
Government of India
New Delhi, India

G.B. Pant Institute of Himalayan Environment & Development
Sikkim Unit, Pangthang-Gangtok, Sikkim, India

Revised: January 2015

Khangchendzonga Landscape Conservation and Development Initiative

Feasibility Assessment Report: India

Submitted to

Ministry of Environment, Forests & Climate Change,
Government of India
New Delhi, India

G.B. Pant Institute of Himalayan Environment & Development
Sikkim Unit, Pangthang-Gangtok, Sikkim, India

In collaboration with

Forest Environment & Wildlife Management Department (FEWMD), Govt. of Sikkim
&
Directorate of Forests (DoF), Govt. of West Bengal

Revised: January 2015

Lead Coordinator - India

PP Dhyani, Director, GBPIHED, Kosi-Katarmal, Almora, Uttarakhand

Nodal Scientist – India

HK Badola, Scientist F & in-charge, GBPIHED, Sikkim Unit

Nodal Persons

P Kumar, IFS, CCF (Wildlife) (now: CS Rao, IFS, CCF-Wildlife), FEWMD, Govt. of Sikkim

VK Sood, IFS, CCF (Wildlife, north), DoF, Govt. of West Bengal

Facilitation

RS Rawal, GBPIHED, Kosi-Katarmal, Almora, Uttarakhand, India
N Chettri, ICIMOD, Kathmandu, Nepal

Contributors

GBPIHED: HK Badola, LK Rai, KS Gaira
DoF (N), West Bengal: VK Sood
FEWMD, Sikkim: Pradeep Kumar, U. Lachungpa
ICIMOD, Nepal: N. Chettri, Kabir, Manohara Khadka

TMI, Sikkim: G. Sharma
WII, India: PK Mathur
ECOSS, Sikkim: R. Gurung
ATREE, Sikkim: Sunita Pradhan
ATREE, Darjeeling: Thomas Samuel
PRERNA, Darjeeling: R. Rai
WWF, Gangtok: P Shrestha

Other contributors

KK Singh, SC Joshi, M Singh, YK Rai (GBPIHED, Sikkim), B.K Pradhan (FEWMD, Sikkim), Savita Chettri (Sikkim), DR Dahal (Sikkim), Animesh Bose (HNAF, Siliguri), Manju Rana, V Khawas (Sikkim University), Jwala (ECOSS, Sikkim)

Report Compilation

Overall coordination: PP Dhyani
Compilation: HK Badola
Back-up/assistance: LK Rai and KS Gaira

PREFACE

With modest beginning, I profoundly appreciate this initiative of International Centre for Integrated Mountain Development (ICIMOD), Nepal on addressing the most relevant issue of transboundary cooperation, facilitating the systematic assessment of existing data base, for developing conservation and development priorities in Khangchendzonga landscape (KL), by involving three partner countries, the Bhutan, India and Nepal. The ICIMOD has successfully identified seven transboundary landscapes in Hindu-kush Himalaya, representing the biophysical, socio-economic and cultural characteristics and the environmental components of the region at large. The efforts initiating the transboundary dialogue and establishing mechanisms of regional cooperation in identified landscape is one the most appreciable initiatives.

The proposed Khangchendzonga landscape (KL), one of such priority landscapes, is surrounded along the southern stretches of Mount Khangchendzonga, the third highest peak in the world includes the eastern Nepal, Indian state of Sikkim, northern part of west Bengal and extends to Toorsa strict nature reserve in Bhutan and thus connects to Jigme Dorjii national park (Bhutan). The entire landscape is one of the biodiversity and culturally rich regions in Himalaya, and put before many challenges of conservation and development, in the face of climate change and growing aspirations of the local communities. However, at the same time, the landscape offers tremendous opportunities of common interests through sustainable use of natural resources and thus upholding the quality life for millions of people living at the edge in and around the landscape. The Indian part of proposed landscape comprises the state of Sikkim, and the Darjeeling and Jalpaiguri districts (the later recently bifurcated to another district Alipurduar) of west Bengal in northern part. Having 17 protected areas the landscape is rich depository of several endemic, rare and threatened taxa. The KL, India is blessed with two major river systems, the mighty Tista and Rangit besides a complex of numerous tributaries and wetlands, nourishing immensely high biological diversity and habitats and people. The high ethnicity of the KL, India further strengthens cooperation and approaches of sustainable livelihoods. Nonetheless, the geo-climatic fragility, on-going conservation threats to existing biodiversity and cultural fabric, and other socio-political forces, make this ecosystem greatly vulnerable. These all factors call for an appropriately developed conservation and development strategy following sound feasibility assessment of the landscape, should provide valuable guidelines for preparing road maps for developing regional cooperation framework in broader canvas.

In view of the above, on Indian context, in mid November 2013, a letter of agreement (LoA) was signed between the GBPIHED, India and ICIMOD, Nepal for initiating a preparatory phase of the project, the 'Khangchendzonga landscape conservation and development initiative' (KLCDI), targeting developing a Regional Cooperation Framework, geared up by other documents, viz. FA report, CDS, CEMSP and the implementation programme plan for the Khangchendzonga landscape in India. The Ministry of Environment, Forests & Climate Change, Government of India has approved the proposal, and designated G.B. Pant Institute of Himalayan Environment & Development (GBPIHED) as lead institute, whereas, the forest departments of both Sikkim and West Bengal as major partner organizations for implementation of this programme in Indian part. The GBPIHED has been working in close contacts with MoEFCC and ICIMOD. The present document vividly provides the objectives and envisaged outcome of the programme.

In pursuit, as first proposed outcome of the KLCDI, India project, this feasibility assessment document for the Indian part of Khangchendzonga landscape has been prepared, following the defined approach through intensive consultations (workshops and meetings) with a diverse array of stakeholders and individual experts, and by going through extensive review of literature and other information sources. The nodal organizations (forest departments of Sikkim and west Bengal) were consulted time to time and information and inputs received from different working members and experts, NGOs, etc are used in the preparation of the report (complete approach is provided in the report). All the interactions helped identifying major issues, gaps and priorities for developing feasibility framework as future action plan.

I strongly believe that this feasibility status report will offer a strong foundation for developing environmental monitoring plans, conservation and developmental strategies and finally strengthening the envisaged process of Regional Cooperation Framework for supporting collaboration amongst partner countries addressing and resolving transboundary landscape issues in the Khangchendzonga landscape.

June 2014

Dr. PP Dhyani
Director, GBPIHED
Lead Coordinator,
KLCDI –India

ACKNOWLEDGEMENTS

The nodal ministry, Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India (GoI), after thorough consultation with concerned ministries and organizations agreed to the concept of the proposal "Khangchendzonga Landscape Conservation and Development Initiative: Developing a Trans-boundary framework for Conservation and Sustainable Development in Khangchendzonga landscape", covering Bhutan, India and Nepal", and designated the G.B. Pant Institute of Himalayan Environment & Development (GBPIHED) as Lead Institute for implementation of the project in the Indian part. In addition, MoEF also identified Forest Departments of both Sikkim and West Bengal as major national partners, and guided streamlining the process of project implementation.

From the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India, Shri Hem Pande, IAS, Additional Secretary, Dr. S.S. Garbyal, IFS, Director General of Forests and Special Secretary, MoEF and Shri BMS Rathore, IFS, Joint Secretary, keenly provided immensely valuable facilitation by taking special interest.

The presence of the then Chief Secretary, Govt. of Sikkim, Shri Alok Srivastava, IAS on 9th April 2014 in 2nd national consultation at Gangtok gave much boost to KLCDI India programme. The Additional Chief Secretary (Forests) of Govt. of West Bengal, Dr SK Das, IAS has been highly cooperative and supportive to KLCDI throughout and especially during the high level meeting in Kolkata in forest secretariat during March 2014. Shri Arvind Kumar, IFS, the PCCF cum Principal Secretary, Forest Environment and Wildlife Management Department, Govt of Sikkim, has been very supportive and he rendered full cooperation to KLCDI efforts in Sikkim and deserve immense appreciation. Cooperation and high support from Shri NC Bahuguna, IFS the Principal Chief Conservation of Forest and Head of Forest Force, Govt of West Bengal is deeply acknowledged.

The present Feasibility Assessment Report on KL, India is an outcome of a collaborative venture between lead and partner organizations. The authorities of these organizations deeply deserve appreciation. From both the state Governments, viz. Sikkim and West Bengal, the respective forest departments as key partners immensely cooperated in the entire process towards making the Feasibility Assessment Report. The cooperation and extended support from Shri UC Bhattacharya, IFS (PPCF-Wildlife & Chief Wildlife Warden) and Shri A Zaidi, IFS (PCCF-General) from the Directorate of Forests, Govt. of West Bengal, through their department and at personal level, and especially including their first hand involvement in different consultations has been inspiring, and greatly appreciated.

Dr HK Badola, Scientist F & in-charge, GBPIHED, Sikkim unit was designated as Nodal Scientist, and Dr Vipan K Sood (CCF-Wildlife North, Director of Forests, Govt of West Bengal) and Shri Pradeep Kumar (CCF, Wildlife, FEWMD, Govt of Sikkim) designated as Nodal persons from respective organizations (now: Shri CS Rao, CCF is the nodal person from FEWMD, Govt of Sikkim). Their proficient and dynamic leadership enabled in successful completion of the task within time.

Acknowledgment goes to Shri MG Kiran, IAS, Principal Secretary (Home and Finance, Govt of Sikkim), Dr Anil Mainra, PCCF, FEWMD, Govt of Sikkim and Prof TB Subba, the Vice-Chancellor of Sikkim University, for their interest and cooperation in the programme by making their presence in second national consultation. and Shri SBS Bhadauria (Special PCCF & Director, JICA project) e from the FEWMD, Govt of Sikkim has shown keen interest and providing continued cooperation in the KLCDI (India). Thanks are due to the Additional PCCF (north Bengal), Special Additional PCCF & CCF northern circle (north Bengal), the

Spl Addl PCCF & CCF Hill circle (north Bengal) and the Field Director, Buxa Tiger Reserve (north Bengal) and Dr PT Bhutia (CCF, northern circle, West Bengal) for their cooperation and interest in programme. The authorities of various institutions such as, the FEWMD (Govt of Sikkim) and Directorate of Forests, Gov. of West Bengal, Sikkim University, Botanical Survey of India, Wildlife Institute of India, Department of Science & Technology (Govt of Sikkim), RMDD Govt. of Sikkim, Department of Tourism, etc deserve appreciation for directing their officials for various levels of participation in programme.

A range of partners, individual experts and stakeholders gave their inputs to accomplish the task of preparing FAR for KLCDI, India. These include Dr VK Sood, DoF, north Bengal, Shri Pradeep Kumar, Ms U Lachungpa and Dr Bharat Pradhan from FEWMD, Gangtok, Dr Nakul Chettri, Dr Manohara Khadka, Shri Kabir (ICIMOD, Nepal), Prof PK Mathur (WII), Dr G. Sharma (TMI, Gangok), Shri R Gurung and Ms Jwala (ECOSS, Gangtok), Ms P Shrestha (WWF, Gangtok), Shri R Rai (PRERNA, Darjeeling), Dr Manju Rana and Dr V Khawas (Sikkim University), Shri DR Dahal and Dr Savita Chettri (Sikkim), Shri Animesh Bose (HNAF, Siliguri). Thanks offered to Shri JB Subba, Director KBR, FEWMD, Sikkim, Shri Mika Lepcha, Advisor (MLAS, Dzongu, Sikkim) , Dr BS Kholia, BSI Gangtok, Dr N Sathyanarayana (Sikkim University), Shri Parth Pratim (Victor) Basu (Doors jargon, Jalpaiguri) for their interest in different programme and progress of KLCDI. HK Badola has contributed the cover photograph of this report.

From ICIMOD, Nepal, the role of Dr Eklabya Sharma has been highly motivating and helpful and deserve very high appreciation and acknowledgement; the admiration is due to Dr Rajan Katru and Dr GS Rawat, Shri Nawraj Pradhan, Dr Janita Gurung for their support to programme. The role of Dr N. Chettri (KLCDI programme coordinator at ICIMOD, Nepal) has been very encouraging throughout the course of programme progress and in making the FAR through various levels of personal interactions, and providing inputs and suggestions, which is highly appreciated and acknowledged.

The role of facilitator at GBPIHED hqts (Kosi, Almora, Uttarakhand), Dr RS Rawal is highly appreciated who has been the motivating factor to the programme, particularly for his experience from Kailash landscape initiative and his ever ready attitude to render his advices and facilitation from hqts and elsewhere. From GBPIHED (Sikkim unit), Shri LK Rai and Dr KS Gaira deserve high admiration for their assistance in compilation of the material. The secretarial assistance of Miss Milan Rai (project staff KLCDI India) is very much admired who has been working hard with the main team. The inputs from Dr KK Singh, Dr SC Joshi, Dr M Singh and Dr YK Rai are acknowledged. Appreciation is due to junior research fellows, Shri Bijoy Chettri and Miss Shiela Sinha for minor assistance. Shri RK Das (Office Account) and unit drivers (Shri Nirmal Pradhan and Vimal Pradhan) deserve admiration for their patience and supportive attitude particularly during late hours working and travels.

The local communities and various stakeholders involved in different consultations and interactions in the field in both Sikkim and north Bengal are acknowledged for their various inputs helping indentifying various issues and gaps, which are incorporated in places in FAR. For making this report, numerous literature and information sources from academic and technical site have been generously utilized and we appreciatively acknowledge the same. Not limited to this only, on behalf of entire project team (lead and partner institutions), appreciation goes to those who might have left out in the acknowledgement for their direct or indirect involvement helping team in accomplishing the task within specified time.

Table of contents

List of tables

List of Figures

List of Appendices

Executive Summary

In recent few decades, conservation of biodiversity and the sustainable development taking the community as integral part of the ecosystems has been fully acknowledged as the mantra of conservation efforts, however, at the same time, adhering with the international as well as national legal directions as guiding force is imperative. For the Khangchendzonga landscape where three countries, Bhutan, India and Nepal, are sharing many challenges together but having collective opportunities of common interest, may these be, the natural resources, the biodiversity or at the socio-economic fabric level. Culturally too, these countries share many similarities, and the way of life style and livelihood options are same, at large. The countries automatically bring choices at a common platform for taking transboundary initiative agenda as the core of cooperation and that will make this region better furnished with sustainable resources and thus helping lives of millions of people living at the edge, of this landscape, improved. Landscape concept is not much new for world, though, in recent times, this has gained tremendous impetus as a suitable tool to manage and sustain biodiversity under a broader framework involving communities as the pivotal components. The regional initiatives, especially from the ICIMOD have been widely appreciated and the Khangchendzonga landscape conservation and development programme is one of such initiatives where partner countries may work together taking the above approaches for utilizing strength of the region within a complex climate driven array of risk and opportunities.

In the context of Indian part, in November mid 2013 a letter of agreement was signed between the GBPIHED, India and ICIMOD, Nepal for initiating a preparatory phase, targeting the Regional Cooperation Framework, geared up by other documents, viz. FA report, CDS, CEMSP and the implementation programme plan for the Khangchendzonga landscape in India. The Ministry of Environment, Forests & Climate Change, Government of India has approved proposal, and designated the G.B. Pant Institute of Himalayan Environment & Development (GBPIHED) as lead institute, whereas, forest departments of both Sikkim and West Bengal as major partner organizations for implementation of this programme in the Indian part. The GBPIHED has been working in close contacts with MoEFCC and ICIMOD.

For KLCDI, India, the preparation of Feasibility Report is the first deliverable. A big volume of primary and secondary information has been used for analyzing data and writing the chapters. Together, many consultations and interactions, national to local, with different stakeholders' groups, ranging from academicians, researchers, government and non-government agencies and organizations, private entrepreneurs, individual experts gave vital information, which helped in identifying important issues, gaps in knowledge and developing priorities for the area. The sartorial and isolated inputs from different experts from different parts of the KL were inculcated and a cumulative picture from review work and analysis were drafted. The FA report deals with 11 chapters highlighting the KL boundary (India), physical characteristics and land use, socio-economic profile, biodiversity and ecosystem services, resources management, environmental issue and climate change, policy and enabling environment, the major issues and concern the KL, India is encountering and with the associated gaps and priorities for conservation and development of the landscape, etc. A need assessment framework is provided in the end and a section of references support the entire report.

- The proposed Khangchendzonga landscape in India (26° 29' 13.56" to 28° 7' 51.6" latitudes and 87° 59' 1.32" to 89° 53' 42.96" longitudes), spreads along 40m to 8586m asl and covers 14126.36 Km^2 area, and comprised of Sikkim and northern districts of West Bengal (Darjeeling, and Jalpaiguri-now bifurcated with Alipurduar), however, this excludes blocks along the borders of Bangladesh.

- The lowlands of KL, India are highly populated, whereas, human habitation is not encountered above 3000 m elevations except a few transhumance people (about 6 families of Drokpa tribe) carry on their life on pastoralism. There are over 15 major peaks and >14 important mountains passes.
- Maximum of 28% of total area fall below 200m asl; other large area comprising temperate to high altitude zones (3000-5000m asl) covers >19.50 % of the entire KL, India. There are 259 high altitude wetlands. Glaciers and snow covers 1456.81 km^2 areas. Cumulatively, 22%, 21.5% and 11.1% area of KL, India is covered under agriculture, broadleaved forest, and Snow/glacier, respectively. Sikkim has highest land under forest cover (51 %). Tista and Rangit are the main rivers. Tropical, sub-tropical, temperate and alpine are the broad vegetation zone.

- Landscape comprised of a diverse range of socio-economic setting in both hills and plains and has maximum population in Jalpaiguri and Alipurduar districts- 3,872,846 combined, and followed by Darjeeling district (1,842,034) and Sikkim (610,577), with highest density (622/Km^2) in Jalpaiguri and Alipurduar districts and least in Sikkim (86/Km^2), with highly diverse ethnicity. The literacy rate is highest in Sikkim (82.20) than Darjeeling (79.56) and Jalpaiguri/Alipurduar (73.25). Agriculture and animal husbandry is the major livelihoods; major crops are Rice, wheat, maize and potato, etc. Tea, Large cardamom, ginger, mandarin, pineapple, vegetables are major cash crops, with increasing crop diversification. Tea plantation covers approx 2,168.77 Km^2 area. A flow of both domestic and international tourists in KL, India, indicates an opportunity for livelihood option. Increased literacy rate the landscape is showing signs of greater awareness; the gender wise 87.30 % and 76.43 % (Sikkim), 79.95 and 66.23 (Darjeeling), and 72.83 and 52.21 (Jalpaiguri and Alipurduar, combined) literacy, respectively for male and female, indicates the hills have better environment for female literacy. The landscape has high number of education institutions.

- In KL, India, on the basis of altitudinal zones, forests can broadly be categorized in to, a) tropical, b) sub-tropical, c) warm temperate, d) cool temperate, e) sub-alpine and f) alpine types, which further grouped in to 7 broad types. Having very rich biodiversity the KL, India represents about 4,458 species of flowering plants in Sikkim and 4,000 species in Darjeeling district; with significant elements like, 38 Rhododendrons, 12 Gymnosperms, 523 orchids, over 31 bamboos, 551 Pteridophytes species; with 464 species of mosses in Sikkim and 422 species in Darjeeling. Lichens diversity represents 506 species for Sikkim and Darjeeling; and 151 Agaricale species documented for KL-India. Sikkim alone has avian diversity of 550 species, and 48 fishes and 700 butterfly species. There are 17 protected areas network covering 4,418 Km^2 total area, suggests need of corridors connectivity and feasibility between them. Review suggests after 1980 a rapid increase of publications on fauna appeared, focusing largely on ecology. For KL, India, over 180 species of mammals and 246 fishes are documented. Fourteen important bird areas are described for KL, India, having many endemic and threatened taxa. The landscape is also a rich depository of endemic and threatened plants and faunal elements, having global significance. The high biodiversity resources offer great potential for a diversified ecosystem services, ranging from pastures to wetlands. A high traditional knowledge is documented; alone 404 species under 136 families of ethnomedicinal use offered big potential for the pharmaceuticals. Over 251 wild edible species further highlight the big potential of ecosystem services. The crop diversity status between the locations and on-farm crop diversity under exiting traditional farming systems of the landscape is discussed. Horticulture crops and livestock variability under different management systems are the important source of diversity.

- The KL (India) has total 17 protected areas. The forest management practices on forest fires, grazing control, forest restoration, agroforestry and forest utilization are discussed along with the functional forest management schemes. Also, wildlife management systems under different area of concern like

human-wildlife conflicts and their mitigation approaches for the existing wildlife management system along with functioning schemes and their limitations are included. Agrobiodiversity, wetland and solid waste management systems are broadly discussed. Besides, trans-boundary cooperation and pasture land management issues are highlighted. As a strength of the landscape, community based management systems and initiatives i.e. Joint Forest Management (JFM), JICA initiative and ecotourism management, etc are functional, and as unique traditional management systems, for example, Dzumsa is the operating management system in around the protected areas. Role of women in forest management system is broadly discussed with respect to gender equality.

- The KL, India is facing problems of climate change, as any part of the world. Climate data analysis trying initiating for climate change model (1981 to 2010), indicated the annual mean temperature is giving warming signal (0.42 - 0.58 °C per decade) significantly ($p<0.001$). Also, an increment in mean annual relative humidity (i.e. 0.53 - 1.21 %) is estimated, while sunshine hours indicates decline (i.e. 220 - 283 hrs) per decade significantly ($p<0.02$). Such inferences support argument on climate change. The impact of climatic change on sensitivity of biodiversity and its elements, i.e. species range shift, phenology change as major concern of the landscape discussed. Importance of glaciers and their complexity and sensitivity with respect to climate change are the major concern resulting diverse effects in the landscape. Also, the earthquake and landslides are other prominent environmental hazards.

- Various policies and acts designed for different sectors i.e. forest and wildlife management, forest resource management, biodiversity, agrobiodiversity, and socio-economic development, etc. are purposeful for enabling environment in KL, India. Some important action plans especially relating biodiversity, climate change, tourism, social wellbeing, etc., and including their specific objectives and activities offer high utility for better environment. However, some gaps and challenges in the implementation, regulation and compatibility of policies and acts are always required to further revisions and formation of the new policies and regulation at landscape level.

- Several issues identified and related to conservation and development for KL, India are arranged into respective thematic areas of land, viz., use, climate and environment vulnerability, Socio-economics, Biodiversity, agrobiodiversity, ecosystem services, resource management, pollution, long term conservation and monitoring and policy and enabling environment. Also, certain gaps within the issues have been identified with respect to series of issues and are discussed.

- Priorities on taking up various activities for the conservation and development in KL, India are identified under different thematic groups for further consideration while implementing the project activities in coming time. Keeping the above in mind, and on the basis of the priorities, the goals and strategies have to be developed to implement envisaged activities accordingly in the landscape.

Chapter 1: Introduction

1.1 Background

Understanding, assessing and conserving the biological diversity in a landscape is a major aim of any management approach for sustaining existing natural resources towards their long-term maintenance and judicial utilization. Concurrently, efforts for restoration of landscape using different management tools and/or spiritual tools have been successfully emerged widely (Dhyani, 2003). In the mid 80s, the approach of integrated conservation and development for an area targeting conservation of biodiversity as a primary objective was implemented. The approach aimed to build up the idea of conserving biodiversity and sustaining developmental activities by utilizing the tools such as socio-economic investment, having additional supports from different organizations and agencies engaged with conservation programmes. Along with IUCN (World Conservation Union), in the early phase of 90s, International Tropical Timber Organization (ITTO) had initiated formulating a set of guidelines for the purpose of conservation of biological diversity in tropical production forests, which came out in 1993, aiming biodiversity conservation as the goal of national forest policy. Through subsequent efforts over couple of decades, different field based examples provided the directions for linking protected area network at the level of ecosystems. It has been noted that connecting the protected areas through corridors also provides opportunities for both vertical and horizontal coverage of habitats, ensuring sustenance of environmental goods and services for the future (Bennett and Mulongoy, 2006). It would be equally important to understand if landscape beyond protected areas can potentially be taken for the biodiversity conservation efforts. The protected landscape models have helped understanding the idea that the conservation cannot be effective unless involvement of people closest to resource is ensured (Michell, 2003), whether this is a biodiversity rich area or a cultural or heritage landscape. By recognizing civil society as indispensible component in the management planning and taking scientific institutions helping capacity building of stakeholders for creating bioresources based livelihood ventures, the initiatives will meet the basic conservation and poverty reduction objectives simultaneously (Badola and Aitken, 2010). Further, it has been extensively realized that conservation and preservation of a landscape will define the well-being of human kind together with the advancement of environmental and economic security and safety, and regional cooperation between and /or among the countries sharing trans-boundary landscape.

At regional ground, taking Himalayan countries in to consideration, the approach of landscape level biodiversity conservation, by connecting protected areas, started well over a decade back to begin with having initial dialogues amongst stakeholders and with the government agencies and by developing and standardizing the concepts (Sharma *et al*., 2007). As off shoot of the efforts, recently, the Kailash Sacred Landscape Conservation and Development Initiative (KLCDI) has been initiated involving three partner countries, the China, India and Nepal and envisage to deliver ecosystem benefits to local communities and offers supporting evidence to become a part of adaptive management process (Rawal *et al*., 2012). For the Indian part, GB Pant Institute of Himalayan Environment & Development is the nodal organization for the programme. Amongst others, Khangchendzonga landscape emerged as one of the potential areas for

addressing biodiversity conservation and development at the same time, advocating benefits of the trans-boundary approach. Here, three countries, viz. Bhutan, India and Nepal signatories of CBD, came up to share the transboundary problems and looking jointly for a unique cooperation initiative. Earlier, over the past many decades, several efforts on the conservation of Khangchendzonga landscape have successfully resulted in the establishment of many protected areas.

The proposed Khangchendzonga landscape (KL hereafter), located at the southern stretch of Mount Khangchendzonga, the third highest mountain in the world that spreads across Nepal (eastern part), Indian state of Sikkim and northern parts of west Bengal and further extending to JD national park in Bhutan (in western part). The Khangchendzonga landscape, one of the biodiversity and culturally richest biomes, is a part of one of the 34 'biodiversity hotspots' (Mittermeier *et al*. 2004) and recognized as one of the most critical centers of biodiversity in the world (WWF and ICIMOD, 2001). It is one of the seven-transboundary landscapes identified by International Centre for Integrated Mountain Development (ICIMOD) in the Hindu Kush Himalayas (Chettri *et al*. 2009). Some of the important and transboundary protected areas include Kangchenjunga Conservation Area (KCA, Nepal-India), Khangchendzonga Biosphere Reserve (KBR, India-Nepal; Badola and Subba, 2012), Barsey Rhododendron Sanctuary (BRS, India-Nepal), Singalila National Park (SNP, India-Nepal), Pangolakha Wildlife Sanctuary (PWS, India-China-Bhutan), and Toorsa Strict Nature Reserve (TSNR, Bhutan-India).

This entire KL complex represents tremendously rich biodiversity and great cultural diversity; the welfare of the resident communities within landscape and the millions downstream can largely be linked with KL potential for its unique and immensely valuable ecosystem services. During ICIMOD-GBPIHED regional consultation of August 2012 in Gangtok, Royel Government of Bhutan has suggested extending the area with an additional corridor in the south of Toorsa Strict Nature Reserve. Connecting the eastern Nepal with Mahananda Wildlife Sanctuary in north Bengal, the Government of Nepal has proposed a corridor for Elephant movements, too. Realizing the significance of KL at regional and global level, the regional consultation of August 2012 offered a common platform to share the progress made in the KL, and discussed the key challenges. Further, it agreed on future course of action to implement the Khangchendzonga Landscape Initiative for biodiversity conservation management and climate change adaptation, in three countries, viz. Bhutan, India and Nepal. The KLCDI aimed to contribute to the biodiversity conservation and sustainable development of KL as a unit, taking the approaches of ecosystem management at transboundary scale. These approaches will consider climate change driven risk and opportunities as well harnessing the strength of the region. The initiative also aims to promote transboundary and cultural conservation, ecosystem management, climate change adaptation. Moreover, the conservation efforts are focused on developing habitat contiguity by connecting isolated protected areas with ecologically well managed corridors, so as, to reduce habitat shrinkage and isolation of already small populations thereby making them less vulnerable to extinction.

In the Indian context, on 15.11.2013, under the guidance of Ministry of Environment & Forests (MoEF, *then*), Government of India, a '*Memo of Agreement*' was signed between the International Centre for Integrated Mountain Development -Nepal

(facilitator, signed by Mr D. Molden, Director General, ICIMOD, Nepal) and GB Pant Institute of Himalayan Environment and Development-India (lead organization/ collaborator, signed by Dr PP Dhyani, Director, GBPIHED, Kosi-Almora, India). The Ministry of Environment, Forests & Climate Change (MOEFCC, *now*), Government of India approved the same, to carry forward the implementation process of KLCDI, to begin with executing a preparatory phase, with three major objectives. It is worth mentioning here to highlight here that, initially, on 28-29 January 2014, in the inception (national) consultation, it was proposed that the entire Sikkim and two districts of west Bengal, i.e. Darjeeling and Jalpaiguri would be the part of Khangchendzonga landscape in India. Later on in the high-level meeting in the Ministry of Environment & Forests, Government of India on 31.01.2014, the area was agreed and it was suggested to exclude the blocks along the borders with Bangladesh from KL, India. However, recently on 25th June 2014, vide extraordinary Government notification No. 634-PAR (AR)/O/2R-4/12, Kolkata, the 20th June, 2014 of Government of west Bengal, the district Jalpaiguri has been divided in to two districts, viz. Jalpaiguri and Alipurduar. The objectives of the KLCDI (India) preparatory phase are following:

1.2 Objectives

I. To prepare country wise as well as regional Feasibility Assessment report (FA), Conservation and Development Strategy (CDS), and Comprehensive Environmental Monitoring Plan (CEMP) with a special focus on long term monitoring including conservation and development activities;

II. Prepare a Regional Cooperation Framework (RCF) for conservation and management of rich biological diversity, cultural heritage, and vital ecosystem services through transboundary ecosystem management and participatory approaches fostering human wellbeing in the landscape; and

III. To enhance cooperation among the participating countries with a common goal of conservation and sustainable development within the landscape.

The first step of the agreement was to prepare a Feasibility Assessment Report (FA) by GB Pant Institute of Himalayan Environment and Development-India, using primary and secondary information, and contributing inputs from various organizations, especially including the two core partners, viz. the Forest, Environment and Wildlife Department, Government of Sikkim and the Directorate of Forests, Government of West Bengal, and individual experts.

1.3 Scope and Coverage

For developing strategic plan of Khangchendzonga Landscape, conservation of natural resource base within the same remains as the fundamental component. The protection and sustainable use of biological diversity including entire species, ecosystem and their services are the basic ideas of the programme; customizing the CBD (and other global conservation conventions) framework to the KL as to the needs and the existing situation would be the primary aim. The actions and partnerships between communities and government agencies will largely decide the scope of gaining success. As per the guidelines on the scope and coverage laid down in the Letter of Agreement (LoA) singed between ICIMOD and GBPIHED on 15.11.2013, the present Feasibility Assessment Report covers various dimensions of Khangchendzonga landscape in India. The potential of KL, India as repository of rich biodiversity and at the same time fragility of ecosystems in view of needs and

aspirations of the people inhabiting in the landscape has been taken as the priority area. The boundary delineation of the Indian part has been the biggest and most critical aspect. This is primarily for the proposition emerged during the January 2014 national consultation, where it was suggested inclusion of entire state of Sikkim with Darjeeling district and further expansion by adding the Jalpaiguri district (now with newly created Alipurduar district), which further excluded the blocks along boundaries with Bangladesh.

The situation was challenging, as the feasibility had to cover two different states of India having very different setting and governance. For the Khangchendzonga landscape of Indian part, the feasibility assessment, in addition to boundary delineation, covers physical characteristics, socio-economic scenario, the extensive and largest detailing on the biodiversity and ecosystem services having separate part on the agrobiodiversity section, resource management systems. An exploratory coverage is added on the environment and climate change issues. The reporting on policy and enabling environment and exhaustively various issues and research gaps are discussed and provided under different areas, besides place to place mention in the entire report. The priorities for conservation and development in KL, India are discussed and highlighted in separate chapters; whereas, the need assessment framework as way forward and future perspectives has been given in yet another chapter of FA. The entire feasibility assessment report is largely based on review and analysis of the available literature (published or unpublished) and the primary information and experience; the various formal and informal consultations and one to one interaction with experts helped identifying various issues, developing many lines of priorities, etc.

1.4 Methodology

Largely, the secondary information was used to develop feasibility assessment report; in addition, first hand experiences and primary data were incorporated. A thorough review of available literature, including numerous journals, magazines, newspapers, unpublished documents and checklists, reports, projects' drafts, various official /governmental notifications, policies and acts was made. The extensive internet search helped a lot in finding out a range of publications and other information. The information gathered out of first hand interactions of the compilers with different groups and individuals in field and in institutions, and with business and enterprise groups, entrepreneurs in the region, relevant line agencies and government officials, etc. greatly helped to generate primary information. A range of stakeholders' consultations, both at national level and local level were useful. Report preparation systematically utilized and endorsed the contributions and even smaller inputs from different individuals and partner institutions, at places. A review based publication trend on faunal aspects from ICIMOD was added signifying the biodiversity potential of study area. Many of the previous works of GBPIHED were reviewed and synthesized as important material. Substantial amount of information back up from north Bengal and Sikkim forest department were further computed and synthesized. Shape files were procured from forest departments of both Sikkim and west Bengal and also shared with ICIMOD, and used in developing landscape maps. Photographs, contributed by different individuals are used in the report.

Field experiences of GBPIHED and others were used in the report. Two national consultations, two high level meetings, and other consultations at local levels and

within working groups and within the scientific staff of GBPIHED were highly useful in both finalizing the delineation of KL, India boundaries as well as drawing various issues and gaps in the knowledge. Some of them are briefly provided below:

- *National consultation (inception meeting) was organized on 28-29 January 2014 in Gangtok*, Sikkim (by GBPIHED, in collaboration with ICIMOD), where over 30 participants representing academic and research institutes, state and national Governments; local/regional NGOs, regional and international organizations; and ICIMOD and GBPIHED were gathered for various deliberations and extensive/intensive discussions (Appendix 1.1). Consultation discussed the issues like criteria to be used for boundary line delineation, and on how to go about preparation of Feasibility Assessment Report (FA) as well as other reports like CEMP, CDS, RCF, etc., and implementation planning of programme, etc. High-level meeting in the Ministry of Environment and Forests, Government of India in New Delhi by MoEF in assistance with ICIMDO and GBPIHED on 31 January 2014, gave highly useful guidelines especially regarding boundary delineation (*further elaborated in Chapter 2*).
- In inception meeting of 28-29 January 2014, two nodal persons, one each from respective forest departments of Sikkim and West Bengal, viz. (i) Nodal Person for Sikkim- Mr. Pradeep Kumar, CCF-Wildlife, FEWMD, Govt. of Sikkim; and (ii) Nodal Person for North Bengal -Dr. Vipan K. Sood, CCF-Wildlife (N), Directorate of Forests, Govt. of West Bengal were identified. In addition to Nodal Scientist (GBPIHED, Sikkim) and above two nodal persons, two more members (one each from ATREE (Darjeeling) and WWF (Sikkim) were proposed for a core team, speeding up the FA report. However, two working groups (one each for Sikkim and Darjeeling) and other individuals were identified for providing inputs for the preparation of FA report.
- *Stakeholder's consultation at Sukna, West Bengal on 28 February 2014* (organized by GBPIHED in joint collaboration with Directorate of Forests, Govt. of West Bengal) Over 40 participants representing forest department, NGOs, individual experts, scientific organizations, etc. very actively deliberated and interacted on various biodiversity conservation management and livelihood issues of Darjeeling and Jalpaiguri parts of KL.
- *Consultations/interactions of subject experts and Sikkim working group on 4 March 2014 in Gangtok, Sikkim*- (organized by GBPIHED-Forest Department Sikkim) the experts overviewed the progress and discussed.
- *GBPIHED-ICIMOD meeting with High level officials of Govt. of West Bengal, Kolkata on 28 March 2014*, apprising the importance and rationale of KLCDI, including inclusion of Jalpaiguri and Darjeeling within the proposed landscape, etc. by representatives from GBPIHED and ICIMOD, and received very positive support assurance of the Govt of West Bengal.
- *2nd national KLCDI India consultation was organized on 9th April 2014 in Gangtok, Sikkim* (by GBPIHED, in collaboration with ICIMOD)- progress on feasibility assessment was presented; participants highlighted different issues and gaps, which are incorporated in this report. The suggestions and interactions emerged out of the KLCDI 2nd regional consultation of Bhutan, organized by ICIMDO (in collaboration with Bhutan counterpart) on 16-17 April 2014 further incorporated in the FA report. The generated information from primary and secondary sources

were analyzed, tabulated and prioritized to fulfill the main objectives of the study.

1.4.1 Data analysis

All kinds of information-based data were systematically computed for both qualitative and quantitative assessment and analysis. As the studies especially covered three different areas (Sikkim, Darjeeling and Jalpaiguri; recently Jalpaiguri is bifurcated in to two districts), the review and literature search yielded a vast chunk of scattered and isolated data, which had to be placed with possible systematization so that the meaningful interpretations could be developed. Various narrations emerged through consultations and from small-scale interactions and /or individual level discussions were transcripted and further interpreted under different aspects and focused subjects within objectives of FA. In many cases, GBPIHED team used statistical tools like mean and standard errors, and developed linear regression models and data represented in the pictorial forms at logarithmic scale. Since, Government of west Bengal very recently created, with effect from the 25th day of June 2014, two districts named as Jalpaiguri and Alipurduar, by dividing the existing district of Jalpaiguri, vide extraordinary Government notification No. 634-PAR (AR)/O/2R-4/12, Kolkata, the 20th June, 2014, in the present report, most of the information and data are available and referred to Jalpaiguri district in that case. Land-used data emerged from GIS mapping (State forest departments, ICIMOD and GBPIHED) exercise were further represented as graphical forms.

1.5 Organization of the report

Constituting 11 chapters, in addition to B part of Biodiversity chapter as Agrobiodiversity, the Feasibility Assessment Report for Khangchendzonga Landscape Conservation and Development Initiative for India can broadly be viewed in three groups. These groups may be seen as, (i) the preliminary discourse (introduction with objectives ad methodology, KLCDI boundary delineation, etc.), (ii) the descriptive part (data section, Chapters 3-9), and (iii) feasibility aspects vis-à-vis the policies related to the project objectives and activities proposed as well as the way forward towards accessing the goals.

A background scenario touching the international to regional perspective of landscape and biodiversity conservation advocating the necessity of people's involvement in the process and further general description of Khangchendzonga landscape, especially in Indian context, is presented in Chapter 1. The chapter also gives objectives, scope and coverage of the FA, the methods and data analysis, etc. The processes, approaches and criteria determined for the delineation of boundaries of Khangchendzonga landscape in India is provided in Chapter 2. The chapter 3 focused on the physical features including physiography dimensions of KL, India. However, socio-economic profile of KL, India is detailed about in the Chapter 4. However, the biggest of all, the Chapter 5 comprised of different aspects of biodiversity and ecosystems services and further it makes a second part on agrobiodiversity of landscape. A holistic account on the management aspects of resources is discussed in Chapter 6; whereas, an interesting assessment of environmental issues and climate change scenario is provided in Chapter 7. The policy and enabling environment issues concerning biodiversity conservation and developmental aspects have been worked out in Chapter 8. The Chapter 9 highlights the major issues, which are identified for the KL, India and spells out gaps.

The priorities for KL, India are identified and discussed in the Chapter 10; however, at the end, as Chapter 11, a framework on need assessment and the way forward are offered. At the end, relevant references are placed.

Chapter 2: Boundary Delineation of Khangchendzonga landscape, India

2.1 Initiation of KL-India operational boundary

Over decade back following the concept of CBD's Ecosystem approach, which acknowledge that the linkages amongst protected areas through habitat corridors for managing the integrity of ecosystems and thus supporting associated community livelihoods would be of greater importance, ICIMOD took the initiatives of landscape conservation. The concept building amongst stakeholders in Khangchendzonga landscape member countries accelerated since the year 2002, which strongly foster the strategic process including concept development, strengthening partnerships, generating baseline data, assessing, and understanding the elements of landscape and issues on transboundary.

In India the process of national-level KL boundary delineation was commence through Ministry of Forests and Environment, Government of India, the nodal agency for Khangchendzonga Landscape Conservation and Development Initiative and major NGOs and CBOs of the region; the ICIMOD has been instrumental for the same. In August 2012, the first regional consultation workshop on Transboundary Biodiversity Management in Kangchenjunga Landscape (ICIMOD and GBPIHED organized) recognized that the Sikkim and Darjeeling representing the part of KL with eastern Nepal and western Bhutan. Following the signing of the letter of agreement between GBPIHED-India and ICIMOD-Nepal in November 2013 and that was approved by the then Ministry of Environment & Forest, Govt. of India, a preparatory phase begin in India. During the national consultation (inception) of 28-29 January 2014 in Gangtok, the expansion of boundaries was suggested, which included the entire Sikkim, the district of Darjeeling and Jalpaiguri in west Bengal. Recently with official notification of Govt. of West Bengal on 25 June 2014, however, Jalpaiguri was bifurcated in to two districts, viz. Jalpaiguri and Alipurduar. On 30 January 2014, in the high level meeting of MoEF, Govt. of India in New Delhi, MoEF suggested to exclude the blocks along the boundaries of Bangladesh while delineating the KL, India. Thus, the new delineated Khangchendzonga landscape in India spread over vast altitudinal amplitude having warm low-land/plains to mighty snow-clad Mt. Khangchendzonga, supporting one of the most biodiversity riches and diversified biomes in the world.

2.1.1 Criteria used for boundary delineation

Various criteria were suggested and agreed upon through different consultative processes, especially including the benchmark event, the national (inception) consultation on 28-29 January 2014. Importantly, the first national consultation of technical working groups looked into, (i) Technical feasibility (*ecological, socio-economic, cultural and development*) and (ii) the Management feasibility (*workability, and long-term management considerations*) for delineating the boundaries of KL, India. The consultative process further expanded to north Bengal based Sukna workshop in February 2014. In addition, the boundary delineation was agreed in the high-level meetings in MoEF at New Delhi (30 January 2014) and in Kolkata (Govt. of West Bengal) on 28 March 2014.

Expert opinions and technical help of ICIMOD were invaluable throughout the process for delineating the landscape boundary. The primary criteria used for KL,

India boundary delineation under three distinct categories, viz., (i) physical and cultural, (ii) biological, and (iii) planning and management. The following tools were incorporated for consideration of boundary delineation of KL, India:

- Representativeness, richness, uniqueness (biophysical, socio-cultural)
- Rivers and watersheds- the headwater spread of major rivers originating from KL, India
- Contiguity of tans-boundary ecosystems and services, including Protected Areas and important wetlands and other conservation priority areas, including important bird areas
- Culture: *potential heritage site, multi-communities, cultural heritage sites, religious transects and routes*
- Tourism and eco-tourism potential and expansion possibilities along transboundary routes
- Sacredness, as *an important criteria*
- Key biodiversity areas, including migratory habitats and potential biodiversity corridors
- Endemism (biodiversity and culture), and Indicator/flagship, rare, endangered and threatened species (and their habitat ranges), genetic diversity
- Viability of biodiversity corridors and type of species using it (e.g. *Elephant movement in lower zone-strongest; Red Panda habitats, etc along transboundary landscape*]
- Agrobiodiversity potential and Traditional knowledge
- Inter-state linkages of communities and livelihood
- Areas vulnerable to globalization, climate change, migration and other processes of change
- Management feasibility- considering conservation threats, animals movements across boundaries, climate change, expertise and logistics, etc.

2.2 Methodology

In case of Khangchendzonga landscape in India, overshadowing the earlier proposition on delineating boundaries limited to the parts of Sikkim and Darjeeling, the national consultation (inception) of 28-29 January 2014 held in Gangtok (Appendix 1.1, for list of participants), on common agreements, proposed that the landscape will include the entire Sikkim and two districts of west Bengal, viz. Darjeeling and Jalpaiguri. This proposal on landscape delineation preliminary came from the intensive and participatory interactions of the national partners and other individual experts, based on ecosystem management criteria and socio-cultural aspects; various presentations helped building up the broader and expanded proposal as suitable idea for a better conservation and development management and planning. While discussing the possible delineation of landscape, in addition to several criteria (mentioned earlier in this chapter) many major issues were emerged:

1. Viability of corridor and the type of species using a corridor is important
2. Land use map of Sikkim is required
3. Corridor connecting the protected areas is still left out in case of Sikkim
4. Sacredness of forests as criteria for delineation
5. Apart from animal migration other perspectives should also be looked into
6. Land management should include protected forests, state-owned forests, community and privately owned agricultural systems
7. Corridors should be in continuity in trans-boundary areas

National consultation (inception) of 28-29 January 2014 in Gangtok (Sikkim)

Subsequently, in the high level meeting in the then Ministry of Environment and Forests, Government of India in New Delhi by MoEF (ICIMDO and GBPIHED assisted) on 31 January 2014, agreed on the delineation of KL, India, however, it was suggested that the blocks along boundary with Bangladesh should be excluded. In another high level meeting with the high officials of Govt of West Bengal in Kolkata *on 28 March 2014*, GBPIHED and ICIMOD representatives appraised the importance and rationale of KLCDI, including inclusion of Jalpaiguri and Darjeeling within the proposed landscape, etc, and received very positive support assurance. In between, on 28 February 2014 the sstakeholders' consultation at Sukna, West Bengal highlighted the delineation matter and positive notions obtained.

Stakeholders' consultation on 28.2.2014 in Sukna, West Bengal

In addition, extensive review of available information/literature immensely helped in confirming delineation of KL, India. Later on in the 2nd national consultation held on 9th April 2014 in Gangtok and finally in the 2nd Regional Consultation held on 16-17 April 2014 in Thimpu-Bhutan the landscape delineation was discussed and approved. GIS mapping utilized the available shape files from the respective government offices.

2nd national consultation on 9th April 2014 in Gangtok (Sikkim)

Overall, the exercise on area delineation considered the linkages in transboundary point of view, the ecosystem services, watershed and the boundaries of river basin; biodiversity rich areas with endemism and flagship species and rare and threatened species, protected areas and possible corridor linkages both within country and at transboundary locations, cultural sites and wetlands, etc.

2.3 Proposed boundary of KL, India

The proposed Khangchendzonga landscape in India (KL, India) has two major parts, the state of Sikkim, and the northern part of West Bengal, comprising initially two districts, Darjeeling and Jalpaiguri districts. Here, KL, India excludes the blocks along the borders with Bangladesh. However, on 25.6.2014, the district Jalpaiguri has been bifurcated in to two districts, Jalpaiguri and Alipurduar by the government of west Bengal, retaining the total spatial cover area of the KL, India. In this report, the data referred to Jalpaiguri includes the representation of district Alipurduar, as per availability. The total spatial geographical area of KL, India is 14126.36 Km^2, which includes 17 protected areas, with having high transboundary strategic locations with Bhutan and Nepal (Figure 2.1). The KL, India is located along 26° 29' 13.56" to 28° 7' 51.6" latitudes and 87° 59' 1.32" to 89° 53' 42.96" longitudes, spreads over very high altitudinal gradient of 40m to 8586m. The proposed corridors connect Sikkim, Darjeeling and Jalpaiguri (WB) and taken along with Nepal (Kanchanjunga Conservation Area) in west and Bhutan (Torsa Strict Nature Reserve and Jigme Dorji National Park) in east.

The state of Sikkim in KL, India lies in the lesser and greater Himalayan zone; the great elevation variations along 284 to 8586 m asl provide tremendous physiographic diversity and ranges in climates. Covering a spatial area of 7096 Km^2, the state of Sikkim is located between 27°5' N to 20°9' N latitude and 87°59' E to 88°56' E longitude with a spread of 100 Km from north to south and 60 Km from east to west. The location between 1700-1900 m receive heavy rains (3500-4200 mm), which gradually declines in either elevations below or upwards, however, 2638 mm is the average recorded rainfall. One of the smallest states in India, Sikkim connects Nepal in west and Bhutan to the east, and at the north and north-east the Tibetan Autonomous Region of China forms boundaries. The state has four administrative districts, viz. north, west, east and south. Thus, the entire KL, India has seven districts, after bifurcation of Jalpaiguri on 25.6.2014. Within country, the state of west Bengal touches it southern boundary. The two major rivers Tista and Rangit, with over

hundred tributaries, act as potential headwater drainage systems to the Sikkim and Darjeeling and down to Jalpaiguri.

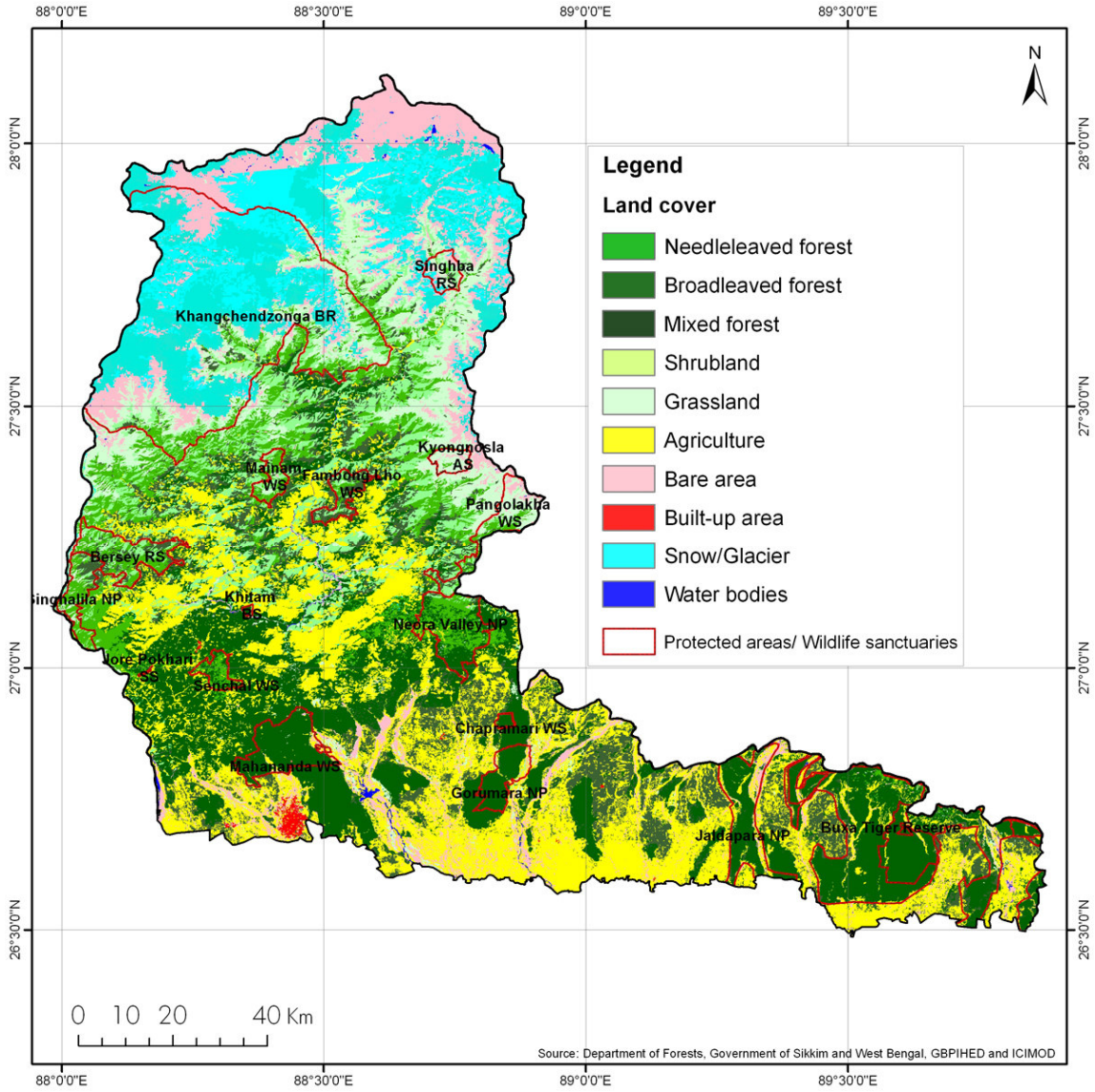


Figure 2.1 Map of Khangchendzonga landscape in India with proposed boundaries

The north Bengal part of KL, India shares international borders with Nepal, Bhutan and Bangladesh. District Darjeeling, the gateway to north-east state of India, makes the international borders with Nepal (Ilam and Pachthar districts) in the west, Bhutan in the east, and located between 26°31' and 27°13' N latitude and between 87°59' and 88°53' E longitude. The entire hilly region of the district comes under the Gorkhaland Territorial Administration; a semi-autonomous administrative body under the state government of West Bengal (www.flywidus.com/darjeeling.html; accessed 9.03.2014), with three hill subdivisions, viz. Darjeeling, Kalimpong and Kurseong. Spread over 29 Km from north to south and 26 Km from east to west, the Darjeeling district is the second least populous district in the state of west Bengal. Whereas, the River Tista separates the Himalayan State of Sikkim in the north and Jalpaiguri and Purnea (Bihar) lies in the south. The boundaries of Sikkim, Nepal and Darjeeling meet at Phalut of Singalila Range in the Singalila National Park. Similarly, a tri-junction of boundaries is also formed at Rachela in the Neora Valley National Park where boundaries of Bhutan, Sikkim and Darjeeling meet. The districts of Jalpaiguri and

Alipurduar, make international boundaries with Bhutan in the north; however, as suggested by Ministry of Environment & Forests, Government of India in the high level meeting on 30.01.2014 in New Delhi, the blocks along the borders with Bangladesh have been excluded in the KL, India. These areas form borders with Assam and Darjeeling hills in the east, west and northwest. Altitude wise, north Bengal part of KL, India reaches to maximum of 3639 m asl. However, the entire Khangchendzonga landscape has a tremendous altitudinal spread from 40 to 8586 m, the third highest mountain of the world, Mt Khangchendzonga, which supports a wide range of habitat niches to immensely rich biodiversity and diversified physiography regimes. Being the neighboring states, Sikkim and West Bengal (particularly the KL Indian part) share not only common boundary but also exhibit many common features including deep cultural affinity and livelihood options. The north Bengal and Sikkim shares the Singalila range in western border of Sikkim; at the east Sikkim is separated by Chola range from north Bengal; however, the Donkia range reaches out to Chinese governed Tibetan plateau. For KL, India, snow line touches the altitude of 6000 m, beyond this landscape occupied with perennial snow; interestingly, pastoral habitations can be encountered up to 5000 m altitude.

Chapter 3: Physical Features

3.1 General physiographic features

A broader form of description will interpret the proposed Khangchendzonga Landscape (KL) - India as being primarily made up of hilly terrain with a patch of foothills at its southern flange representing the Terai belt of Dooars and Jalpaiguri. The northern boundary, represented by the state of Sikkim is characterized by the variation of elevation within a short distance. A large part of Sikkim lies between lesser and the Greater Himalayan zones. Sikkim is girdled by the longitudinal ridges in the North, East and West and this appears like an amphitheatre. To the north a convex arc of the Greater Himalaya separates Sikkim from Tibetan highlands. The hills of Darjeeling and Sikkim are in the upper part of Tista basin; the plains of north Bengal in KL, India further nourishes with Tista River. The landscape of these areas owes much to the drainage network of the river Tista. The structural slope of the land is from North to South resulting in the southerly flow of major rivers. Owing to high relief in the Western and North-eastern part of Sikkim has resulted in the typical glaciated topography. Additionally, the glaciated landscape has resulted in wetland formation and peri-glacial features. There are over 15 major peaks concentrating at the western part and over 14 important mountain passes fall in the north-east boundary. Such features are found all along the northern and eastern highlands of Sikkim (Choudhury 1998). On-going glacial, peri-glacial, glacio-fluvial, fluvial and pluvial activities are continually reshaping the mountain topography. GSI (2012) have reported that the total relief picture of Sikkim-Darjeeling Himalaya is such that the northern part is always above 3300 to 7000 m forming a part of Tibetan Plateau. The middle part slowly decreases its height towards south and central part giving rise to an amphitheater type relief feature. The amphitheatre follows the trend of Main Central thrust (MCT) indicating that Higher Himalaya is uplifted relative to the Lower Himalaya. Alluvial plains of Dooars area in north Bengal is characterized by flat and undulating relief interspersed with streams running through north-south courses. The upper reaches of Dooars suggest an easy incline towards the hills. The lower part is completely flat as in the Indian plains with constant pedalogic, biotic and climatic aspects.

3.2 Land cover along altitudinal gradients

The entire KL India provides a diversified gradients and land cover regimes (Figure 3.1 and Figure 3.2). The figures depict a maximum of 28 % (396.20 Km^2) of total area below 200 m altitude, falling within Jalpaiguri and Alipurduar and plains and foothills of Darjeeling districts. However, other large area comprising the temperate to high altitude zones (3000-5000 m asl) cover >19.50 % of entire land of KL, India. The area above 5000 m asl, mostly represents snow bound mountains, cover >10.88 % of the entire land of KL, India.

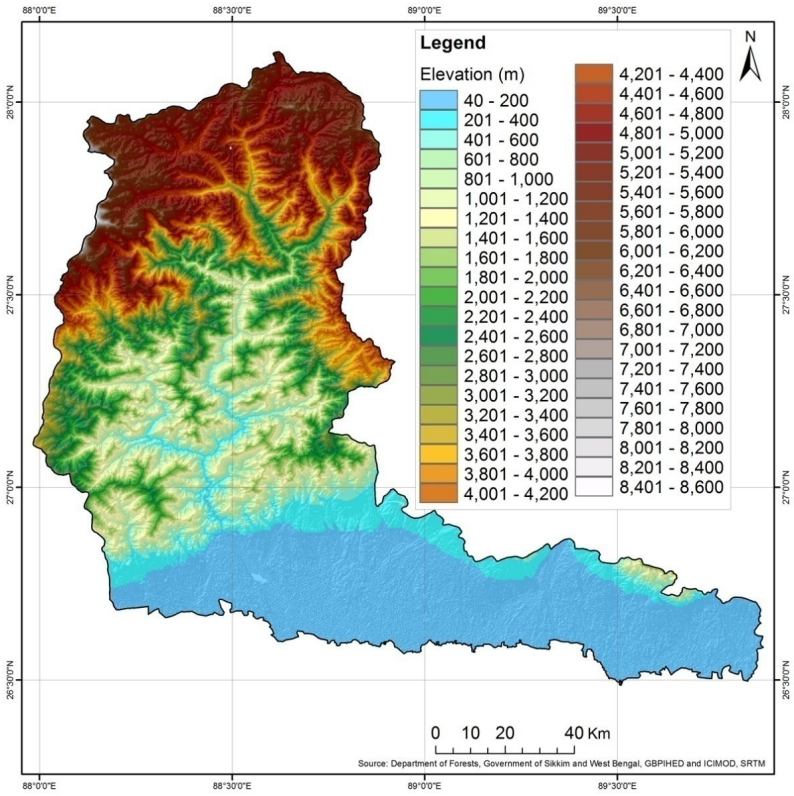


Figure 3.1 Land cover along different altitudinal gradients in KL (India)

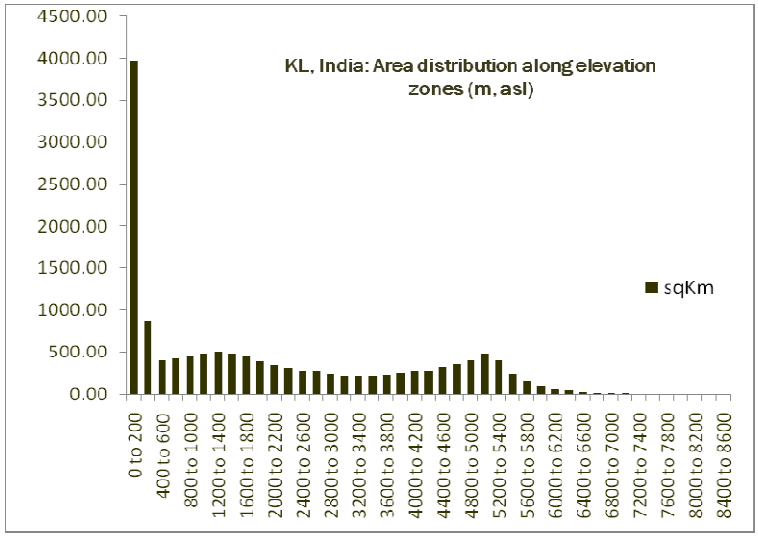


Figure 3.2 Land cover along different altitudinal range in KL (India)

3.3 Climatic variables

KL- India comprises distinct climatic variations along the elevation ranges. The landscape is one of the most humid places due to its proximity to the Bay of Bengal, and direct exposure to the effects of moisture laden SW monsoon. The significant factor determining the rainfall at a place is its altitude. The climate of landscape has been roughly divided into the tropical, sub-tropical, temperate and alpine zone. Moreover, the timber line zone – the transition zone - of the Himalaya harbours both alpine as well as temperate elements, separating two floristically distinct regions i.e. alpine scrub and alpine meadows on the upper limit and the temperate zone towards the lower limit (Rawal *et al*., 1991).

3.3.1 Monthly climate variability

In three distinct locations of Khangchendzonga landscape (India), the climatic variability data have been provided in figures, which differ amongst each other. The monthly average maximum temperature varies between 8-19 °C in Darjeeling (Figure 3.3). In Sikkim (Gangtok), it varies between 17-27 °C, and between 23-32 °C in Jalpaiguri terai region. The minimum average temperature varies between 2-14 °C in Darjeeling, between 7-20 °C in Sikkim (Gangtok) and between 11-25 °C in Jalpaiguri (Figure 3.4). Further, the total monthly rainfall varies between 8-798 mm in Darjeeling, between 20-537 mm in Sikkim (Gangtok) and between 2-972 mm in Jalpaiguri region (Figure 3.5). Regarding elevation variations, monthly temperature (maximum and minimum) varies along the elevation gradients. However, monthly rainfall data do not show many variations along altitudes.

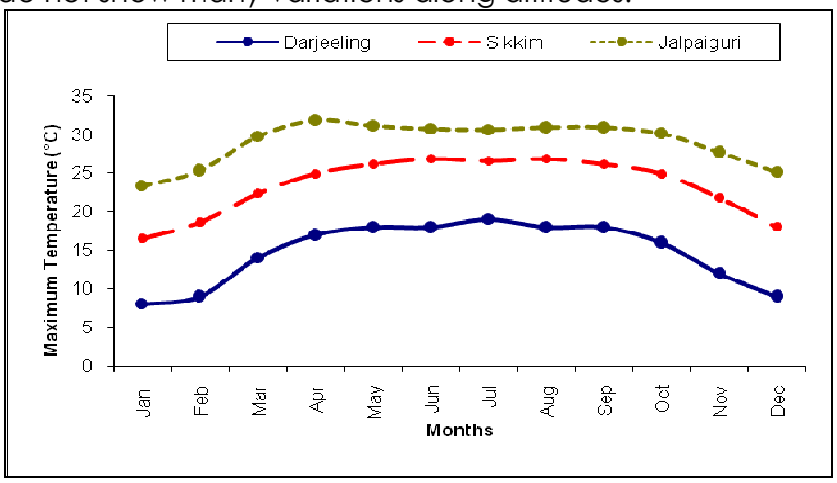


Figure 3.3 Monthly mean variability of maximum temperature across the Khangchendzonga landscape (India) at three distinct locations

3.3.2 Spatial/elevation variability

Considering the mean annual temperature variability along the elevation gradients in KL-India, the maximum and minimum temperatures indicate sharp declining trends with increasing elevation gradients (Figure 3.6 and 3.7). As far as the rainfall in concern, it is depicted a declining trend along the elevation (Figure 3.8). In the KL India, climatic gradients are the major phenomena towards controlling the biotic and abiotic activities and directly or indirectly influence the whole landscape.

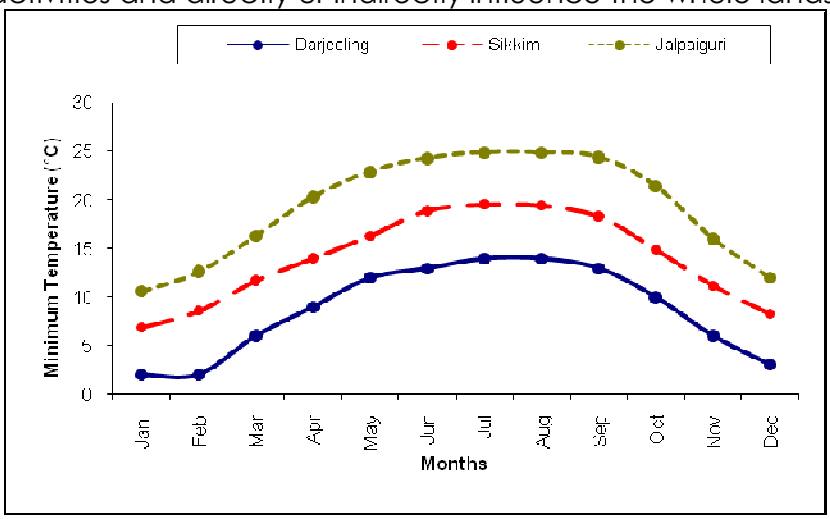


Figure 3.4 Monthly mean variability of minimum temperature across the Khangchendzonga landscape (India) at three distinct locations

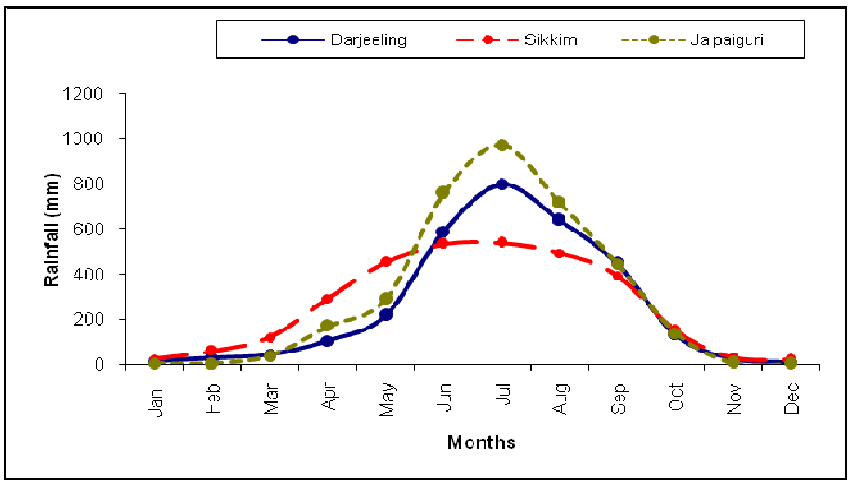


Figure 3.5 Monthly variability of total rainfall across the KL (India) at three distinct locations

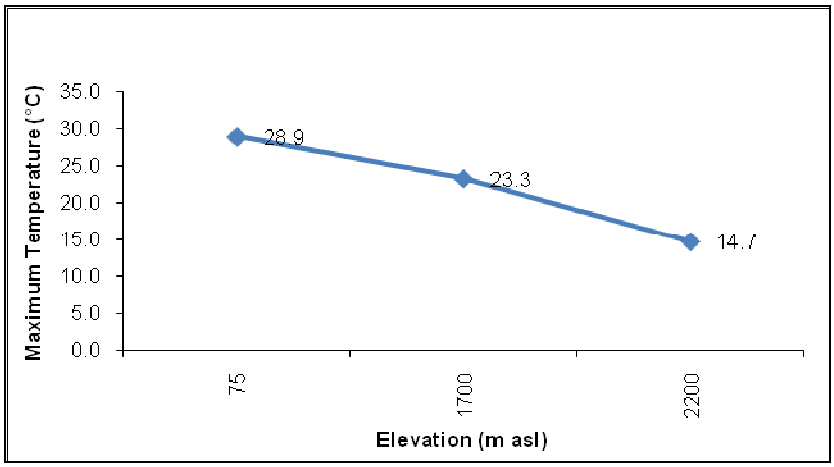


Figure 3.6 Annual mean variability of maximum temperature along elevations in KL (India)

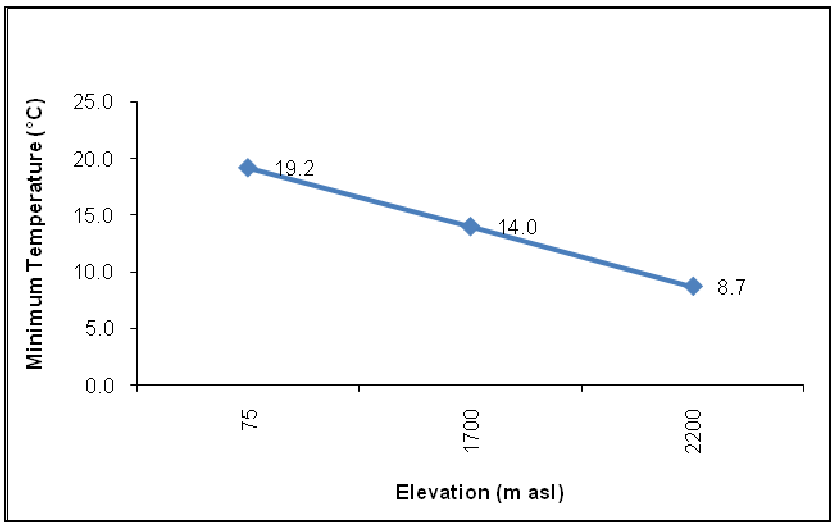


Figure 3.7 Annual mean variability of minimum temperature along elevations in KL (India)

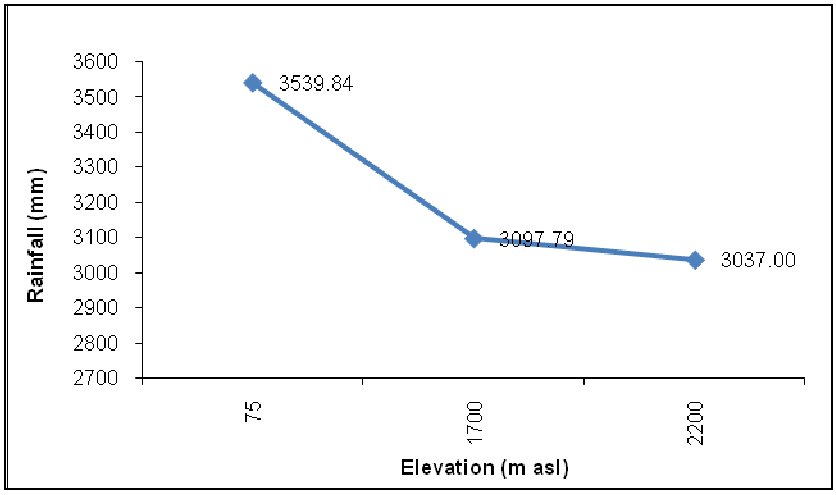


Figure 3.8 Annual variability of total rainfall along elevations in KL (India)

Within Sikkim, the highest rainfall is recorded for Pangthang (1900 m, rainfall- 4497 mm) and lowest at Thangu (3834 m, rainfall- 1232 mm). The substantial amount of rainfall (58-76 %) of the annual total received during SW monsoon, while in the pre-monsoon season it has received 16-30 % annual rainfall (Singh and Bandhopadhyay, 1998). At places of low altitudes viz., Rangpo, Singtam and Jorethang lying very close to Tista and Rangit river, temperature varies between 4 °C to 35 °C (Verma, 2012). However, at Gangtok (1800 m) temperature varies between 1 °C and 25 °C; areas > 4000 m temperature never goes >15 °C, remains much below freezing point in winters and grater part of spring and the autumn.

3.4 Stream flows

The hills of entire KL-India especially of Sikkim, north Bengal acts as the drainage basin for Tista river, a major river of the Eastern Himalaya. The two important river systems, i.e., Tista and Rangit. ***Tista River –*** It is the largest and the longest river in KL-India and emanates from Tista Khangse glacier in the NNE part of Sikkim. It has been sustaining power projects, agriculture, fishing and white river rafting in the downstream. Besides, it provides several types of ecosystem services to the region. The river finally joins Brahmaputra in the Rangpur district of Bangladesh after travelling 315 km long distance from its source. **Rangit River** originates comparatively at low altitude area of Sikkim. While, its main feeder Rathong Chu originates from the Rathong glacier, West Sikkim. In Sikkim it is also fed by Rimbi, Kalej, Rishi, Rothak, Rammam and Manpur Khola. After its confluence with the Ramam, the Rangit river comes to be known as the Great Rangit. The combined course of the Ramam and the great Rangit marks the southern boundary of the state. Tista has been recognized as a main stream of landscape because it flows from Sikkim, to Jalapiguri and most prominently source for irrigation in Jalpaiguri area. However, in Jalpaiguri, there are some small stream flows like Torsa, Jaldhaka, Raidak and Sankosh, Mahananda. Apart from Tista, Darjeeling has several other rivers great Rangit, Mechi, Balason, Mahananda, Lish, Gish, Chel, Ramman, Murti and Jaldhaka.

3.5 Peaks and passes

KL-India is arranged by the longitudinal ridges in the North, East and West and this appears like an amphitheatre. The prominent longitudinal mountain range separating from its neighbours are *Chorten Nyima* in the North, *Chola* in the Northeast and *Pangolia* in the East, and *Singalila* and *Khangchendzonga* range in

the West. The important mountains of the landscape are listed in the table 3.1. Elevation wise, there are total 47 high peak mountains in the landscape and maximum numbers of peaks (16 Nos) vary in between 15001-18000 ft elevation (Figure 3.9). Also, there are 9 important passes listed in the table 3.2

Table 3.1 Important Mountains of the Khangchendzonga landscape-India

S.No.	Name of mountain	District	Height (Ft)
1.	Mt. Khangchendzonga	West	28,156
2.	Mt. Kabru	West	24,215
3.	Mt. Talung	North	24,200
4.	Mt. Siniolchu	west	22,600
5.	Mt. Simvo	West	22,476
6.	Mt. Pandim	West	22,100
7.	Mt. Rathong	West	22,100
8.	Mt. Paunhri	East	22,000
9.	Mt. Kotkthang	West	20,162
10.	Mt. Lamaonngden	East	19,366
11.	Mt. Masunyane	East	19,300

(**Source**: Sikkim: A Statistical Journal 2013)

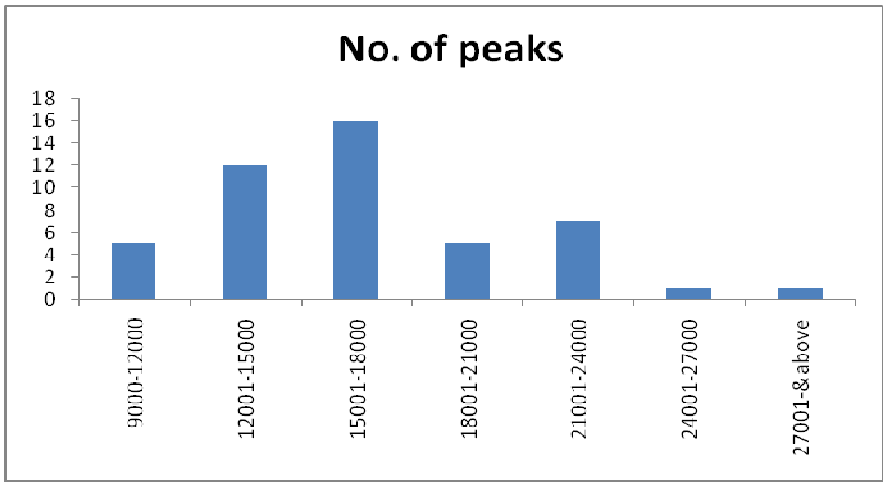


Figure 3.9 Number of peaks along elevations in Khangchendzonga landscape (India); Based on, Sikkim: A Statistical Journal 2013)

Table 3.2 Impotant passes of Khangchendzonga Landscape-India

S.No.	Passes	Altitude (ft)
1.	Nathu-La	14,400
2.	Jelep-La	14,500
3.	Batang-La	13,000
4.	Cho-La	-
5.	Chiwabhanjang	10,300
6.	Chorten Nyima-La	19,000
7.	Kongra-La	-
8.	Lungma-La	-
9.	Donkia-La	18,400

(Source: Sikkim: A Statistical Journal 2013)

3.6 Wetlands

Wetland in the Khangchendzonga landscape-India comprises in different forms i.e. lakes/ponds, Ox-bow lakes/cut-off meanders, high altitude wetlands and riverine wetlands. These offer different kinds of ecosystem services to people and wildlife. As

per National Wetland Atlas, Sikkim (2010) and MSME (2010) details on the wetlands of north Bengal as well as Sikkim are are provided in Table 3.3 and Table 3.4. The space application centre study (National Wetland Atlas: Sikkim 2010) mapped the wetlands of Sikkim and estimated areas of various wetland area categories for Sikkim using GIS layers of wetland boundary, water-spread, aquatic vegetation and turbidity. Total 272 wetlands have been mapped at 1:50,000 scale in the state so far. The study, in addition, also identified 281 wetlands (smaller than 02.25 Km^2). As per above study, in Sikkim part, a total estimated area of wetlands is 74.77 Km^2 accounting to about 1.05 per cent of the geographic area of state. The mapping further accounted the high altitude wetlands for about 40.79 % of the wetlands (30.50 Km^2), river/stream (41.31 Km^2 Km^2), Lake/ponds (0.15 Km^2) in Sikkim. The similar study (MSME 2010) provides figures of 479.15 Km^2 area under wetlands in north Bengal part of KL, India.

Gurudongmar lake in north Sikkim, an important wetland in transboundary area of Khangchendzonga landscape, India (Photo: Sanjyoti Subba)

Table 3.3 Wetlands in Khangchendzonga landscape, India

Sl. No.	Location in KL-India	Wetland category	Number	Total area (Km^2)
1	North Bengal	Lakes/Ponds	28	0.56
		Ox-bow lakes/ Cut-off meanders	33	0.18
		High altitude wetlands	3	0.85
		Riverine wetlands	22	0.09
2	Sikkim*	Lakes/Ponds	160	19.85
		High altitude wetlands*	259	30.5
		River/stream*	12	41.31

*Figures based on National Wetland Atlas, Sikkim (2010) mapping

Table 3.4 Wetlands of north Bengal part (part of Khangchendzonga landscape, India)

	Wetland Category	Number	Total area (Km²)
Inland Wetlands - Natural	Lakes/Ponds	28	0.56
	Ox-bow lakes/ Cut-off meanders	33	0.18
	High altitude wetlands	3	0.85
	Riverine wetlands	22	0.09
	Waterlogged	0	0
	River/Stream	63	61.1
Inland Wetlands -Man-made	Reservoirs/Barrages	0	0
	Tanks/Ponds	30	0.18
	Waterlogged	0	0
	Salt pans	0	0
	Sub-Total	179	62.96
	Wetlands (<2.25 ha), mainly Tanks	596	2.9
	Total	**775**	**65.86**

(Source: MSME, 2010)

As per personal communication from the CCF (WL) West Bengal (N) the three important wetlands in north Bengal are: (i) Teesta water reservoir- area appx 7 km² adjacent to Mahananda WS in Jalpaiguri District is an important Bird Area. Important endangered Avifauna recorded is slender billed vulture, Oriental white backed vulture, Greater spotted Eagle, lesser Adjutant, Pallas Fish eagle, Ferruginous Pochard, Pallid Harrier, lesser whistling Teals, Ruddy Shelduck, Cotton Teal, large Cormorant, Imperial eagle, Darter etc. Many migratory birds visit the area every year, (ii) Fulbari Barrage area- 5 km² appx. in Darjeeling and Jalpaiguri District surrounded by Mahananda River. A large number of migratory birds visit here every year (November-February), (iii) Narthali Wetland in Buxa Tiger Reserve (Alipurduar Distt)-this 5ha wetland is located in Narathali 2 compartment of Narathali bock of Buxa Tiger Reserve. It is old remnant of Rydak 1 river and is crescent moon shaped (local name: Bara beel), measuring around 5000m in length and 50—75 m in width. This wetland harbours, many species of fishes, tortoises, and good number of pythons and snakes, and importantly the water birds and aquatic fauna. Large number of winter migratory birds visits the wetland from October to February.

3.7 Snow, ice and glaciers

The glaciers are the remnant of the ice that accumulated over millions of years (Raina, 2006), during the Ice Age. In KL-India, only Sikkim possesses a substantial area lies above snowline around 5000 m (Pradhan *et al.,* 2004). Extensive alpine region of Sikkim remains under snow cover throughout the year particularly, Northern, Western and Eastern parts. Tista and Rathong basins, Sikkim Himalaya has been monitored through IRS-P6 satellite data using Normalized Difference Snow Index (NDSI) by Basnett and Kulkarni (2012) using NDSI algorithm; maximum snow extent of over 50 % in February. They confirmed that aerial extent of snow is comparatively high (30-40 %) even in the summer months indicating different snow accumulation and ablation pattern. The concurrent feature of Tista River is its influence on the life pattern and economy of the Sikkim, as well as the Tista has great bearing upon the landscape wellbeing downstream, viz., West Bengal and Bangladesh (Mukhopadhyay 1982). Irrigation, hydel power and adventure tourism are highly depend on the meltdown from seasonal snow cover of river (Bahuguna *et al.,* 2001). It is estimated the total snow cover area of the KL-India and which accounted for a total of 1456.81 Km² (Krishna, 2005; Table 3.5). Additionally, the perception of indigenous communities

have confirmed that snowfall pattern has change by (30 %), rise in temperature (15 %), rapid deglaciation (20 %), increase lowest area in rock and snow avalanche incidences (8 %) increase in the number of high altitude trekkers in the Yoksum-Goechela trek, West Sikkim (27 %) due to, i) change in snow fall pattern, ii) reduction in temporal spread of rainfall, iii) rise in temperature, and iv) forest fire incidences in tropical/temperate eco-regions of Tista.

Table 3.5 Snow and glacier covers interpreted from IRS-1B and -1C data for the Himalayan part of Khangchendzonga landscape, India

Snow, glacier and other land covers	**Pixel occupancy by snow (%)**	**Area**	
		(Km^2)	**(%)**
Dense snow cover	80.10	327.12	4.61
Medium snow cover	60.10	75.22	1.06
Thin snow cover	40.10	343.45	4.84
Alpine barren with marginal snow cover	20.10	621.61	8.76
Glacier	Not uniform/identified by shape	89.41	1.26
Other land covers	0	5639.19	79.47
Total	**-**	**7096**	**100**

(**Source:** Krishna, 2005)

In KL (India), Bahuguna *et al.* (2001) have reported 84 glaciers with an area of 440 Km^2 (Table 3.6). The permanent snow fields have been measured around 251 Km^2. In total, glacierized (glacier area plus permanent snow field) area is 691 Km^2. The permanent glacial and snow cover stored 145 cu Km of water in Sikkim (Source: Glacier Atlas of Sikkim, 2001; Govt of Sikkim). Among the glaciers in KL, India, Zemu-Siniolchu glacier covers maximum area i.e. 36 Km^2, while minimum area covers by Simvo glacier i.e. 4 Km^2.

Table 3.6 Total glacier area in Each Sub-basin of Tista Basin in the KL, India

Sub-basin Name	**No. of Glaciers**	**Total Area (Km^2)**
Tsakchurong chu	8	30.8
Prek chu	3	20.37
Rilli chu	2	1.3
Rangyong chu	8	71.15
Umaran chu	4	25.93
Zemu chu	2	80
Goma chu	22	82.72
Chumbo chu (Tista River)	15	41.81
Lachung chu	11	49.15
Sebuzung chu	9	37.01
Total	**84**	**440.24**

3.8 Land use

For the entire KL, India, agriculture and broadleaved forest cover maximum area coverage, i.e. 3110.95 and 3035.67 Km^2, respectively, accounting for 22 and 21.5 % of its total area, respectively (Figure 3.10 and Figure 3.11). For agriculture, the contribution of plains and foot-hills of KL is the biggest, as vast land cover by tea

gardens is also included in the agriculture. The agriculture is not a big activity in mountain areas. Bare land is also huge as that makes 12.1 % of land use area. Owing to high mountains ranges including the mighty Mt. Khangchendzonga, the snow/glacier cover is vast, i.e. 11.1 % of the entire spatial land cover of KL, India. Table 3.7 provides location wise land use pattern of the KL India. Around 3.79 % of the land in the district Jalpaiguri (with Alipurduar) is under different land degradation problems viz. ravenous/gully erosion, water logged area, under mining, under land slide/slip. A large area has already been treated under various land Development programmes (Comprehensive District Agriculture Plan for Jalpaiguri District, 2007-12). A lion's share of the land use falls under the agriculture sector and tea industry. Nearly 84 % of the total geographical area of Sikkim is under the control of the forest department.

The forest cover of the State is 3190.00 Km^2, which is 45 % of the total geographical area. The state of Sikkim does not have a land use policy thus agriculture land is under rapid transformation to non-agriculture sector mainly for development activities such as establishing Pharmaceutical Industries and Hydropower projects (Sharma and Acharya 2013). Considering Darjeeling district net area sown has major area (1601.40 Km^2).

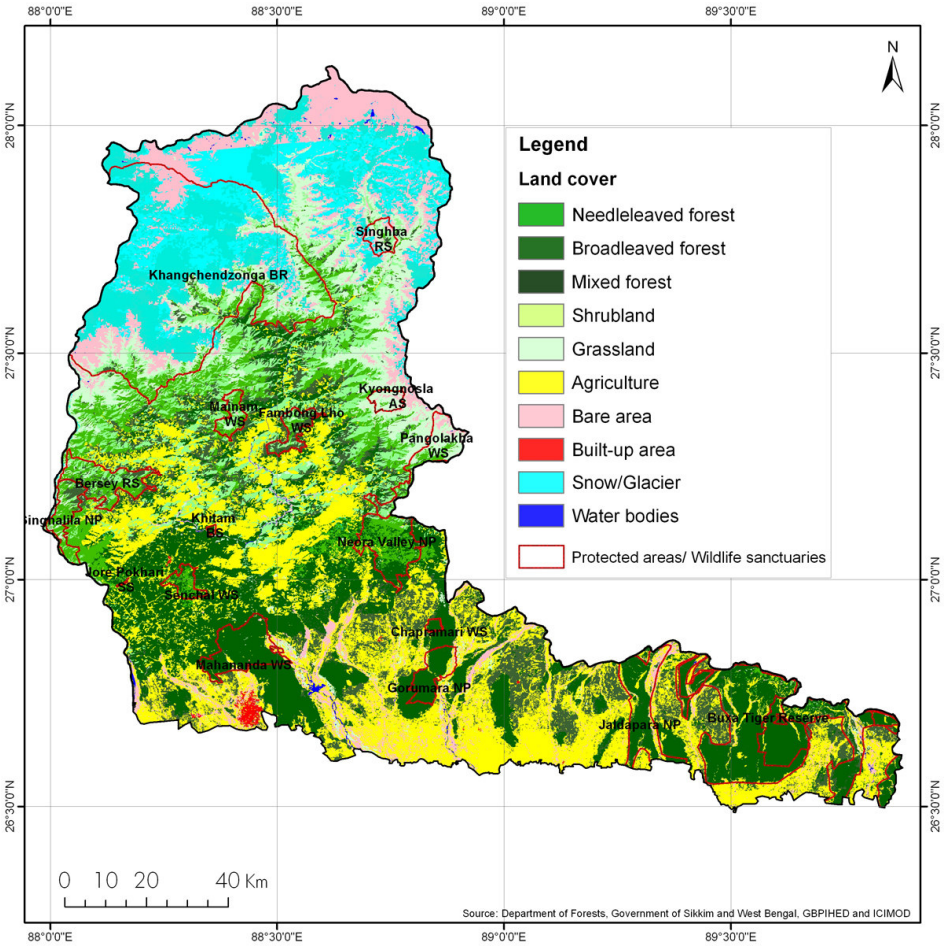


Figure 3.10 Major land use pattern in Khangchendzonga landscape (India)

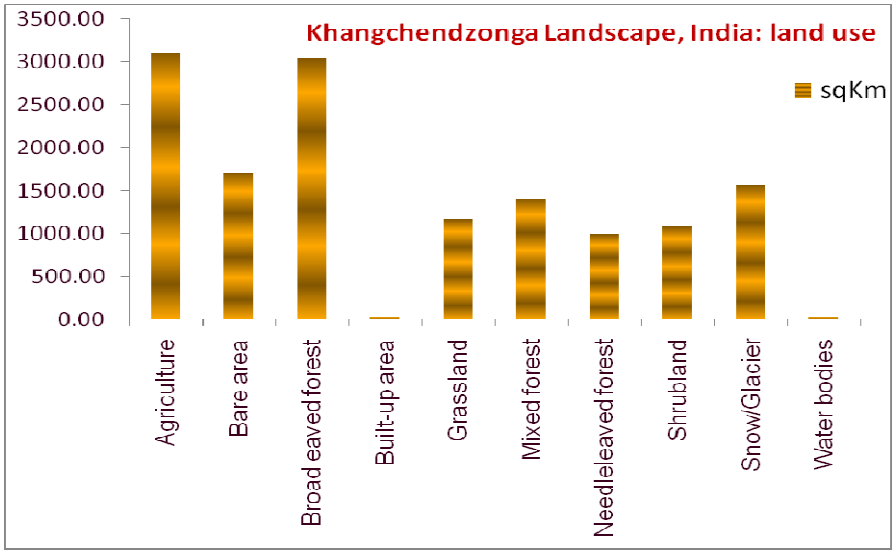


Figure 3.11 Major land use cover area (Km²) in Khangchendzonga landscape (India)

Table 3.7 Land use pattern (in Km²) of entire Khangchendzonga Landscape-India

Classification	**Sikkim**	**Darjeeling**	**Jalpaiguri***
Reporting area	7100.00	3254.60	6227.00
Forest area	3190.00	1245.00	1790.00
Under non argil. Use	2500.00	372.00	835.22
Barren and uncultivated land	40.00	0.025	32.61
Land under misc. crops and grooves not included in net sown area	50.00	20.00	50.46
Cultivable wasteland	20.00	18.00	0.56
Fallow land other than current fallow	300.00	3.8.00	0.41
Current Fallow	50.00	133.40	160.48
Net area sown	1070.00	1601.40	3357.26

(Source: Land Use Statistics Ministry of Agriculture GOI 2008-2009; Comprehensive District Agriculture Plan for Jalpaiguri District 2007-12; Agriculture Contingency Plan for Darjeeling); * including the part of Alipurduar district.

3.9 Water and spring discharge

Springs are the points in which groundwater come into contact with the surface. Reviving dry season discharge of streams by taking up artificial recharge works in their upper catchments to increase their base-flow during dry season has been initiated in KL especially Sikkim. During the lean season of 2012 in the months of February and March an extensive field survey was carried out to monitor the important springs and streams in the drought prone region of Sikkim (Tambe *et al.,* 2012). The study covered south-central part of the state spanning across mid hills (500 – 2500 m) of East South and West. The average lean period discharge of water sources was 29 lpm and catered to 35 households (Table 3.8).

Table 3.8 Variation in spring discharge with elevation during the lean season in the drought prone region of Sikkim

Parameters	**500-1000 m**	**1000-1500 m**	**1500-2000 m**	**Total**
Number of water sources	59	73	19	151
Average discharge in lpm	40	24	18	29
Household dependency	31	36	42	35
Water availability at source in liters per capita per day (lpcd)	186	96	62	119

3.10 Geology and soil types

The geology of the KL-India is much varied and exhibits predominantly covered by metamorphic and crystalline rocks grouped under the inner and axial tectonic belts. Inner belt is made up of Daling and Darjeelling group of meta-sediments for the Sikkim hills. This is followed by an axial belt which exposes the crystallines of Central region and intrusive granites. There are two predominant zones i.e. gnessic and Daling group. Major portion is covered by the pre-Cambrian rock consisting of phyllite and schists. Similarly the Darjeeling hills follow the Siwalik system comprised of mudstones sandstones shale and conglomerates along with the bands of shale and lignite. Coarse-grained hard sandstone quartzites carbonaceous shale and slates belonging to Damuda series are also found in the landscape. In the higher reaches the Dalings gradually grade into the more metamorphosed rocks which is known as Darjeeling Gneiss. The Jalpaiguri terai area is composed mostly of Recent and Sub-Recent Alluvium and other soils boulder and pebble beds forms the main body. The Miocene Siwaliks are composed of Sandstone with clay and lignite. Lower Gondwana Sandstone shape with veins of Graphite coal and Buxa series Gneiss Schist Slate and Quartzite banded ferruginous rocks are also part of the geological face of Jalpaiguri Terai. Apart from the above the Daling and Darjeeling series formed of Gneiss Schist Slate and Quartzite are observed from the region.

In spite of rugged mountainous topography thick vegetal and soil/debris cover the state of Sikkim houses a number of base metals. Most of the occurrences are in Daling Group of rocks in parts of West South and East districts of Sikkim. As per large areas of KL India still remained unexplored owing to paucity of demand and supply of locally available minerals mineral resource based industries and infrastructural facilities (Tashi 1998). However Tashi (1998) has been reported the availability of coal Dolomite/Limestone Marble base metals Quartz/Quartzite Talc Silliminite/Kynite and graphite etc. in Sikkim. The distribution/description of the mineral resources is presented below.

(a) Graphite: Workable deposits of graphite have been identified by DMMG. The deposits are located at Chitre-Dariely and Dentam-Uttarey West Sikkim. On an average it contains 40-60 % fixed carbon.

(b) Sillimanite: It is found in the form of granular and lumpy variety. An investigation by DMMG reported occurrences of the mineral in the form of boulders and in situ lensoidal bodies at the head waters of Roathak Khola (West Sikkim). The boulders alone show a tentative reserve of 1000 tonnes. However GSI have reported occurrences of the aforesaid mineral and Kyanite bearing Schist in the high grade Biotite Gneiss of Changey Khola. The 50 m thick Sillimanite/Kyanite bearing band has been reported to extend along the strike of the country rock for over 25 m from Changay Khola to Sardung (Peling-Dentam road section).

(c) Quartzite: found in East West and South districts of Sikkim. Presently M/s Sikkim Minerals Pvt. Ltd has been involved in mining the Quartzite occurrences of Rani Khola-Mansari area West Sikkim. Total estimated mineral reserve in the region is 681250 tonnes.

(d) Talc: Availability of Talc in KL India have been reported and located from Rani-Khola-Mansari area West Sikkim as intercalation in quartzite deposit. An estimate reserve of 80000 tonne of talc mineral has been reported.

(e) Limestone and Dolomite: Extensive deposits of Dolomite with bands of limestone have been reported from Rangit Valley Tectonic Window. GSI and DMMG have

been focusing on Reshi-Mangalbaray and Namgaon areas of West Sikkim for its exploration.

(f) Marble: According to KL India is endowed with sizable deposits of marble around Chungthang and Tsomgo (Tashi 1998). However there is a report of occurrences of several bands of marble near Chungthang Theng and Naga in North Sikkim and near the 6th and 6th mile posts and near Tsomgo on the Gangtok-Nathu La road East Sikkim.

(g) Coal: Also Tashi (1998) have reported the coal occurrences in the Rangit Valley Tectonic Window. The GSI has drilled the area in and around Namchi Public School and found a reserve 1.4 lakh tonne of coal. The promising coal areas identified by DMMG in Sikkim are in (Table 3.9). Furthermore study at Reshi by DMMG indicated a reserve of 70000 tonne along one coal seam.

Table 3.9 Promising coal areas and its composition in KL-India (Sikkim)

Location	Fixed Carbon (%)	Ash	Volatile matter (%)	Moisture (%)
Reshi	49.7	43.3	4.4	2.6
Sikkip	68.4	25.7	2.2	3.7
Nandugaon	69.4	24.3	3.2	3.1
Namchi	53.4	39.5	3.4	3.7

(Source: Tashi 1998)

The Darjeeling hill area is formed of comparatively recent rock structure that has a direct bearing on landslides. Heavy monsoon precipitation contributes to the landslides. Soils of Darjeeling hill areas are extremely varied depending on elevation degree of slope vegetative cover and geolithology (MSME 2010).

3.11. Soil diversity

Starting from the lower zone, the soil in Jalpaiguri region ranges from alluvial to sandy and clayey soil and broadly classified under two heads – a) the terai soils covering almost the entire district and b) the brown forest soil covering the northern foot hills of the district. However the soil is predominantly sandy and hence porous with low water holding capacity. The alluvial soil is fertile enough for the growth of crops like paddy jute and tea. This kind of soil is brought down by hilly rivers like Teesta Torsa and Mahananda. In upper region to the north of Dooars (north Bengal) the soil is mainly hard black and clayey. This soil is suitable for growing tea which is a major cash crop of this region. In the lower plain land the soil consists of a mixture of both clay and sand. In addition soil is devoid of organic matter and is prone to erosion. The soils are mostly acidic in nature having soil pH in the range 4.6 to 6.5. But the main feature of the soil is acidity and hence most of these soils are categorized as problem soils. General productivity of such soils is very low making agricultural as a low profit venture. Making the best use of such soil for agricultural development is a real challenge for the technologists (Comprehensive District Agriculture Plan for Jalpaiguri District 2007-12).

The northern hilly region i.e. Darjeeling and Sikkim are a series of steep hills and deep valleys terraces and scarps at different altitudes (Mukhopadhyay 1998). The soil is of diverse property owing to the wide range of climate physiography geology and vegetation that influence the formation of different kinds of soil (Planning Commission 1981). The soils of Sikkim are represented by three orders seven sub-orders 12 great groups and 26 sub-groups as per physiography and terrain features

(Soil Survey Staff 1994). The table 3.10 provides varia9tion of soil as per physiographic units and slope.

Table 3.10 Major physiographic units and the dominant soils therein KL-India (Sikkim)

Physiographic unit	Slope (%)	Dominant Soils
Ridge and Summit	<30	Cumulic Hapludolls Typic Hupludolls Pachic Haplumbrepts Typic Udorthents
Hill slope	15-30	Fluventic Eutrochrepts Mollic Udarents Typic Argiudolls Cumulic Hapludolls
	30-50	Umbric Dystrochrepts Typic Paleudolls Cumulic Hapludolls Lithic Cryorthents Typic Cryumbrepts
	>50	Typic Hapludolls Entic Hapludolls Dystric Eutrochrepts Typic Cryorthents Entic Haplumbrepts
Escarpments	>75	Typic Udorthents Entic Hapludolls
Valleys	<30	Typic Haplumbrepts Aquic Udorthents
Cliff	>75	Lithic Udorthents Typic Udorthents Lithic Cryumbrepts

(Source: Das *et al.*1998)

The kind of soil prevalent in the north-eastern part of KL India is suitable for deciduous and evergreen forests. The soil does not have a high content of organic matter. The soil is not rich in minerals and the texture of this soil is coarse. The soil quality is not very good and the soil level is not thick enough. It has a high content of the chemical compound of iron oxide. The presence of these two kinds of rocks has turned the soil of these regions brown in color and clayey in constituency. Consequently the soil characteristics vary between hilly and terai/plain region in KL-India (Table 3.11).

Table 3.11 Soil characteristic of Darjeeling district is given below (MSME 2010)

Region	Name of Soil	Character	Structure
Plains	ENTI soil	Recent alluvial yet to be formed properly. Has no alluvial horizon. Loamy sand is predominant.	Apedal (neither granular nor angular)
Hill	INCEPTI soil	In situ inception has just begun. Alluvial horizon has begun to take shape. Sandy loam is predominant.	Angular/ sub angular blocky.

Considering the physical features of KL-India it emphasizes unique and ideal feasibility towards conservation which offers:

- Broad study area (i.e.14126.36 Km^2) varying along an altitudinal ranges i.e. 40 to 8586 m asl to work in wider prospective
- Variation in climatic events along the elevational gradients offer to implement the approaches at different levels
- Tista river encompasses as a major stream flow varying from highest part of landscape i.e. glacier (Sikkim) to lowest part of landscape (Jalpaiguri)
- Significance area of snow ice and glacier ranges offer the sustain downstream basin for multiple purpose of conservation and development
- Multiple land use patterns providing wider biodiversity patterns
- High frequency of lakes/ponds providing a significance scope for conservation towards improving socio-economic status and

- Distinct features of soil and minerals providing a source of knowledge about soil conservation and helpful in varying purposes i.e. landslide and soil erosion study agriculture practices soil microorganisms and forest structure etc.

In addition to above there are few meteorological stations functioning since long time ago and collecting data at real-time basis but the region should have automatic weather stations installed at various climatic gradients in the landscape. AWS may be quit suitable with less manpower and provide accurate and precise data on weather at various level. In case of physical features of KL India as a whole some parts have lot of information while other is deficit region of the information. Therefore there is a need to initiate a similar kind of approach for initiating conservation and development approaches in the entire landscape.

Chapter 4: Socio-economic profile

4.0 Salient socio-economic features

4.1 Population and Demography

4.1.1 Population structure

Total population of KL, India is 6,325,457 (3,243,393 male and 3,086,853 female), with 1,294 persons/Km^2 human density (Table 4.1). For north Bengal part, the total population is 5,714,880 (2,920,323 male and 2,799,346 female), with a high density of 1,208 persons/ Km^2 as compared to Sikkim (i.e. (86 persons/Km^2). For the entire KL-India, over 69.81% population inhabits rural areas and 30.19 % is urban (Table 4.1).

Table 4.1 Population structure and density in KL, India (based on Census of India, 2011)

Locations	**Male**	**Female**	**Total**	**Density (per Km^2)**
Darjeeling [WB]	937259	909564	1842034	586
Jalpaiguri [with Alipurduar, WB]	1983064	1889782	3872846	622
Sikkim	323070	287507	610577	86
Total (KL)	**3243393**	**3086853**	**6325457**	**1294**

Table 4.2 Rural and urban population and sex distribution of KL-India (2011)

State/ District	**Sector Rural/Urban**	**Population**		
		Persons	**Male**	**Female**
North	Rural	39065	22274	16791
	Urban	4644	2456	2188
	Total	43709	24730	18979
East	Rural	161096	87147	73949
	Urban	122487	64285	58202
	Total	283583	151432	132151
South	Rural	125651	65848	59803
	Urban	21199	10822	10377
	Total	146850	70238	70180
West	Rural	131187	67528	63659
	Urban	5248	2710	2538
	Total	136435	70238	66197
Sikkim	Rural	456999	242797	214202
	Urban	153578	80273	73305
	Total	610577	323070	287507
Darjeeling	Rural	1118860	566965	551895
	Urban	727963	370294	357669
	Total	1846823	937259	909564
Jalpaiguri including Alipurduar)	Rural	2812495	1437286	1375209
	Urban	1060351	545778	514573
	Total	3872846	1983064	1889782
Total (KL, India)	Rural	4845353	2489845	2355508
	Urban	2095470	1076618	1018852
	Total	**6940823**	**3560031**	**3374360**

(Source: Sikkim: A Statistical Journal 2013, Census 2011 Darjeeling; Census 2011 Jalpaiguri)

4.1.2 Ethnic scenario and religion structures

The KL-India exhibits a myriad of ethnicity and clans and sub-clan orders within groups with its individual language/dialects, culture, social make-up and religious beliefs. In Sikkim and the hill region of Darjeeling, Lepchas, Bhutias, Nepali, Limboo constitute the major caste/ethnic groups. Among ethnic groups, there are the Scheduled Tribe (ST) such as Lepcha, Bhutia, Chumbipa, Dopthapa, Dukpa, Kagatey, Sherpa, Tibetan, Tromopa, Yolmo, and the Scheduled Castes (SC) such as Kami, Damai, Lobar, Majhi and Sarki. Within the ST, for Sikkim, Tamang, Gurung, Rai, Limbu, Sunwar are disadvantaged ethnic groups (Lama, 2001); however, Rai and Gurung and Sunwar come under OBC categories in west Bengal. In Darjeeling, ST constitutes 10.92 % (Gurung, 1999). People of Sikkim and Darjeeling share the common language 'Nepali'. The Lepchas are the ancient tribe of Sikkim (Pradhan and Badola, 2008). However, the Limbu are other historically old inhabitants of the same areas (Badola and Pradhan, 2013). The greater bulk of the people in the hills today are the Gorkha. Several evidences indicate that there is another popular group known as Denzongpa (Bhutia) which is a considerable population of Tibetans. In plains, Adivasi people originally from Chotanagpur and Santhal Parganas and a greater bulk of Bengali people. Official language of West Bengal is Bengali. In KL, India, people speak English, Nepali, Lepcha, Tibetan, Sunuwar, Limbu, Rai languages, Tamang, Denzongke, Rajbonshi and Bijori (a Munda Language). There are several tribes, including the Oraon, Munda and Kheria, but these are not indigenous to the region. There is still a small enclave of Toto tribe, who retains much of their original lifestyle.

4.1.3 Cultural Infrastructure

In KL India, Buddhism and Hinduism are the two main religions followed in Sikkim. It has nearly 200 monasteries, of which the most well known Buddhist circuits are the Pemayangste, Tashiding, Rumtek, Enchey, Phensang, Ralong, Khecheopalri, Phodong and Tholung. Tholung Gumpa, the famous monastery is one of the oldest cultural structure in Sikkim, which was constructed in early 18th century located at 2600 m asl (Pradhan and Badola, 2008). The culture of Darjeeling is quite diverse. The Tibetan ethnic groups like the Lepcha, Bhutia, Gurung and Tamang celebrate New Year Losar in January/February, Maghe Sankranti, Chotrul Duchen. Buddha Jayanti and Tendong-Lho-Rum-Faat to name a few. In Jalpaiguri, majority of tribal cultures are folk cultures.Apart from the major festivals like the 'Durga Puja' and the 'Kali Puja', there is the 'Tista Burir Puja' epitomising the lifeline of this region (www.jalpaiguri.gov.in/html/culture.html; accessed 9.03.2014).

4.2 Livelihood and Economic Activities

4.2.1 Crop production

The cereal crops (i.e. rice, maize, wheat, small millets) are grown extensively in KL-India. Among cereals, rice is a major crop in the landscape and used in everyday diet of the people as a stable food. The production of major crops is contributed as a vital role for livelihood of the community. The status of the production of major crops is as given in the Table 4.3.

Table 4.3 Major crop production ('000MT) in Khangchendzonga landscape-India

Crops	Jalpaiguri (with Alipurduar)	Darjeeling	Sikkim
Rice	579.79	60.700	20.930
Wheat	50.730	4.700	4.720
Maize	18.880	29.200	64.690
Oil seeds	7.968	0.500	8.200
Pulses	4.405	-	6.060
Potato	601.05	113.100	4.840

(**Source**: State contingency plan for Darjeeling and Jalpaiguri; GoS 2001; Achievement Report 1975-2010; DESME (2002, 2006-07); Annual Progress Report 2009-10, Food Security and Agriculture Development Department, Government of Sikkim; North Bengal Pineapple Growers Association, North Bengal)

4.2.2 Cash crop

The KL India has many cash crops, viz. large Cardamom, Ginger, Orange, Pineapple, etc. The large Cardamom is one of top crops, cultivated along 600-2000 m asl in the Sikkim and Darjeeling region, covering about 30,000 ha and producing annually 5000-5500 metric tonnes (http://www.indianspices.com /html/spices_spfarm_cardSm.html; 26 June, 2014), which is cost effective as compared to other crops (Singh *et al.,* 2005). Another cash crops ginger and turmeric in lower (Jalpaiguri) to higher region (Sikkim). First successful production of Pineapple (Mauritius variety) was introduced in Jalpaiguri by about 29000 north Bengal growers in June 2014. For Jalpaiguri, an area expansion plan was proposed (Figure 4.1) with growing priority over years. In recent years, greater emphasis has been given on vegetation cultivation. It is an attempt to represent the vegetables and its allied crops (spices) are grown progressively in the Sikkim region (Figure 4.2) and showed remarkable growth in vegetable production in 2009-2010 as compared to 2005-2006.

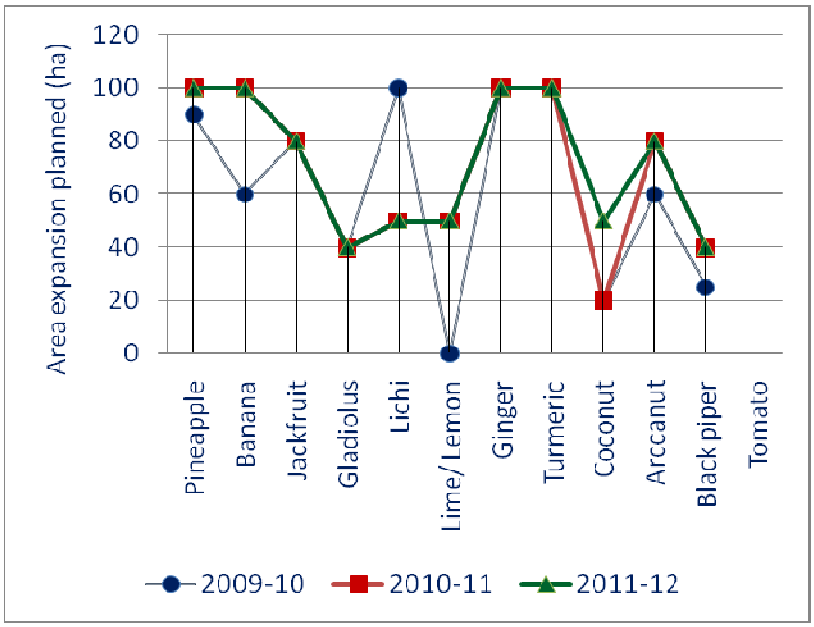


Figure 4.1 Area expansion plan for horticultural crops for Jalpaiguri (Graphic representation based on District Horticulture Office, Jalpaiguri)

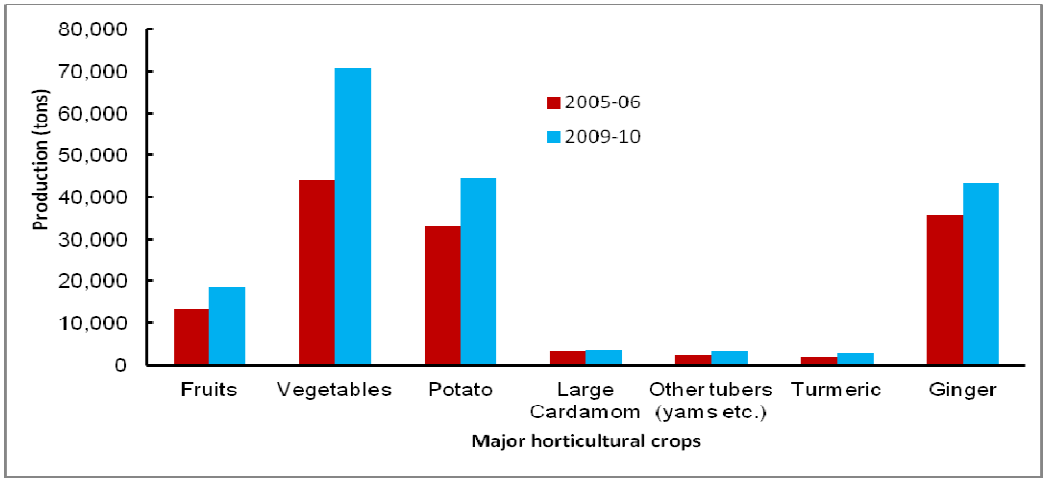


Figure 4.2 Horticultural crop production in Sikkim (Data source: DESME, 2002; 2006-07; Annual Progress Report 2009-10 Department of Horticulture and Cash Crop Development, Government of Sikkim modified by Sharma G., 2014)

4.2.3 Other food resources

The NTFPs grown within the agroforestry systems and in the natural forest areas adjacent to the cultivated systems provide alternative sources of food and income during the periods of crop failure. The indigenous communities harvest wild vegetables, fruits, medicinal plants, tubers and other edibles from the forest during the year, especially in the season of greatest food scarcity. In addition, mushroom is an accepted ideal food item. For generations the indigenous people follow the traditional practice of gathering of wild edible mushrooms.

4.2.4 Crop Diversification

Crop Diversification is expected to be able to contribute towards a higher nutrition level, poverty alleviation, employment generation, and sustainable natural resources management (Badola, 2009). Bhattacharya (2008) evaluated the district wise growth rate of high value crops in west Begal; in Jalpaiguri the fruits Sapeta (435 %) and Guava (168 %) are the major gainers in terms of area while other fruits (-38 %) lost in area under cultivation in Darjeeling (Figure 4.3). Considering the extent of diversification across the year, it has been indicated an increasing trend for Darjeeling district while Jalpaiguri district indicated a constant trend (Bhattacharya, 2008; Figure 4.4). Such kind of information is not available for Sikkim.

4.2.5 Tea plantation

The tea industry in the Khangchendzonga landscape, India is considered very important bringing economy to the region as backbone since inception. Tea plantations are the major source of employment in the landscape for livelihood, which cover approximately 216,877 ha total area (i.e. 198,700 ha Jalpaiguri, 18,000 ha in Darjeeling, and 177 ha in Sikkim) are under the tea plantations. It is a glimpse of estimation that total 243,630 persons are directly or indirectly engaged in tea plantations in the part of landscape (Darjeeling) (Table 4.4).

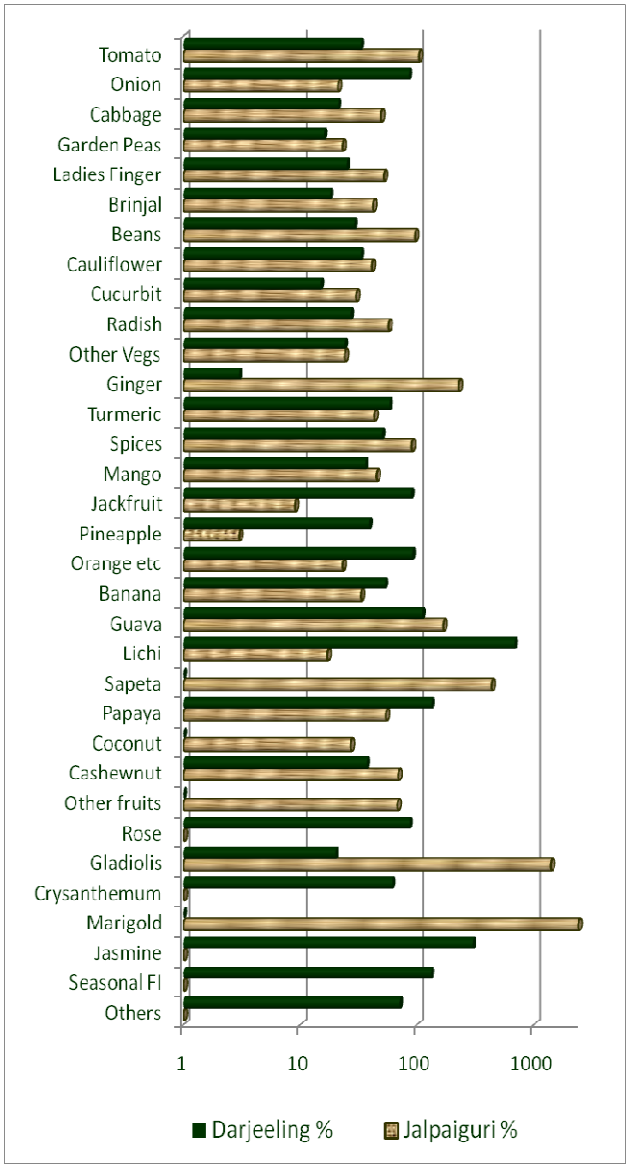


Figure 4.3 Compound growth rates (%) of high value crops in Khangchendzonga landscape, India (district Darjeeling and Jalpaiguri) between 1997-98 to 2004-05 (Graphic representation by GBPIHED, unpublished: based on Bhattacharya, 2008)

Tea harvesting by labours in Khangchendzonga landscape, India (Photo: K Gaira)

Table 4.4 Estimated total number of labour in tea garden in a part of KL-India (Darjeeling)

Resident	Outside		Total	Estimated no. of bonafide dependents of resident workers on roll
	Permanent	Temporary		
167017	4652	15479	187148	243630

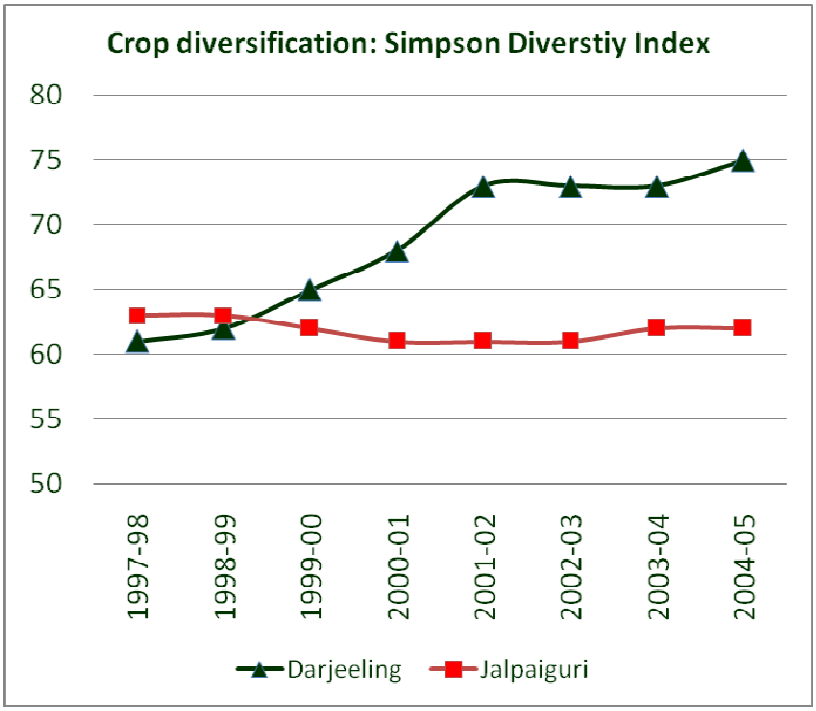


Figure 4.4 Extent of diversification during 1997-98 to 2004-05 in Khangchendzonga landscape, India (north Bengal part), as expressed by Simpson Diversity Index (Graphic representation by GBPIHED, unpublished: based on Bhattacharya, 2008)

4.2.6 Medicinal plant cultivation

The Himalayan part of KL India is one of the richest regions in Himalaya for having immensely high medicinal plant diversity having great proven use potential (Badola and Aitken, 2010). To attain conservation approaches, both *in-situ* and *ex-situ* mechanisms need further strengthening with strong scientific support and guidance for proper cultivation of the MPs (Badola and Pal, 2002; Dhyani and Kala, 2005). It is essential to identify the medicinal plant diversity and their conservation status for any big commercial venture. Based on their threatened category and high economic value, it should be prioritized for immediate conservation initiatives (Sikkim biodiversity action plan, FEWMD, Govt of Sikkim, 20011). A proper matrix of prioritisation further helps to identify appropriate agro-climatic zone and the suitability of species being targeted for ex-situ cultivation (Badola and Pal, 2003). The KL, India provides very suitable agro climatic conditions for cultivation of a variety of medicinal plant of high value. For example, cultivation demonstrations on one of the critically and high value medicinal plants in KL, India successfully offers lucrative economic benefits, if taken with precautions under scientific guidelines (Badola and Pradhan, 2011). The Medicinal Plant Boards in either states have been trying and motivating farmers for cultivation of medicinal plants including with contract farming method.

4.2.7 Trade, marketing, off farm activity and local markets

A unique concept in the landscape (KL-India) has been the setting up of local bazaars or hats, which are appropriately offer opportunities to farmers and villagers for show-casing their agriculture/agro-biodiversity produces and earning economy by selling the products as important livelihood option. Often such markets are set up on weekly basis in nearby townships. Farmers also sell their agricultural goods (dairy products, vegetables, fruits and local cereals and pulses, etc.) and wild edibles in the town and in village area (based on village boundary at road head) as well. In recent years, women growers sell their vegetable produces along the motor roads and they earn good money.

For the trading of major cash crops i.e. large cardamom and ginger, there is a ready market in KL-India (Sikkim and north Bengal). About 30 % produce of the crops is sold in the village itself to the local merchants or commission agents. The remaining produce is taken to the market for sale to commission agents/wholesalers. The main marketing centres are Gangtok, Pakyong, Singtam and Rangpo in the East district, Gyalshing, Reshi, Legship and Nayabazer in the West district Namchi, Jorethang and Melli in South district and Mangan and Dikchu in the North district of Sikkim. Apart from this, the major wholesale market is available in Siliguri (Darjeeling) for entire landscape. Orchid trade is regulated in under the Convention on International Trade in Endangered Species (CITES) for which India is a signatory. The orchids are placed under Schedule VI Wild Life Protection Act (1972), with an amendment in 1992. In KL, India and north-east, there are many orchids known and in practice as beautiful ornamentals and contribute to commercial hybrids, such as, *Paphiopedilum insigne, P. villosum, P. venustum, Aerides multiflora, Vanda coerulea, V. teres, Rhynchostylis retusa, Pleione maculate, P. humilis, Cymbidium devonianum, C. gigantium, Dendrobium aphyllum, D. densiflorum,* and *D. thrysiflorum* and which offer significantly high potential to improve the livelihoods of people by strengthening floriculture industries in KL (Lucksom, 2007; Badola and Aitken, 2010). In recent years domestication of ornamental plants have taken up as a huge business through cultivation under floriculture. At rural sectors, orchid cultivation and marketing has taken a big space in recent times. The illegal trade of an endangered medicinal orchid, *Dendrobium denudans* in Mizorum is reported by Mao (2006), which sold at the meagre price of 1000 to 3000 Indian rupees per kg ($22- 65 USD) and in Manipur for even less by local villagers. A rapid increase in selling rate for dry tubers of a critically endangered medicinal orchid, *Dactylorhiza hatagirea*, traded internationally from Himalaya (Badola and Pal, 2002), between 1999 and 2002 (Butola and Badola, 2006) have been recorded. On the trans-boundary trade, the re-opening of the trading market along the Nathula Pass trade route in Sikkim has been a significant development in the history of trans-boundary trade in KL, India. Many domestic goods and items as well as some traditional medicinal products are traded through the Nathula trade mart to Tibetan autonomous region of China.

Road head selling of agriculture produce in south Sikkim of Khangchendzonga landscape, India (Photo: K Gaira)

4.2.8 Organic Mission- promoting better livelihood

On especially focusing the organic farming in KL-India, the Government of Sikkim on 15 August 2010 launched State Organic Mission for strengthening organic process in a holistic manner. With a view of turning Sikkim into a 'fully organic state' which envisages converting 500.00 Km^2 out of the around 790.00 Km^2 of farmland in the State into organic by the year 2015, the Sikkim State Organic Board was constituted by the state in 2003. A policy ban on chemical fertilizers, insecticides, and pesticides was passed in the same year. Sikkim Organic Mission, after its inception in 2010, has credibly accelerated the work for making a Sikkim fully organic state by 2015. The mission has drawn the necessary road map for certification, marketing, human resource development and sustenance of enterprises. Sikkim has over 4,607 ha organic certified area until 2014. In 2010-11 and 2011-12, 380.00 Km^2 area was outsourced to different service providers for developing Internal Control System and simultaneous certification. By 2014-15, the entire area of the state will be under conversion and state is expected to be fully organic.

4.2.9 Weaving and knitting

Women in High Mountain areas (Sikkim and Darjeeling) of the landscape involve in carpet weaving, their involvement is greater, relatively, in weaving/knitting of shawls and bags from cotton fiber using indigenous handicraft weaving techniques. In Darjeeling and Sikkim, the cloth woven by women is used for traditional coat material. Cotton yarn is the basic material whereas they use woolen yarn for the motifs over the coat. Local artists also work on items such as bags, gloves etc. Government has offered many schemes for scheduled castes, scheduled tribes, other backward classes and handicapped persons belonging to low income group, with special focus on educated unemployment and women and promoting economic development. Bamboo production is a priority sector for the investment, having with 28 varieties of bamboo, offering potential for developing the handicrafts, construction, medicine, packaging and food processing industries.

4.2.10 Animal husbandry

To identify sustainable interventions allowing environmental conservation combined with socio-economic development of community people, information on indigenous animal husbandry and associated land-use practices is desired (Stave et al., 2001; McNeely, 2003; Badola, 2009). In this context, animal husbandry, as an integral element of farming system, is the principal source of farm economy to the farmers in the landscape (KL-India). Milk and milk products, and meat are necessary food supplements to the households. Besides, skin and wool are rare marketable products. The draught animals such as the oxen are important for ploughing in the agriculture field, while the population of draught animals (oxen) is rapidly declining due to shortage of farm-labour and feed. However, many dairy cooperatives have been established and milk production has become one of the major economic activities. Human habitation is not encountered above 3000 m elevations and a few transhumance people (about 6 families of Drokpa tribe) carry on their life on pastoralism. The people living at and around 1800-3000 m also practice pastoralism at different magnitude because of the large tract of rangeland (over 4000 Km^2) available for the animals. Figure 4.5 provides a graphical representation of the population of livestock of the Khangchendzonga landscape-India. The figure depicts that the poultry enterprise has been emerged with high population in all region as compared to other sector of animal husbandry. Indication emerged from the figure, that yak rearing enterprises has been adopted in the higher elevation area (Sikkim) which is extensively used for milk, meat and carrying good purposes in the area. Cattle rearing is a prime dairy enterprises of the region and used for their own purposes. Moreover, fishery is a most prominent traditional practice for the Bengali people and it is exaggeratedly taken as stable food. The fishery enterprise has been progressively taken place in the Jalpaiguri region as compared to the other parts in KL, India.

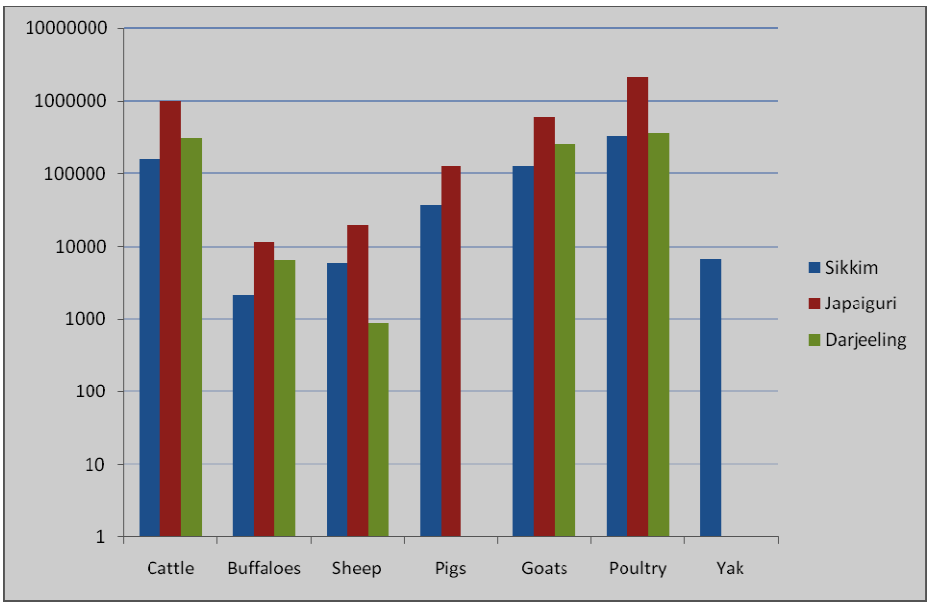


Figure 4.5 Livestock population in Khangchendzonga landscape-India and logarithmic value represented in the figure by transformation (Graphic representation by GBPIHED, based on: Comprehensive District Agriculture Plan, For Jalpaiguri District 2007-2012 by NABARD; Agriculture Contingency Plan for District: Darjeeling; Annual Progress Report 2009-10, Food Security and Agriculture Development Department, Government of Sikkim

4.2.11 Cooperatives promoting livelihood and income generation activities

Over 3013 cooperatives are functional in Sikkim part of KL-India (Table 4.5). Cooperative societies play an essential role to promote farm and non-farm based small-scale enterprises, value chains of selected niche products, and economic empowerment labours of women.

Table 4.5 Cooperatives promoting livelihood and income generation activities KL-India (Sikkim)

S.No.	Type of Society	East	West	North	South	Total
1.	Sikkim State Co-operative Union	01	-	-	-	01
2.	**Cooperative Banks**					
	a) Sikkim State Coop. Bank Ltd.	01	-	-	-	01
	b) Urban Cooperative Bank Ltd.	01	-	-	-	01
3.	Primary Agri. Coop. Societies	50	53	19	47	169
4.	Farmer/Service Co-operatives	65	19	05	16	105
5.	Labour/Contract Co-operatives	11	02	02	08	23
6.	Non Agri. Credit Societies	05	-	-	-	05
7.	**Marketing Co-operatives**					
	a) Apex Co-op. Societies	02	-	-	-	02
	b) Primary Co-operatives	21	08	01	09	39
8.	**Milk Producers Union/Societies**					
	a) Apex Co-op. Society	01	-	0 1	-	02
	b) Primary Co-operatives	54	77	37	48	216
9.	Livestock Products Societies	09	03	02	09	23
10.	Weaver Societies	04	02	01	02	09
11.	Other Industrial Societies	11	01	01	03	16
12.	Consumers' Co-op. Societies	41	07	09	07	64
13.	G.P. level Construction Coops	670	732	161	774	2337
Total		**844**	**904**	**211**	**817**	**3013**

(**Source**: Sikkim State Cooperative Society, Gangtok)

In northern west Bengal, around 344 cooperative societies are functional. Out of these, 12 Co-operative Societies / Federations are functional in the entire state (WB), while district level functioning cooperative societies are 10 under KL-India part of Darjeeling and Jalpaiguri districts (Table 4.6). These cooperative societies are coordinated under government rule and functioning under government plans.

Table 4.6 Cooperatives societies in KL-India (Darjeeling and Jalpaiguri)

Functioning heads	**Name of Societies**
Co-operative Societies / Federations of West Bengal	• The West Bengal State Co-operative Bank Ltd. • The West Bengal State Co-operative Union • West Bengal State Handicrafts Co-operative Society Ltd. • West Bengal Co-operative Milk Producers' Federation Ltd. • West Bengal Co-operative Spinning Mills Ltd. • West Bengal State Consumers' Co-operative Federation Ltd. • West Bengal State Co-operative Agriculture and Rural Development Bank Ltd. • West Bengal State Co-operative Housing Federation Ltd. • West Bengal State Co-operative Marketing Federation Ltd. (BENFED) • West Bengal Tribal Development Co-operative Corporation Ltd. • West Bengal State Fishermen's Co-operative Federation Ltd. • West Bengal State Handloom Weavers' Co-operative Society Ltd.
Districts- Co-operative Societies	• Darjeeling District Central Co-operative Bank Ltd. • Jalpaiguri Central Co-operative Bank Ltd. • Jalpaiguri Wholesale Consumers' Co-operative Society Ltd. • Himalayan Co-operative Milk Union Ltd. (Darjeeling District) • Jalpaiguri Co-operative Milk Union Ltd. (Jalpaiguri District) • Darjeeling District Co-operative Union • Jalpaiguri District Co-operative Union • Hill Agricultural Co-operative Marketing Society Ltd. • Jalpaiguri Thana Large-sized Co-operative Marketing Society Ltd. • Jalpaiguri Co-operative Agriculture and Rural Development Bank Ltd. • North Bengal Pineapple Growers Association, North Bengal

4.2.12 Tourism

In Sikkim and Darjeeling, tourism offers wide potential. The Sikkim state, had much restricted entry for the foreigners and outsiders to maintain the special state laws and due to military forces on the international borders but with a view to promote tourism, restrictions on the entry for foreigners into restricted areas have been relaxed. Tourists from abroad can now visit Gangtok, Rumtek, Phodong, Pemayangste and the Yuksom-Dzongri trekking route on the basis of restricted area permits. Estimated a total of 700,011 domestic tourists visited Sikkim in the year 2010 but that declined in the year 2011 (552,453) and henceforth after implementing some relaxation on state laws there was considerable increase in tourist visit in the year 2012 and 2013 (Figure 4.6). Since 2009, there has been a steady flow of international tourists in Sikkim (Figure 4.7). Darjeeling, is famous for its tea production and Himalayan Railways, a UNESCO World Heritage Site. Darjeeling continues to be a popular holiday destination in India, owing to its scenic beauty and pleasant climate. Apart from tourism, Darjeeling is said to comprise six Ts: Tea, Tourism, Teak, Toy train, Tiger Hill, and Trekkers' paradise (Desai, 2011). A phenomenal rise in tourism in Darjeeling can be seen from the rise in record of 3299 International tourists to Darjeeling in 1974 to c. 50,000 International tourists and 5, 00,000 domestic visitors in 2013. Tourism has been generating an annual tourism business of approximately 3500 million (350 crores) Indian rupees. Protected areas such as Singalila National Park and Neora Valley are important trekking destinations. In Jalpaiguri, Dooars and the Terai plains have been important for tourism; various protected areas such as Gorumara, Jaldaphara, Buxa serve as important resource base for tourism. A tourist

visitors' growth in early 2000 and late 2000 in some of the forest areas of north Bengal is provided in Figure 4.8. The Forest Department and the West Bengal Corporation has provided various infrastructural supports for promotion of tourism in different Protected Areas. Singalila National, with its borders with Nepal Park offers an important opportunity for Transboundary trekking tourism in the landscape.

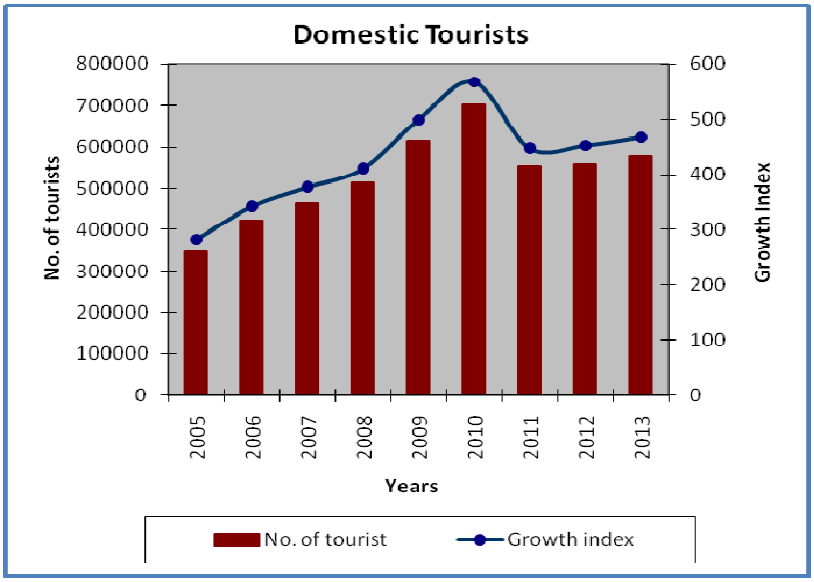


Figure 4.6 Domestic tourists visit in the Khangchendzonga landscape-India (Sikkim)
Graphic representation based on: Government of Sikkim, Department of Tourism website

Jalpaiguri (now with Alipurduar) is potentially rich in tourism. There are various protected reserve areas like national Parks and Tiger Reserves, Gorumara National Park, Jaldapara Wildlife Sanctuary for special attraction for tourists. One can leisure out his time by the sides of the turbulent rivers or simply roll through the Tea Gardens. Apart from these, there are very old temples like the Jalpeshwar and Jatileshwar. Places like Jayanti, Murti, Santale Khola, Mongpong will get any tourists imagination run wild (www.westbengaltourism.gov.in/web/guest/jalpaiguri; accessed on 14.3.2014). Growth and development in tourism invariably leads to economic growth of the landscape, which is manifested in terms of increase in income and employment opportunities, infrastructural growth, improvement in the standard of living, etc. (Joshi and Dhyani, 2009). Tourism, in particular, has contributed in several important ways to the positive performance of the average small economy. KL-India have a potential to become a diversified tourist destination due to its natural attraction and sacred and historical places (Table 4.7) Interestingly, about 30% of tourists who visit Nepal also travel to Sikkim and/or Darjeeling Himalaya (http://www.indiangorkhas.in/2014/01/30-tourists-arriving-nepal-visits.html), thus boost socio-economy of KL, India.

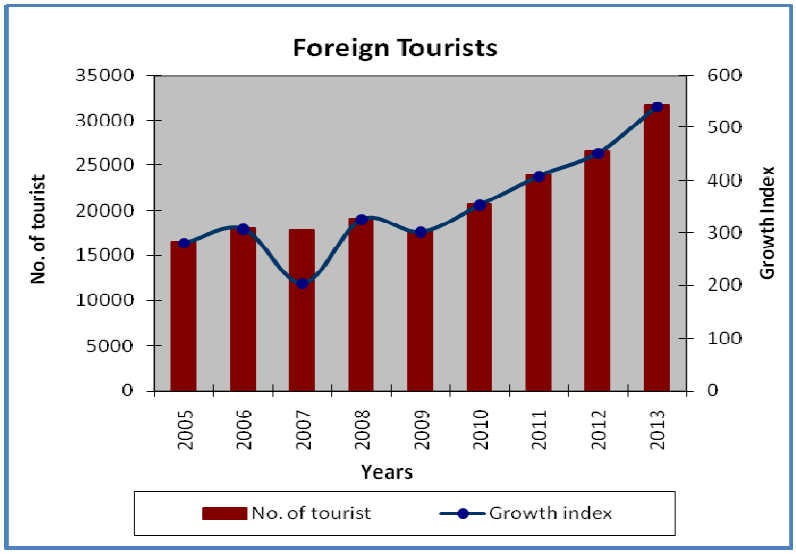


Figure 4.7 Foreign tourists visit in the Khangchendzonga landscape-India (Sikkim)
Graphic representation based on Government of Sikkim, Department of Tourism website

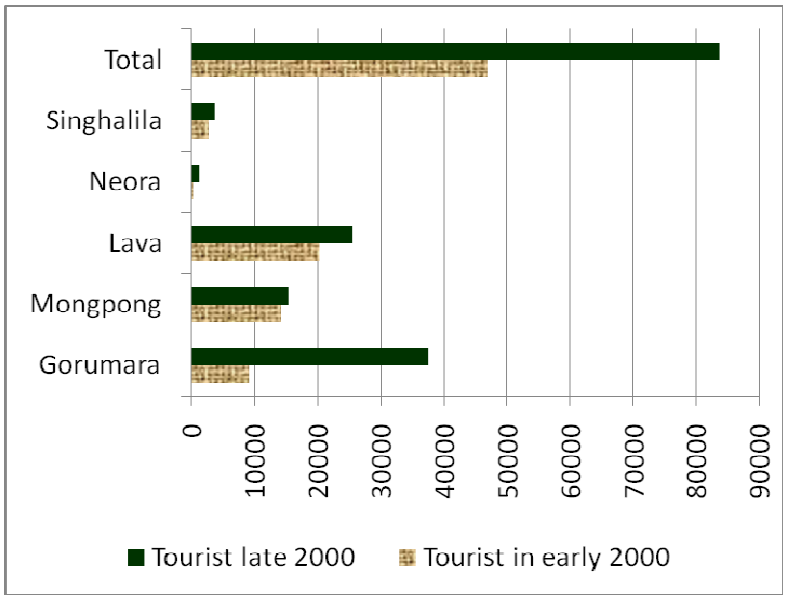


Figure 4.8 Tourism growths in some forest areas of north Bengal (Khangchendzonga landscape-India)

Table 4.7 Tourist destinations with different places in the Khangchendzonga landscape-India

Locations	Places of natural attractions	Sacred places	Historical places
Jalpaiguri	Places like Jayanti, Murti, Chapramari, Jaldapara, Gorumara Jubilee park, and River Karaya	Jogomaya Kalibari, Jalpeshwar, Jatileshwar, Jayanti, Murti, Santale Khola, Mongpong,	Rajbari Palace and Sarojendra Deb Raikat Kala Kendra,
Darjeeling	Tea gardens, Seven points, Tiger hills, Rock garden, Darjeeling-Zoological and botanical park,	Ghoom Monastery, Mahakali mandeer, Japanees temple, Durpen Monestry-Kalingpoong,	Batasia Loop, Tibetian refugee centre, Tenzing rock, Himalayan Mountaineering Institute (HMI), Lal Kothi,

	Kurseong, Dello peak, Mirik lake,		
Sikkim	Tsomgo, Menmecho – Zoological park, Jhakri fall-Gangtok East, Khecheopalri. Karthok-Wast, Yumthang, Chungtang-North, Timi tea garden, Chungthang, Lachung, Peelling, Tari bhir-Namchi	Guru Dongmar Lake-North, Tsomgo Lake-East, Khecheopalri lake-West, Kathok Lake Yuksam- West, Namchi-Char Dham, Sambduptse temple, Ravangla-Bhudha park, Rumtek monastery, Gangtok-Hanuman and Ganesh toak, Phudung Gumpa,	Gangtok-Raja palace, Norbugang Throne in Yuksam, West Dzongri,

4.3. Gender in social fabric

4.3.1 Gender wise Literacy Rates

The rate of literacy in KL India is about 14 per cent over the last 10 years (Table 4.8). In Sikkim, improvement has been shown in both male and female literacy, which is 87.30 % and 76.43 %, respectively. In Darjeeling, male and female literacy are 85.61 and 73.33, respectively. For 2001 census, same figures stood at 80.05 and 62.94. For Jalpaiguri the male and female literacy was 79.95 and 66.23, respectively. Considering the entire landscape, the education status indicates satisfactory remarks.

Table 4.8 Literacy rates by Gender for the KL-India

District Code	State/District	Literacy rate*					
		Persons		Males		Females	
		2001	2011	2001	2011	2001	2011
	SIKKIM	**68.81**	**82.20**	**76.04**	**87.30**	**60.41**	**76.43**
01.	North District	67.21	77.39	75.69	83.03	55.39	69.92
02.	West District	58.81	78.69	66.82	84.86	50.10	72.12
03.	South District	67.31	82.07	74.29	87.06	59.73	79.58
04.	East District	74.68	84.67	81.20	89.22	66.81	79.41
	North Bengal	**134.64**	**152.81**	**152.88**	**165.56**	**115.15**	**139.56**
05.	Darjeeling	71.79	79.56	80.05	85.61	62.94	73.33
06.	Jalpaiguri (with Alipurduar)	62.85	73.25	72.83	79.95	52.21	66.23

Note - *Literacy rate is the percentage of literates to population aged 7 years and above.
(**Source**: Provisional Population Totals, Paper 1 of 2011, Sikkim series 12, Census of India 2011)

4.3.2 Educational Infrastructure

In KL, India, Darjeeling is renowned for its centres of educational excellence, having many quality schools/colleges. The Sikkim distance education is available for students through SMU and Indira Gandhi National Open University (IGNOU). Jalpaiguri also has some of the renowned schools and colleges, which are responsible for raising literacy rate. A list of major educational institutions is provided for the KL, India including Sikkim (Appendix 4.1).

To remove illiteracy from the area there are several primary schools, middle schools and high schools operating at rural and urban area of the landscape. Also, to promote the technical skill among the youngsters, there are several Polytechnic, ITI and Teacher Training institute are functional at district or block level in the entire landscape (Table 4.9).

Table 4.9 Status of primary to high schools in KL-India

No of educational institutions	Sikkim	Jalpaiguri
Primary schools	772	2044
Middle schools	221	30
High schools	164	328
Religious schools	89	NA
Polytechnic, ITI and Teacher Training Institutes	6	-

(Source: HRD Ministry of Sikkim, Economic Survey, 2006-07)
Department of School Education and Literacy and Department of Higher Education Annual Report, 2009-2010 for year 2007-2008

4.3.3 Women employment

Women in the hill society are the backbone of families and in agriculture, as they have to contribute time on the field for harvesting and weeding, taking care of the animals, needing several hours for collecting and carrying the quite heavy loads of fuel wood and fodder and of course running the household and the families. These farming women of the Himalayas barely have four hours of sleep every day, due to the enormous workload (ICIMOD, 1998). In addition, the employment of women as field staff and officers in forest department help improve participation of the grassroots women in micro planning and forest management (Gera 2002). The inclusion of women in forest departments however is also far lower than their contribution to forest-based livelihoods and forest uses. The Indian Forest Service opened to women in 1979, but there are only few women foresters in the government institutions. As of 2002, 81 women officers are working in the senior officers (Forest Service Officer) which constitutes only 3 of the total staffing in the category (Gera 2002). West Bengal had made an affirmative a policy decision to reserve one-third of all government jobs, including those in forest departments, for women (MoEF, 1999 in Gera, 2002, p 11).

4.4 Living Standard of the people

The majority of people living in KL-India exhibits living standard, which conform to the lower to lower-middle classes. According to data provided by the Planning Commission on Sikkim, the proportion of people below the poverty line (BPL) came down from 30.9 percent in 2004-05 to 8.19 percent in 2011-12, a decline of 22 percentage points due to inclusive and equitable development of the entire Sikkim. Sikkim ranked fourth out of six states with the least proportion of poor living below poverty line (Table 4.10).

Table 4.10 Percentage of people below poverty line in Khangchendzonga landscape, India (Sikkim)

Years	All India	Sikkim	Ranking
1973-74	54.88	50.86	16
1977-78	51.32	55.89	9
1983	44.48	39.71	15
1987-88	38.86	36.06	14
1993-94	35.97	41.43	5
1999-2000	26.10	36.55	4

(**Source**: Planning Commission, Government of India)

Per capita income of the Darjeeling district emerge as on top ranking among the all other district of West Bengal, while Jalpaiguri scores 3rd rank (Table 4.11).

Table 4.11 District performance index (in 5 Poverty Alleviation Programmes) in 1998-99, Compared with District per capita income, Rural Monthly Per Capita Consumption and Rural Poverty Ratio for two District of West Bengal (Jalpaiguri and Darjeeling). Also, Darjeeling district has lesser poverty level as compared to Jalpaiguri

Parameters	Darjeeling	Jalpaiguri
Integrated Rural Development Programme (IRDP) Index	0.211	1.000
Training of Rural Youth for Self-Employment (TRYSEM) Index	0.358	0.525
Development of Women and Children in the Rural Areas (DWCRA) Index	0.148	0.284
Jawahar Rozgar Yojana (JRY) Index	0.835	0.742
Employment Assurance Scheme (EAS) Index	0.857	0.754
District Performance Index (DPI)	0.482	0.661
Rank of DPI	5	1
Rank of (Per Capita Income) PCI	1	3
Rank of Rural monthly per capita consumption*	9	13
Rank of poverty rate*	14	5

(**Source**: West Bengal Development Report, Planning commission, Govt. of India, New Delhi 2010)

4.4.1 Drinking water sources

In the KL-India, tap or piped water supply is the main source of drinking water for majority of the population. In the lower part of the landscape (Jalpaiguri and Siliguri), the main source of drinking water is tube-well/hand pump. Other sources of drinking water are well/kuwa, uncovered well/kuwa, spout water, and river/stream. Besides, springs are discharge points of ground water and supply the immediate need of drinking water in mountains. The springs (*Dharo* or *Pandhero* or *Muhan* or *Kuwa*) originating from the underground unconfined aquifer are the crucial water resource for drinking and a key element of human life and well being. The patch of forests that help recharging them surrounds most of these scared springs. Realizing the importance of springs, More than 700 springs have been inventoried and marked out in Sikkim. While, in Darjeeling mountains area, there are 24 natural springs recorded and most of the people draw their safe drinking water.

4.4.2 Health Profile

There has been tremendous improvement in health of the people with due regard to the establishment of various hospitals and health visionary mission programs that are being successively carried out in KL India. The Table 4.12 depicts the health profile of Sikkim.

Table 4.12 Health Profile of a part of Khangchendzonga landscape, India (Sikkim)

Sl. No.	HEALTH INDICATORS	KL-India	INDIA
1.	Crude Birth Rate (SRS 2008)	18.4*	22.8
2.	Crude Death Rate (SRS 2008)	5.2	7.4
3.	Infant Mortality Rate (SRS 2008)	33**	53**
4.	Population below Poverty line (%)	36.55	26.10

*per thousand persons **per thousand live births [**Source**: Census of India 2011 Sample Registration System (SRS), 2008]

4.4.3 Major energy sources

In the KL-India, LP gas is the major source of energy followed by electricity, firewood, cow dung, and biogas. Landscape has sufficient availability of LP gas and electricity in urban and even in the rural area but the farmers and people living in remote areas are dependable on fuel wood. Alternative Energy Technologies (AET's) like biogas plants and stoves, wind-solar hybrid system, solar systems, micro hydro power project etc. have increased. Only Sikkim is consuming about 20,000 tons of fuel wood annually to dry the harvested crop of large cardamom (Roy et al. 2013). Figure 4.9 provides an insight on the fuel wise breakup of installed capacity in the state with respect to AET's. In addition to above, all India Coordinated Research Project on Renewable Energy Sources (AICRP-RES) along with the help of Coordinated Agricultural Engineering and Post-Harvest Technology (CAEPHT) centre of the AICRP on RES have helped to install projects at many villages around Ranipool, Sikkim.

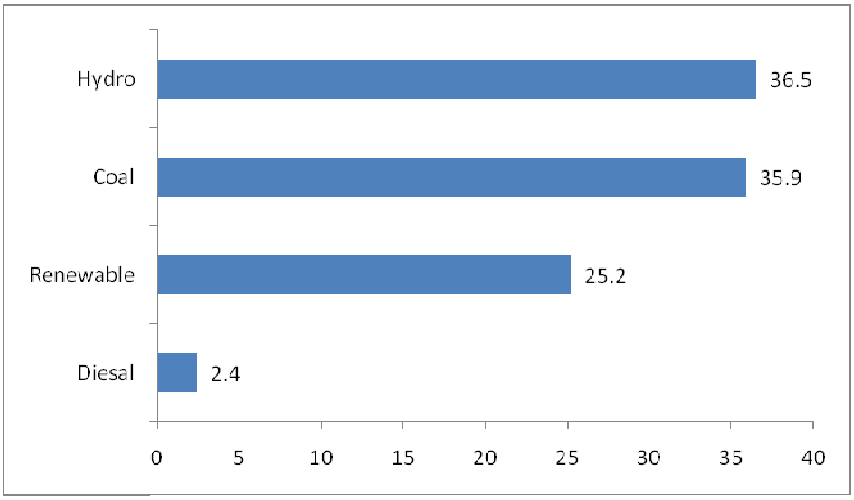


Figure 4.9 Fuel wise break-up of installed capacity of part of landscape (Graphic representation based on Roy *et al.*, 2013)

4.5 Transportation Infrastructure (Roads, railways and airports)

The Khangchendzonga Landscape-India region can boast of a robust transportation infrastructure in the form of surface and air travel where most of the major towns and large villages are interconnected in the transport network facilitating practical means for people and goods movement. Sikkim has a total road length of 2,873 km with a road density of 41 km per 100 Km^2 (Table 4.13). The state Public Works Department (PWD) and the Border Roads Organization (BRO) maintain the roads. The Sikkim Nationalized Transport (SNT) operates buses and trucks across the state, carrying 60 per cent of the state's total freight and covering 43 routes. Rail connectivity is being created between Rangpo and Siliguri in West Bengal. Airport

construction is underway in Pakyong. Helicopter services are available from Bagdogra (West Bengal) to Gangtok.

Table 4.13 Transportation types in the Himalayan part of Khangchendzonga landscape, India

Locations	Road/railway type	Length (km)
Sikkim	National Highways (NH)	62
	State Highways	184
	District roads	1,695
	Border roads including NH	894
Darjeeling	National Highway	111
	State Highway	191
	Main District Highway	79
	Rail line	111

[**Source**: Survey 2006-07, Government of Sikkim; Ministry of Road Transport and Highways, 2007-08; Brief Industrial Profile of Darjeeling district, west Bengal MSME-Development Institute Kolkata (Ministry of MSME, Govt. of India, accessed 27 June, 2014]

Darjeeling has road and railways network (111 km length) for transportation. The Darjeeling Himalayan Railway, a World Heritage Site by UNESCO in 1999, is a 600 mm (2 ft) narrow-gauge railway. This was to serve as a model for similar developments in many parts of the world (World Heritage Committee: Report of the 23rd Session, Marrakesh, 1999). Bus services and hired vehicles connect Darjeeling with Siliguri and Darjeeling The nearest airport is in Bagdogra, located 90 km from Darjeeling. Jalpaiguri is well connected by rail, road and air from any part of the country. The New Jalpaiguri railway station is the nearest railway station for the people of neighbouring state of Sikkim and Darjeeling district.

Chapter 5A: Biodiversity and Ecosystem Services

5A.0 Background

It is well acknowledged fact that the biodiversity is diminishing worldwide at an at an alarming rate; and the science and management have so far failed to either understand it or halt this ever-increasing onslaught. The World Wide Fund for Nature and the Global Environmental Facility initiated the *Root Causes* project in an effort to explore the socioeconomic and political drivers of habitat degradation and species loss and in the process the document, *The Root Causes of Biodiversity Loss* (Wood *et al.*, 2000) came up. Most of the research studies address the immediate causes of biodiversity loss, such as agricultural expansion, logging, and hunting and suggest an approach, which is based on the belief that preventing biodiversity loss requires policy makers to understand and mediate the distant and diffuse forces that produce these proximate causes (Geist and Lambin, 2002). Nearly half of the world's ecosystem services are being degraded (15 out of 24 services are in a state of decline) and used unsustainably (Millenium Ecosystem Assessment (2005a); this is likely to owe large negative impacts on future human welfare. With three quarters of loss occurring in the last two centuries, in the last three centuries, global forest has reduced by 40 %. Many remaining forests have been under severe ruined (Geist and Lammbin, 2002; Millenium Ecosystem Assessment, 2005b). Fundamental social processes such human population dynamics, agricultural policies, monetization of economy, marginalization of farmers, formal pro-deforestation policies and subsidies (for colonization, agriculture expansion, logging, etc.), policy failure associated with mismanagement and corruption), and ambiguous property rights have been identified as the main drivers of deforestation (Geist and Lammbin, 2002) and consequent loss of biological resources (Badola and Aitken, 2010).

The mountain ecosystems besides their fragility due to compression of climatic zones over small range display high biodiversity (Korner, 2009). One quarter of terrestrial biodiversity, i.e., 32 % of the protected areas (approx. 1.7 million Km^2), and nearly half of the world's biodiversity hotspots are located in the mountains. About 1.2 billion of world's population lives here and as reservoirs or "water towers" they serve nearly half of the world's population. Nearly 90 % of the global mountain population lives in developing countries. The mountains offer numerous ecosystem services. In recent years, various factors both anthropogenic and natural, such as land-use pressure, forest destruction, population growth and disturbance, globalization, overgrazing, inappropriate cropping practices and property regimes, institutional fallacies and climatic perturbations have tremendously affected the integrity of these ecosystems and their perpetual flow services (Millenium Ecosystem Assessment 2005a). For planning conservation and sustainable resource utilization, assessment of biodiversity is realized as an important tool, providing valuable guidelines for the prioritisation of important landscape including protected areas (Badola, 1998; 2009, Sharma *et al.*, 2007; Badola and Aitken, 2010).

5A.1 Biological diversity in KL, India

The proposed Khangchendzonga landscape (India) falling within the eastern Himalayan region, is a part of one of the 34 'biodiversity hotspots' (Mittermier *et al.,* 2004). The KL

provides habitat for more than 160 mammal species, 550 bird species, 600 butterfly species and many threatened and endangered species (Chettri *et al.,* 2008). Earlier known as the *Cradle of Flowering Plants* (Takhtajan, 1969), eastern Himalaya known to have a largest number of endemics and Schedule I species than recorded anywhere in the country (McKinnon and McKinnon, 1986). This region is a meeting ground of Indo-Malayan and Sino-Indian bio geographic realms as well as Himalayan and Peninsular Indian elements.

Within KL India, the Eastern Himalayan group Sikkim and Darjeeling hills depict a more or less similar biotic richness with those of Arunachal Pradesh and Bhutan. This is exhibited through the presence of several of flagship and sensitive faunal species, viz. *Ailurus fulgens* (Red Panda), *Capricornis thar* (Himalayan Serow), *Neofelis nebulosa* (Clouded Leopard) and floral species, viz. the orchids, medicinal plants and rhododendrons, etc. The KL has many important biodiversity elements from the north-west Himalaya, viz. *Hemitragus jemlahicus* (Himalayan Tahr) and *Pseudois nayaur* (blue sheep) and *Uncia uncia* (Snow Leopard), etc. The foot-hills of KL, India, where many of the high value and conservation sensitive taxa, including Asian Elephant (*Elephas maximus*), on and off plunge to severe anthropogenic dangers, further compounded the situation for seeking greater conservation concern than ever before. The KL India for its great altitudinal amplitudes offers unique features which cover along tropical to alpine vegetation zone within a short span, extending from tropical lowland at 40 to 8500 m above sea level, constitutes the extreme topographic variations that provides highly suitable micro-climatic niches to flourish the habitat diversity (Badola and Subba, 2012; Pradhan and Bhujel, 2000).

It is estimated that the entire KL India may offer a flowering plant diversity of about 5000 species. IIndividually for Sikkim, there are over 4,500 species of plants including orchids and rhododendrons are the important elements of the regional flora. For monocotyledons plant in Sikkim alone 1186 species are recorded. About 8 species of Tree Ferns and 11 species of Oak are also significant floral uniqueness of KL, India biodiversity. Possibly 80-100 reptile species, 150 mammals, over 30 amphibians and about 50 fish and 700 butterflies and numerous moth species further make the region more significant for biodiversity. Owing to the great difference between the climatic conditions of the northern hills (Eastern Himalaya) and southern parts (foothills stretching down to the plains), Darjeeling District harbours a rich variety of flora (2,439 species) and fauna (4,166 species) (Alfred *et al.*, 2004), which includes 10 species of lichens, 31 rhododendrons, 23 Bamboo and 85 mammal species. Comparative account for various biotic diversity available for KL, India with those of other important biodiversity hot-spots depicts that in spite of having small geographical areas of Sikkim and Darjeeling Himalaya, their biotic richness is comparatively very high (Table 5A.1).

Table 5A.1 Comparative richness in biotic diversity in Khangchendzonga landscape, India and other regions

Biotic Groups	Species richness			
	Eastern Himalaya			
	Sikkim Himalaya	Bhutan Himalaya	Arunachal Himalaya	North Bengal
Flowering plants	4500	5500	5000	4000
Rhododendrons	38	46	61	16
Orchids	527	579	601	453
Ferns	480	411	305	416
Paddy landrace	48	280	182	6
Maize landrace	45	80		12
Bamboo	25	31	50	23
Birds	574	670	600	210
Mammals	125	200	85	104
Butterflies	689	850	183	
Fishes	48	41	131	71

The KL, India represents a huge richness of taxa within different biotic groups and comparable to global and national status; a summary of the same is given in Table 5A.2.

Table 5A.2 Representation of biotic groups across regions for Khangchendzonga landscape, India (Sikkim)

Biotic groups	Taxa representation		
	Sikkim Himalaya	% representation for India	% representation for World
Ferns	480	48	4.0
Lichens	506	22	2.8
Orchids	527	57	3.1
Primulas	58	57	13.0
Rhododendrons	38	42	3.8
Bamboo	30	18	1.7
Amphibians	50	19	0.7
Birds	574	45	5.7
Butterflies	689	50	0.4
Fishes	48	7	0.4
Mammals	125	31	2.5
Reptiles	88	17	0.9

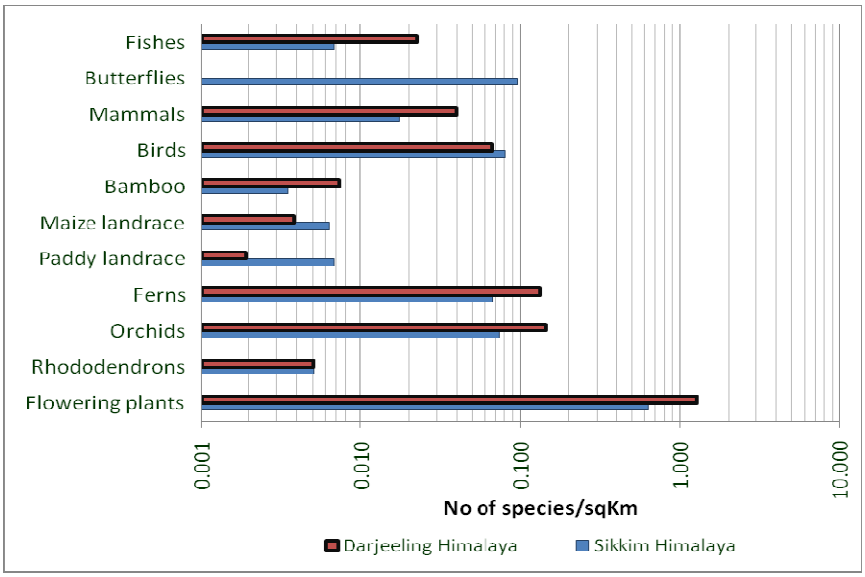


Figure 5A.1 Number of species per Km² in Khangchendzonga landscape, India (logarithmic scale)

On taking the mountain parts of KL India, the Sikkim and Darjeeling Himalaya, and comparing with the two biodiversity-rich areas of eastern Himalaya, Bhutan and Arunachal Himalaya, the species diversity per unit area emerged very high, relatively, in majority of cases (Figure 5A.1 and Table 5A.3).

There is lack of cumulative data for Jalpaiguri area, except for scattered information for some parts. In the chapter elsewhere, details on specific biota groups of entire landscape, including Jalpaiguri have been provided.

Table 5A.3 Comparative richness in biotic diversity in KL- India and other regions

Biotic groups	**Species richness: no of species per Km²**			
	Sikkim Himalaya	**Bhutan Himalaya**	**Arunachal Himalaya**	**Darjeeling Himalaya**
Flowering plants	0.634	0.143	0.056	1.270
Rhododendrons	0.005	0.001	0.001	0.005
Orchids	0.074	0.015	0.007	0.144
Ferns	0.068	0.011	0.003	0.132
Paddy landrace	0.007	0.007	0.002	0.002
Maize landrace	0.006	0.002	0.000	0.004
Bamboo	0.004	0.001	0.001	0.007
Birds	0.081	0.017	0.007	0.067
Mammals	0.018	0.005	0.001	0.039
Butterflies	0.097	0.022	0.002	0.000
Fishes	0.007	0.001	0.001	0.023

5A.2 Forest and Vegetation types

The landscape has a unique feature covering tropical to alpine vegetations within a span of 100 km vertical distance, which constitutes the extreme topographic variation that provides diversity in the micro-climatic conditions and the habitat types (Department of Forest, Government of Sikkim 1997; Pradhan and Bhujel, 2000; Badola and Subba, 2012). On the basis of altitudinal zones, the KL (India) can be broadly categorized into a) tropical, b) sub-tropical, c) warm temperate, d) cool temperate, e) sub-alpine and f) alpine types (Figure 5A.2). Khangchendzonga landscape – a part of the eastern Himalayan ecoregion is actually a complex of three distinct ecoregions, the Eastern Himalayan broad-leaved and conifer forests, the Eastern Himalayan Alpine meadows and the Terai-Duar savannas and grasslands (WWF and ICIMOD, 2001; Wikramanayake *et al.,* 2002). The Eastern Himalayan broad-leaved and conifer forests are important for both their rich species' diversity and species' endemism. This ecoregion represents a band of temperate broad-leaved forest between 2,000 and 3,000 m.

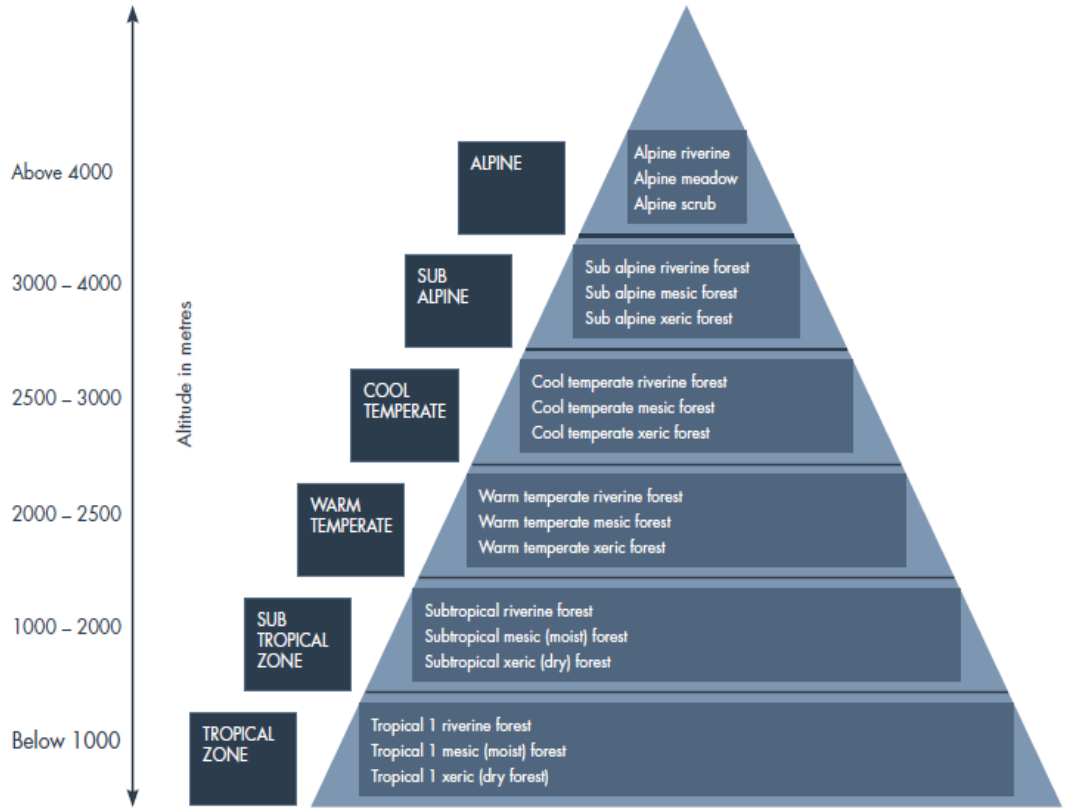


Figure 5A .2 Altitudinal zonation and dominant forest types in proposed Khangchendzonga landscape, India (Graphical representation by Chettri, N, ICIMOD)

In general, the complete forest types with characteristic species structures have not been attended as cumulative picture for the entire landscape, though, the scattered information is available. In-spite of that, the cumulative picture is tried for the KL, India (Appendix 5A.1).

5A.3 Floristic diversity and uniqueness

The KL (India) has attracted the attention of many botanists from different parts of the world over couple of centuries. The eminent botanists like J. D. Hooker (pioneer during 1848 – 49; Hooker 1853), C. B. Clarke, G. King, T. Anderson, W. W. Smith, G. H. Cave, J. M. Cowan, R. Pantling, G. A. Gamie, D. Prain, B. Osmaston, I. H. Burkill and others visited the landscape. However, W. Griffith was perhaps the pioneer plant collector, especially in Sikkim. Profoundly, Hooker was also a naturalist and he has given natural history accounts on some faunal species in the region. Smith and Cave (1911) detailed about the floral world of high altitude zone of KL, India, especially focussing on the Zemu and Llonakh valley of Sikkim. In recent times, some studies added significant knowledge on floral status of KL, India, especially on Rhododendrons (Pradhan and Lachungpa, 1990); Orchids (Lucksom, 2007); Ferns (Kholia, 2010), ethnobiology (Pradhan and Badola, 2008; Badola and Pradhan, 2013), etc). However, 1580 species of vascular plant species was reported from Khangchendzonga National Park by Maity and Maiti in 2007, which included the 1,463 angiosperms (spread along 1207 dicotyledonous and 256 monocotyledonous species representing 598 genera and 138 families), besides 86 Pteridophytes and 11 gymnosperms. Many modern day studies specially focused on the traditional knowledge of local tribes in the KL, India, for example, the ancient tribe, Lepcha (Pradhan and Badola, 2008) and Limbu (Badola and Pradhan, 2013) and other communities (Chettri, 2005; Subba, 2009; Idrisi *et al.*, 2010; Yonzone *et al.*, 2012; Das *et al.,* 2013, etc.).

5A.3.1 Angiosperms

For the entire KL (India) no cumulative data availability is available; except scattered information, that too limited for many parts for providing any combined inventory. For Sikkim alone, the flowering plants are represented by about 4458 species (Singh and Chauhan, 1997), belonging to 1371 genera of 197 families. Darjeeling has high plant species diversity, respresenting to have an estimated one -seventh of the flora of the country, as it harbours about 4000 species of flowering plants under 160 families. Darjeeling and Jalpaiguri and adjoining territory in Eastern Nepal, Sikkim and Western Bhutan display wide-ranging floral resources as this region is at the confluence of several bio geographic realms, e.g. Mediterranean, Ethiopian, Indo-Malayan, Sino-Japanese, Palaearctic and Oriental. For Jalpaiguri district there is limited information for angiosperm plants available.

5A.3.2 Rhododendrons

Arunachal Pradesh represents the largest number of rhododendron species , i.e. 61 (Mao *et al.*, 2001), of which 9 species and 1 subspecies are endemic., Sikkim has 3 species and 1 subspecies as endemic (Paul *et al.*, 2005). In KL, India, 38 species of rhododendrons are reported; in which 16 have common presence for north Bengal (Darjeeling hills). Population discoveries for *Rhododendron niveum* and *R. maddenii* are appeared in recent years (Badola and Pradhan, 2010a, 2010b). Appendix 5A.2 provides status of rhododendrons in KL, India. In majority of cases, either natural rarity or anthropogenic factors are identified as the main factors of endangerment (Pradhan and Lachungpa, 1990; Singh *et al.,* 2003; Badola, 2010a; Badola and Pradhan, 2010a). Conservation efforts are there in KL, India (Badola *et al.,* 2006.

Rhododendron arboreum, one the most fascinating and climate change indicator species of Khangchendzonga landscape (Photo: HK Badola)

5A.3.3 Gymnosperms

Over a dozen species of gymnosperms are reported in different parts of KL India (Appendix 5A.3). *Cephalotaxus* sp. is found in Darjeeling and Cycas sp. in all the three parts of KL (India). However, *Thuja orientalis L.* (Cupressaceae) is also domesticated in Sikkim. *Abies densa* reaches above 3000m altitude and develops good forest system. Individually, Sikkim has maximum number of species in natural habitats, i.e. 11 species, whereas, the Darjeeling records 06 species, and the Jalpaiguri (now bifurcated) represents 04 species of gymnosperms.

5A.3.4 Orchids

Worldwide, the Orchid are represented by an estimated 19,500 species from 750 genera; 1200 species found in India (Lucksom, 2007), KL (specially Sikkim Himalaya) is one of the richest hot-spots for orchid diversity in Indian Himalaya (Figure 5A.3 with over 523 species, which can be compared to trans, north-west and west Himalayan regions as riches. Sir J.D. Hooker (Hooker, 1888-1890) well over one and quarter of a century explored the orchid richness of the KL, India and after a long lapse of time; many of the modern botanists documented the same (Pradhan, 1976; Pradhan, 1979; Lucksom, 2007; Yonzon *et al.,* 2012). Owing to environmental degradation and widespread habitat fragmentation, orchids are categorized as an endangered group (Butola and Badola, 2006; Badola and Aitken, 2010). For north Bengal part of KL, India (Darjeeling hills), Yonzon *et al.,* (2012) reported 283 orchid speciesAnother study highlighted epiphytic diversity of 218 Orchid species under 53 genera in Darjeeling Himalaya (Yunzone *et al.,* 2011).

An orchid of temperate part in Khangchendzonga landscape, India (Photo: HK Badola)

5A.3.5 Bamboos

With enormous global diversity and distribution of about 1250 species within 75 genera of bamboos (family Poaceae; Yang *et al.,* 2004) have taken a great place for their multiple utility and as economic source (Badoni *et al.*, 1989). The KL, India supports over 31 species of bamboos (Tamang *et al.,* 2013; Appendix 5A.4). As per their distribution along the altitude zone, the altitudinal belt, 500-1000 and 1000-1500m found to be most suitable growing conditions for highest bamboo species diversity (Figure 5A.4), with 21 and 23 species, respectively.

5A.3.6 Pteridophytes

P. N. Mehra (1907-1994), the first Indian taxonomist who collected the (ferns) Pteridophytes from Darjeeling and Sikkim area of landscape with his extensive surveys made during 1936 to 1939, and again his studies on the Pteridophytes from this area in 1953, contributed valuable works on the Pteridology (Kholia, 2010). Based on recent collections made by Kholia (2011) and scrutiny of various previous works (Botanical Survey of India; CAL and BSHC), about 500 taxa of ferns have been explored (480 species and 20 subspecies). Following Holtum's splinter genera of *Thelypteridaceae* of total 451 species including total 19 sub-species are found (Appendix 5A.5). Among these, 3 families, 5 genera and 31 species are fern allies (Appendix 5A.6). Kholia (2010) also mentioned that *Selaginellaceae* is the largest fern ally family represented by about 18 species of *Selaginella*,. Darjeeling has 300 fern species, including allies (Seleginiallis, Lycopodium and Equisetum). Of these about eight species are tree ferns.

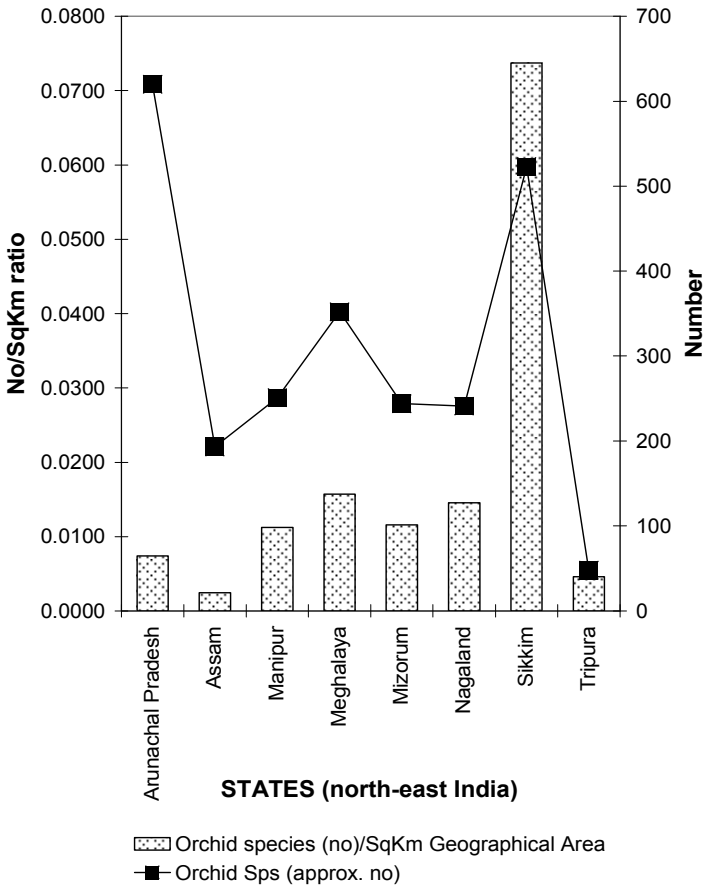


Figure 5A.3 Number of orchid species in relation to geographical area of respective states in north-east Indian Himalaya (**source**: Badola and Aitken, 2010)

5A.3.7 Bryophytes

For KL India, 627 species of moss and 277 species of liverworts are reported (Dandotiya *et al.*, 2011). The moss species are further worked out as 464 species for Sikkim and 422 species in Darjeeling, whereas, only three species are in record for Jalpaiguri (Dandotiya *et al.,* 2011). For liverworts, KL, India is rich in diversity exhibiting 277 species; Sikkim accounted for 267 liverworts and Darjeeling for the 58-liverwort species; however, no data is available for Jalpaiguri. Interestingly, 142 species exclusively reported for Sikkim, whereas, Darjeeling has exclusive diversity of only seven species. Amongst the threatened taxa, *Takakia ceratophylla* is considered Vulnerable and *Pogonatum leucopogon* is endemic to Darjeeling and Kerala; also, the *Ptychomitrium indicum* is endemic to Darjeeling, Calcutta, Eastern Ghats, (Shervaroy hills), Sikkim (Divyadandotiya *et al.*, 2011). *Ditrichum apophysatum* and *Ditrichum darjeelingense* are endemics to Darjeeling, Himalayas and *Ditrichopsis clausa* and *Oreoweisia brevidens* as Sikkim Endemic are important bryophytes; however, Ditrichium *laxissimum* and *Trematodon hookeri* are endemic to both Sikkim and Darjeeling (Divyadandotiya *et al.,* 2011).

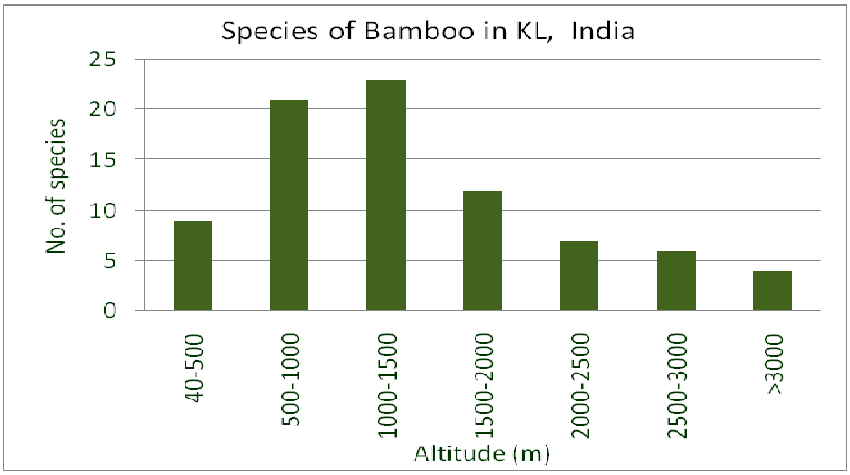


Figure 5A.4 Bamboo species distribution along altitudinal zones in Khangchendzonga landscape, India (Analysis and graphical representation by GBPIHED is based on Tamang *et al.,* 2013)

5A.3.8 Lichens

The lichens play an important role in forest establishment as the primary producers having crucial linkages to nutrient cycling and forest food webs (Jovan, 2008) and for establishing vegetation in bare area as classic example of symbiosis. KL, India is the rich biome for lichens and liverworts (Ramakantha *et al.*, 2003). The lichens of Darjeeling district are mainly foliose or fruticose form. Out of 2450 species, represented in India, the KL (India; largely the Sikkim and Darjeeling) are recorded with 480 species (Kumar *et al.,* 2011). However, for Sikkim, Sinha and Ram (2011) reported 506 species of Lichens.

5A.4 Fungi

Fungi are among the most diverse, important and universal groups of organisms on earth and have high potential for indicating the holistic natural value of a habitat in a way that integrates inputs like historical, nature management, biodiversity, and conservation aspects (Coutecuisse, 2001). Acharya *et al.,* (2010), have reviewed Agaricales with 151 species belonging to 42 genera (Appendix 5A.7). The number of representative species under each of the 42 genera varied with 13 genera having a single species each, and the genera *Mycena* and *Collybia*, having 20 and 16 species respectively (Appendix 5A.4). The evenness of species distribution/genera is significantly low which supports higher diversity, assemblage and distribution of species. Maximum number of genera (31) supported species richness of 1-3/genera and only two genera had more than 10 representative species, which indicates higher Agaricales diversity

5A.5 Faunal diversity

The KL (India) is rich in biodiversity and a great proportion of species are threatened or endemic to the region (Chettri, 2000; Chettri *et al.*, 2008; Rastogi *et al.*, 1997; Arrawatia and Tambe, 2011, Badola and Subba, 2012). Some of the flagship found in India part of KL include, Snow Leopard (*Uncia uncia*), musk deer (*Moschus chrysogaster*), Himalayan black bear (*Ursus thibetanus*) and Tibetan Gazelle (*Procapra picticaudata*) in the high mountains, red panda (*Ailurus fulgens*), takin (*Budorcas taxicolor*) and clouded leopard

(*Neofelis nebulosa*) in mid hills and Bengal tiger (*Panthera tigris*) and Asian Elephant (*Elephas maximus*), in lowlands. Birds can be used as very appropriate bio-indicators (Urfi, 2011) suggesting status of biodiversity in general (Bhatt and Joshi, 2011; Basnet and Badola, 2012). The exhaustive information on the birds of KL, India, and specially targeting Sikkim is known (Ali, 1962). In recent years, some studies appeared on bird diversity from ecological point of view (Chettri, 2000; Acharya and Vijayan, 2010; Acharya *et al.,* 2011a; Basnet and Badola, 2012). For Sikkim alone over 550 bird species are reported. Some 48 different species of fishes have been reported from Sikkim. Studies are there for other animals and lower group from different parts of KL, India.

Spotted dove in Khangchendzonga landscape, India (Photo: Kumar Basnet)

Butterflies in KL, India are known across the world. A detailed study offers extensive information on the butterflies of Sikkim (Haribal, 1992). The Sikkim houses 700 different butterfly species, almost half of the total number of butterfly species found in the whole of Asia.

5A.6 Overview on faunal diversity

The literature revealed that the documentations of species are sporadic, scattered and mostly concentrated in protected areas. Mammals and birds are some of the widely documented taxa and majority of the protected areas of Sikkim and north Bengal have reported a wide range of species richness with highest number of mammals from Mahananda Wildlife Sanctuary followed by Buxa Tiger Reserve, Gorumara National Park and Khangchendzonga Biosphere Reserve. Likewise, many of the lowland protected areas of north Bengal was found to be rich on bird species and the highest number of bird species were reported from Buxa Tiger Reserve and Jaldapara National Park (Appendix 5A.8). The review records showed that there are only a few protected areas, which have documentation for other taxa such as butterflies, reptiles and fishes (Appendix 5A.8).

5A.7 Geographical distribution of the study sites

A total number of 204 studies were reviewed for KL India. However, this is indeed not an exhaustive list and many of the past work are not accessible or overlooked. Among the

204 studies documented, 54 % are from North Bengal and 40 % in Sikkim. About 6 % of the studies have documented their common study sites (Figure 5A.5). In North Bengal, majority of the studies are from Darjeeling district followed by Jalpaiguri district.

5A.8 Publication trend

The first study in our list of publication from KL India dates back to Tickel (1843). Since then until 1980s, very limited researches related to fauna have been documented. Over a span of 140 years (1840-1980), only 36 documents are recorded. However, the research and documentation increased considerably after 1980, during which 82% of the recorded research is documented. Every year, the annual number of studies in the KL appears to become progressively higher. For instance, from 2001 to 2010, a total of 80 studies (8 studies per year) are documented and during 2011 to 2013 a total of 32 studies are carried out (16 studies per year) (Figure 5A.6).

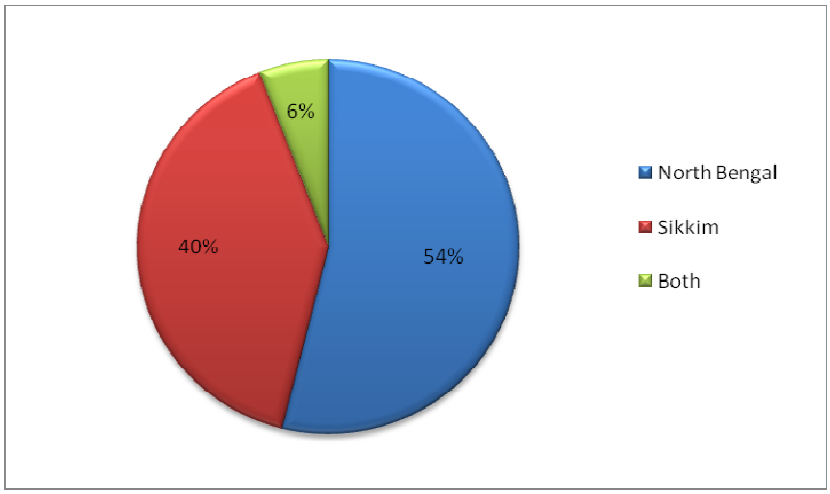


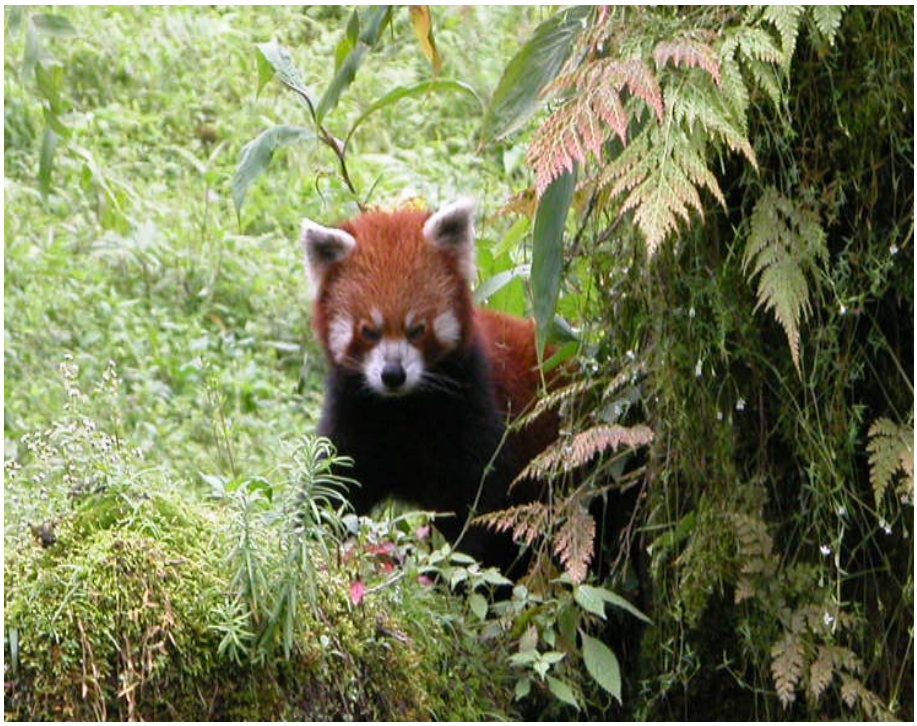
Figure 5A.5 Geographical distribution of the studies in KL (India)

5A.9 Publication based on thematic subjects

Among the 204 publications referred, mammals are the most studied taxa that account 42 % of the total studies (Figure 5A.7). Among the mammals, red panda (*Ailurus fulgens*) is the most studied species, with of 15% publications relating to mammal studies from the Indian part of KL. Other mammals that are studied include Asian Elephant (*Elephas maximus*), tiger (*Panthera tigris*), clouded leopard (*Neofelis nebulosa*), wild dog (*Cuon alpinus*), Assamese monkey (*Macaca assamensis*), Tibetan wild ass (*Equus kiang*), Sikkim vole (*Neodon sikimensis*), gaur (*Bos gaurus*), Himalayan goral (*Naemorhedus goral*), Himalayan serow (*Capricornis thar*), blue sheep (*Pseudois nayaur*), several ungulates, primates and rodents. In the recent years, there has been increasing trend of new studies on the mammals of Sikkim (Bashir *et al.,* 2011; Bhattacharya *et al.,* 2011; Ganguly-Lachungpa, 1996; Changchani *et al.,* 2010; Sathyakumar *et al.,* 2011) and in North Bengal (Bahuguna *et al.,* 1998; Pradhan *et al.,* 2001; Bahuguna and Mallick, 2004; Singh 2012; Borthakur *et al.,* 2013; Mallick, 2010a; 2010b; 2013).

Avifauna (bird) is the second highly studied taxa (24% of total faunal studies). The birds were recorded from as early as the 19th century and many accounts on birds of Sikkim, Darjeeling and Jalpaiguri are available (see Chettri *et al.,* 2001). In the recent years,

numerous studies on bird ecology and altitudinal distribution patterns have been reported from Sikkim (Chettri *et al.,* 2001; Chettri *et al.,* 2010; Acharya 2008; Basnet and Badola, 2012; Acharya *et al.,* 2011a; Acharya and Vijayan, 2010) and north Bengal (Allen *et al.,* 1997; Khaling *et al.,* 1998; Sivakumar and Prakash 2004; Sivakumar *et al.,* 2006; Roy *et al.,* 2011). Insects accounted for 14 % of the total faunal studies. Majority of the studies are concentrated on spiders (35% of the total studies on insects) and are mainly from the north Bengal (e.g. Nandy *et al.,* 2004; Sahga and Raychaudhury, 2006; Ghosh and Sheela, 2008). Butterflies, beetles, diptera species are other insects that are documented from the KL (e.g. Chettri, 2000; Acharya and Vijayan, 2011; Arrawatia and Tambe, 2011; Sengupta *et al.,* 2014). Studies on reptiles are limited (i.e. 7%), while about 13% of the studies are miscellaneous (Figure 5A.7). These include studies related to biodiversity as a whole, fishes, amphibians and livestock (less than five studies under each subject).



Red panda (*Ailurus fulgens*)- the endangered and flagship faunal element in Khangchendzonga landscape, India (Photo: HK Bdola)

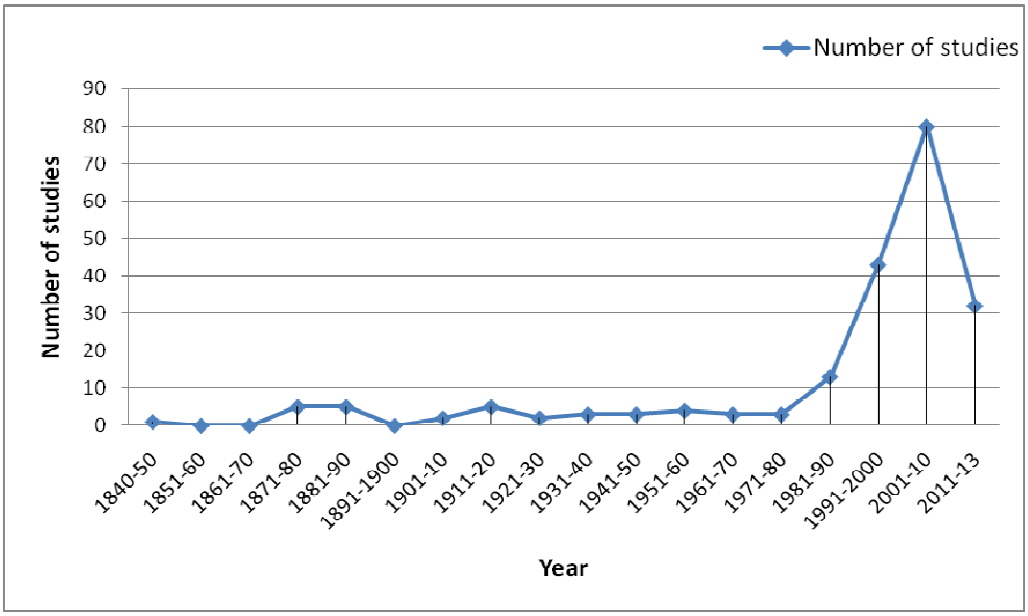


Figure 5A.6 Temporal trend of the studies in Khangchendzonga landscape, India

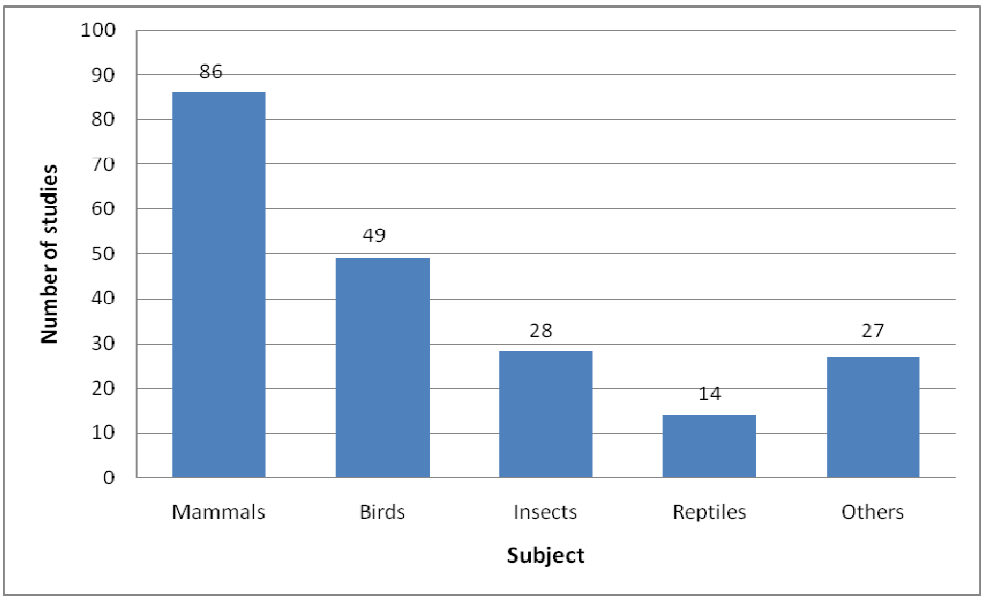


Figure 5A.7 Number of studies based on the thematic subjects from KL, India

5A.9.1 Nature of publications

Species ecology focuses 53 % studies, mainly concentrated on Red Panda, Tiger, Asian Elephant and a few pheasants. This is followed by documentation of species in the form of checklist (25 %). Individual species description comprises only 9 %, followed by sighting records i.e. 5 %. Only 1 % of the research is related to periodic monitoring on range extension (Figure 5A.8). About 7 % of the studies belong to the category other than these. For instance, general overview, policies and management issues etc. Researches on fauna indicate that despite carrying a long history of being a landscape of global

significance, it has received relatively poor attention from scholars around the world. Majority of protected areas are still to be explored for their biodiversity. Studies are becoming progressively higher since 1980's which indicates the growing interest of people towards the landscape. Analysis demonstrates that studies in KL covers varieties of subjects nevertheless, the focus on some of the subjects is scanty. For instance, mammals, especially red panda in the temperate and sub-alpine forests, Asian Elephant and tiger in the tropical forests are mostly studied subjects but with major gaps on systematic research on their ecology (except a few), whereas the invertebrates other than butterflies and spiders appear to be entirely neglected.

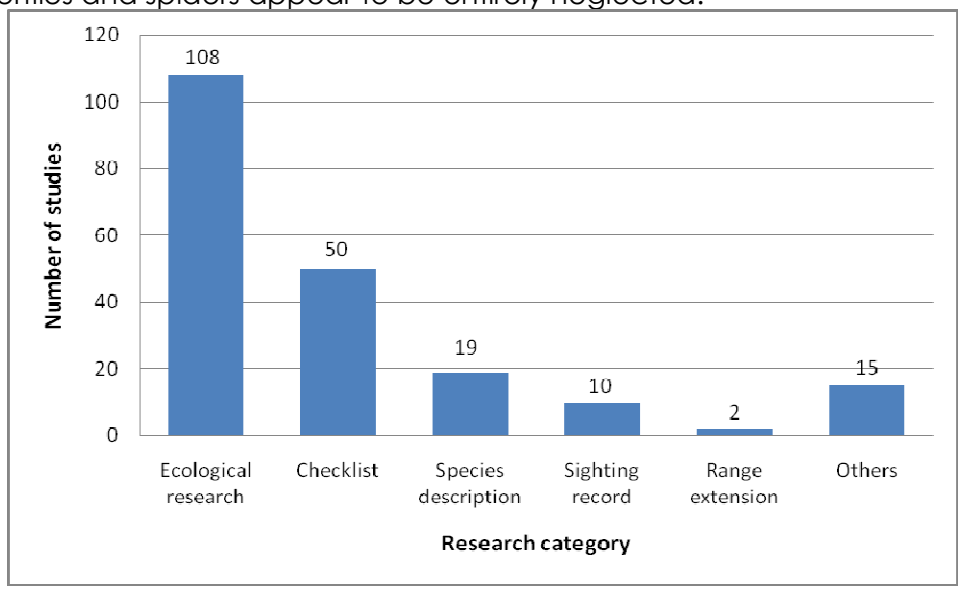


Figure 5A.8 Research type of the studies from KL, India

Approximately, 72 % of West Bengal's mammal diversity is exhibited in Darjeeling Himalaya (Chakraborty and Agrawal, 1993), of which a large number of species are not common to other ecosystems of west Bengal. For north Bengal part of Darjeeling district, 128 species of mammals are reported (Agrawal *et al.,* 1992), whereas, reporting of 180 species (Mitra, 2004) and 126 species of mammals (Sanyal *et al.*, 2007) are in literature. Sanyal (2007s) further reports the existing mammalian species, 71 species are recorded in Kalimpong Forest Division and 65 species are reported from Neora Valley National Park. Carnivora is the most diverse order (32.32 %), followed by Rodentia (24.24 %), Chiroptera (23.23 %), Artiodactyla (9.10%), Eulpotyphla (4.04 %), Primates (3.03 %), Pholidota (2.02 %), Scandentia (1.01 %) and Proboscidea (1.01 %). A list of 147 mammals species documented from different literature is provided as Appendix 5A.9. In KL India, over 246 species of fishes are documented (Appendix 5A.10). The fish diversity further segregated for Sikkim as 59, in Darjeeling 116 and for Jalpaiguri and Alipurduar of north Bengal as 163 in number. For butterflies, the KL, India is one of the riches biomes in the world (Haribal, 1992). Particularly for Sikkim Himalaya, over 700 species of butterflies are reportedThere are collections of butterflies from Sikkim in the National History Museum in London and in almost all major natural history museums across the world. These are particularly found at numerous large or small river valleys of the state, for example the

Tista, Rangit and Rhenok valleys abound in butterflies. Other areas, which have notable butterfly populations, are Rangpo, Thangu, Tholong, Mangan, Rangpo, Gerathang and Zoluk.

5A.10 Protected Areas of KL-INDIA

Out of the existing 21 protected areas in Khangchendzonga landscape as a whole for three participating countries, nine, namely i) Khangchendzonga Conservation Area (KCA) (Nepal-India), ii) Khangchendzonga Biosphere Reserve (KBR) (India-Nepal), iii) Barsey Rhododendron Sanctuary (BRS) (India-Nepal), iv) Singalila National Park (SNP)(India-Nepal), v) Pangolakha Wildlife Sanctuary(PWS) (India-China-Bhutan), vi) Torsa Strict Nature Reserve (TSNR) (Bhutan-India); vii) Jaldhapara National Park (JNP) (India-Bhutan); viii) Buxa Tiger Reserve (BTR) (India-Bhutan) and ix) Phipsoo Wildlife Sanctuary (Bhutan-India) are transboundary in nature. Moreover, the landscape connects the Bhutan Biological Conservation Complex (NDC, 2004) with the Sacred Himalayan Landscape (GoN/MoFSC 2006) forming an important corridor in the eastern Himalayas. Thus, this landscape is an important transboundary complex for biodiversity conservation. The KL-India has 17 protected Areas, comprising of 1 Biosphere Reserve, 4 National Parks and 12 Wildlife Sanctuaries, that covers almost 34.21% of the total geographical area of landscape (Table 5A.4). Of the total, Darjeeling –Jalpaiguri-Alipurduar part has as many as 9 protected areas with four National Parks, five wildlife sanctuaries (Table 5A.4), besides Eastern Duars Elephant Reserve.

Protected areas in Khangchendzonga landscape (India) offer rich habitat diversity (Photo: BK Pradhan)

Table 5A.4 Protected areas of KL- India (Sikkim, Darjeeling and Jalpaiguri) and their flagship species

Sl No	Protected area	Area (Km^2)	Location	IUCN category	Flagship species
1	Khangchendzonga Biosphere Reserve	2,931.12 (including transition zone)	Sikkim, India	-	Rhododendron niveum, Snow leopard, Red panda, Musk deer, Himalayan black bear, Argali, Tibetan Gazelle
2	Barsey Rhododendron Sanctuary	104	Sikkim, India	IV	Rhododendrons, Serow, Asian golden cat, Assamese monkey, Clouded leopard, Marbled cat, Himalayan black bear
3	Fambong Lho Wildlife Sanctuary	52	Sikkim, India	IV	Binturong, Red panda, Clouded leopard, Serow, Himalayan black bear
4	Kyongnosla Alpine Sanctuary	31	Sikkim, India	IV	Red panda, Asian wild dog, Goral, Snow leopard, Musk deer, Serow, Himalayan black bear
5	Mainam Wildlife Sanctuary	35	Sikkim, India	IV	Binturong, Red panda, Musk deer, Clouded leopard
6	Singhba Rhododendron Sanctuary	43	Sikkim, India	IV	Red panda, Clouded leopard
7	Pangolakha Wildlife Sanctuary	128	Sikkim, India	IV	Red panda, Musk deer, Goral, Serow, Clouded leopard, Marbled cat, Himalayan black bear
8	Kitam Bird Sanctuary	6	Sikkim, India	-	Clouded leopard, Assamese monkey, Himalayan black bear
9	Jore Pokhari Salamander Sanctuary	0.04	Darjeeling, India	IV	Himalayan salamander
10	Singalila National Park	79	Darjeeling, India	II	Red panda, Clouded leopard, Himalayan tahr, Himalayan black bear
11	Senchal Wildlife Sanctuary	39	Darjeeling, India	IV	Goral, Serow, Himalayan black bear, Pangolin, Barking deer
12	Mahananda Wildlife Sanctuary	158	Darjeeling, India	IV	Serow, Himalayan black bear, Gaur, Asian Elephant
13	Neora Valley National Park	159.89	Darjeeling, India	II	Red panda, Goral, Serow, Tiger, Clouded leopard
14	Buxa Tiger Reserve	760	Jalpaiguri, India	IV	Tiger, Asian Elephant, Clouded leopard, Gaur, Wild boar, Sambar deer
15	Jaldapara National Park	216.51	Jalpaiguri, India	II	Indian one horned rhinoceros, Tiger, Asian Elephant, Sambar deer, Barking deer, Wild dogs, Bison
16	Chapramari Wildlife Sanctuary	9.6	Jalpaiguri, India	-	Asian Elephant, Tiger, Leopard, Gaur, Wild boar, Pangolin,

					Barking deer, Sambar deer
17	Gorumara National Park	79.99	Jalpaiguri, India	II	Indian rhinoceros, Gaur, Asian Elephant, Sloth bear, Sambar deer, Barking deer, Wild boar

In addition to above protected areas the state of Sikkim has notified at state level, there are five key conservation areas under the Conservation Zones: 1. Areylungchok Musk Deer Conservation Zone, North Sikkim; 2. Blue Sheep Conservation, North Sikkim; 3. Yongzokdrak Blue Sheep Conservation Zone, North Sikkim; 4. Tholung-Kishong Conservation Zonation [Gazette Dated: 11/12/06], and 5. Narsing Conservation Zonation, North Sikkim [Gazette Dated: 11/12/06]

5A.11 Corridors: a management approach to connectivity and feasibility

Secure, viable wild floral and faunal populations thriving in contiguous natural habitats across the KL landscape, as valued flagship species for the region, enabling living in harmony with local communities is a vision to be achieved through effective natural corridor connectivity. The north Bengal part of KL, India has already identified many corridors, which can be considered as potentially prospective transboundary landscape candidates. In Sikkim part, the existing wildlife protected area network of Sikkim has already well established corridor connectivity within and beyond the political limits of the state. The Khangchendzonga National Park with its buffer zone and Biosphere Reserve has natural landscape connectivity along the Singalila Range southwards to Barsey Rhododendron Sanctuary, linking further south to the Singalila National Park in West Bengal. It continues as the Kanchenjunga Conservation Area to its west in the country of Nepal. Within Sikkim itself, it is linked with Maenam Wildlife Sanctuary above Rabongla. Similarly, the Pangolakha Wildlife Sanctuary links southward with Neora Valley National Park in West Bengal and eastwards with the Torsa Strict Nature Reserve in the country of Bhutan. The Reserve Forests of the trans-Himalayan and cold desert region of North Sikkim effectively link the National park with the upper reaches of the Lachung Valley through Dongkiala-Yumesamdong-Yumthang, reaching Singhba Rhododendron Sanctuary. The Important Bird Area is an important Corridor comprising Fambong lho Wildlife Sanctuary - Himalayan Zoological Park, Bulbuley - Ratey Chu RF Complex. Similar is the case with proposed Ramsar Site comprising Khecheopalri-Khangchendzonga-Lhonak Complex.

The globally threatened Snow Leopard habitat in Sikkim can be represented by the entire high altitude catchment area of River Tista, as a gigantic horseshoe from Singalila range (including KNP, KBR) to the left, the Cold Desert to the north and the Tista Khangse – Tembawa – Chola Range (including Singba, Kyongnosla, Pangolakha sanctuaries) to the east, flanking the great Chumbi Valley of TAR of China. This virtually un-fragmented corridor with low human presence links Nepal-Sikkim-Bhutan effectively. The necessity is for the scientific assessment and legal commissioning of these corridors and may be more effective corridors in Sikkim can be identified. For the north Bengal part, following important corridors are of much importance:

5A.11.1 Neora-Mahananda Corridor, Darjeeling

The proposed corridor between Mahananda Wildlife Sanctuary and Neora Valley National Park is an important migratory route for Asian Elephants. It is approximately 292

sq. km, and 40 km long and covers three forest ranges in Kalimpong Forest Division. The corridor passes through southern boundary of the reserve forest areas of Darjeeling and of the reserve forest areas of Mongpong, Lish, Churanthi of Chel Range, Ramthi, Lethi, and Fagu blocks under the Noam Ranges, whole of the Mal Block, parts of Sakam in Darjeeling district, and enters West Nar Block of Neora Valley National Park of Wild Life Division-II in Jalpaiguri district (ICIMOD http://hkhconservationportal.icimod.org/PA.aspx?ID=19; accessed on 13.3.2013). The corridor, apart from forest, has about 40 % of its area under agriculture including tea gardens and cultivable waste (Mission Hill, Ambeok and Upper Fagu) and forest villages (NESPON 2009).

5A.11.2 Senchal-Mahananda Corridor

Under the Kurseong block (Darjeeling district), this corridor covers areas between Chimney-Deorali, Mamring – Sittong, with Chimeny, Mamring more towards Senchal Wildlife Sanctuary and Sittong towards Mahananda Wildlife Sanctuary. Chimney-Deorali Mamring – Sittong. Latpanchar in Sittong falls under the Mahananda Wildlife Sanctuary. It has several tea gardens, Chincona plantation, Khamal villages and forests under the DGHC and the Forest Department. For the sub-divisional headquarter of Kurseong, Chimey-Deorali catchment, is a source for the River Mahananda (Prena, DLR 2007). The corridor supports several mammals (civets, Himalayan Black bear, Himalayan flying squirrel, Himalayan Salamander and Rufous necked hornbill), among some of the threatened fauna, Clouded leopard, Himalayan Black Bear, Barking Deer, Thar, Goral, Hare, Wild Pigs, Porcupine, Royal Bengal Tiger, Sambhar, Elephant, Leopard, etc. In Namthing Pokhari, a good population of the endangered amphibian is found.

5A.11.3 Singalila – Senchal Corridor

Covering Senchal Wildlife Sanctuary and Singalila National Park and the area stretching between these two protected areas the Senchal-Singalila biodiversity complex is an important part of KL, India, lying in Darjeeling districts. This landscape has a variety of flora and fauna, several of them endemic to the regionThe proposed corridor begins at Jaubari, which lies on the way to Rimbick from Manebhanjyang and is in the southern portion of the reserve forest buffering the Singhlaila National Park. This runs further covering areas like Majua, Arubhota and Damigaun, which lies on the southeastern portion of the reserve forest again buffering the Singalila National Park. The corridor then covers habitats between Manebhanjyang and Sukia Pokhari and protrudes a little south covering Simana in an attempt to cover the adjoining forests of Jorepokhari. From Sukhia Pokhari, the corridor forest is interspersed by settlements like Majidhura Parmen, Majidhura Balasan, Lepchajagat, Chataidhura, Bhalukhop, Pussenbong Phatak, Pubung Phatak, and Ghoom Bhanjyang. Around Ghoom Bhanjyang, the Barbatay forest of Senchal sanctuary is covered and then the corridor ends in 14th mile, whch touching the western end of the Senchal Sanctuary, specifically covering the Dootheria forest (ATREE, 2007).

5A.11.4 Elephant Corridor connectivity in Jalpaiguri

The north Bengal has 14 of the 88 corridors identified and proposed for Elephant movements, of which 13 corridors lie within Jalpaiguri and Darjeeling (Tiwari, 2005).

However, fragmentation of Elephant habitat is also found to be most severe in north Bengal. There are about 300 Elephants in this region spread over Darjeeling and Jalpaiguri districts covering nine forest divisions - comprising nine forest divisions, viz. Kurseong, Wildlife-I, Baikunthapur, Kalimpong, Wildlife-II, Jalpaiguri, CoochBehar, Buxa Tiger Reserve (West) and Buxa Tiger Reserve (East). Although the Elephant population in this region is only about 1% of the total Elephant population of India, the human–Elephant conflict is one of the highest in the country. Predominantly, the Elephant holding area is confined to an elevation of 900 m and the Elephant habitat is limited to about 2200 km^2 (Tiwari, 2005); three distinct geographical zones, which are potential Elephant habitats in KL, India are, (i) : The terai stretch between the Mechi River and the Tista River, comprising of the forest areas of the Kurseong Division and the Mahananda Wildlife Sanctuary; (ii) The western duars stretch between the Tista and Torsa rivers comprising Apalchand range of Baikunthapur Division, Jalpaiguri, Kalimpong and Cooch Behar Forest Divisions, Jaldapara Wildlife Sanctuary, Chapramari Wildlife Sanctuary and Gorumara National Park and; (iii) The eastern duars stretch between Torsa and Sankosh River that adjoins Assam and Bhutan and comprises the forests of Cooch Behar Forest Division and Buxa Tiger Reserve (BTR) (Tiwari 2005).

Within Darjeeling and Jalpaiguri having borders with Nepal in the east and Bhutan in the north, Tiwari (2005) identified 13 Elephant corridors, viz. 1. Mahananada – Kolbari Corridor, 2. Alapchand – Mahananda Corridor, 3. Alapchand – Gorumara Corridor, 4. Alapchand – Kalimpong Corridor, 5. Alapchand – Kalimpong (vial Meanglass) Corridor, 6. Chapramari – Kalimpong Corridor, 7. Rethi-Central Diana Corridor, 8. Rethi-Moraghat Corridor, 9. Deemchi-Rethi Corridor, 10. Buxa-Titi (via Torsa) corridor, 11. Buxa – Titi (via Beech and Barnbari Tea Estate), 12. Mimati-Chilpata Corridor, And 13. Buxa-Ripin at Sankosh Corridor. The Eastern Duars Elephant Reserve, declared in 2001, corporate these corridors (Wild Bengal http://www.wildbengal.com/urls/conservation-area-Elephant-reserve-eastern_duars. html downloaded on 17/3/2014) for management and monitoring.

5A.12 Protected Areas- biodiversity and transboundary significance and conservation challenges

In KL India7 protected areas has several transboundary issues with neighbouring countries (Appendix 5A.11).

5A.13 Important Bird Areas

The entire Khangchendzonga landscape in India is one of the riches biome for a very high diversity of birds, be this the Sikkim or the north Bengal part. The Sikkim is an area of 0.2 % of the country, the old tally of over 550 bird species represents around 30 % of the aggregate bird species and subspecies found in the entire Indian subcontinent. This region of the Central Himalayas lies within the Eastern Himalayas Endemic Bird Area (EBA) for several bird species such as Chestnut-breasted Partridge *Arborophila mandelli*, Rusty-bellied Shortwing *Brachypteryx hyperythra* and White-naped Yuhina *Yuhina bakeri*. It also has Globally Threatened species like Black-necked Crane *Grus nigricollis* and Lesser Kestrel *Falco naumanni*.

Appreciating the importance of the landscape for globally threatened (Table 5A. 5) and other important birds found in this region of the Eastern Himalayas, the Government of Sikkim recognized eleven Important Bird Areas or IBAs across the entire state in November 2003 (Table 5A.6), which are rich in endemic elements (Table 5A.5, 7-8). All of them fulfil A1, A2 and A3 criteria. Although some high altitude wetlands are found, none of them fulfils A4 criteria. (A1= Threatened species; A2 = Restricted Range species; A3= Biome species; A4=Congregatory species). Out of the 21 bird species mentioned in the Eastern Himalayas EBA (Jhunjunwala *et al.,* 2001), the following 10 restricted range bird species are reported from Khangchendzonga landscape, India:

1. Ward's Trogon	*Harpactes wardi*
2. Red-breasted Hill-Partridge	*Arborophila mandellii*
3. Blyth's Tragopan (unconfirmed report by ZSI)	*Tragopan blythii*
4. Broad-billed Flycatcher-Warbler	*Tickellia hodgsoni*
5. Hoary-throated Barwing	*Actinodura nipalensis*
6. Rufous-throated Wren-babbler	*Spaeleornis caudatus*
7. Rusty-bellied Shortwing	*Brachypteryx hyperythra*
8. Wedge-billed Wren-babbler	*Sphenocichla humei*
9. White-naped Yuhina	*Yuhina bakeri*
10. Black-browed Leaf-warbler	*Phylloscopus cantator*

Table 5A.5 Status of Red Data Book threatened bird species reported from Khangchendzonga landscape, India

1. White-bellied Heron	*Ardea insignis*	EN
2. Oriental Stork	*Ciconia boyciana*	EN
3. Baer's Pochard	*Aythya baeri*	VU
4. Pallas's Fish-eagle	*Haliaeetus leucoryphus*	VU
5. Greater Spotted Eagle	*Aquila clanga*	VU
6. Lesser Kestrel	*Falco naumanni*	VU
7. Red-breasted Hill-Partridge	*Arborophila mandellii*	VU
8. Blyth's Tragopan ?	*Tragopan blythii?*	VU
9. Black-necked Crane	*Grus nigricollis*	VU
10. Wood Snipe	*Gallinago nemoricola*	VU
11. Rufous-necked Hornbill	*Aceros nipalensis*	VU
12. Rusty-bellied Shortwing	*Brachypteryx hyperythra*	VU
13. Slender-billed Babbler	*Turdoides longirostris*	VU
14. Red-breasted Parrotbill	*Paradoxornis flavirostris*	VU
15. Grey-crowned Prinia	*Prinia cinereocapilla*	VU
16. Beautiful Nuthatch	*Sitta Formosa*	VU
17. White-backed Vulture	*Gyps bengalensis*	CR
18. Long-billed Vulture	*Gyps indicus*	CR

Table 5A.6 IBAs and Protected Areas in Khangchendzonga landscape, India (Sikkim)

IBA site codes	**IBA site names**	IBA	PA
IN-SK-01	Barsey Rhododendron Sanctuary	+	+
IN-SK-02	Dombang Valley – Lachung – Lema – Tsungthang	+	
IN-SK-03	Fambong Lho Wildlife Sanctuary – Himalayan Zoological Park – Ratey Chu Reserve Forest	+	+
IN-SK-04	Khangchendzonga National Park and Biosphere Reserve	+	+
IN-SK-05	Kyongnosla Alpine Sanctuary - Tsomgo -Tamze - Chola Complex	+	+
IN-SK-06	Lhonak Valley	+	
IN-SK-07	Lowland Forests of South Sikkim	+	+
IN-SK-08	Maenam Wildlife Sanctuary – Tendong Reserve Forest	+	+
IN-SK-09	Pangolakha Wildlife Sanctuary - Zuluk - Bedang Tso - Natula Complex	+	+
IN-SK-10	Tso Lhamo Plateau - Lashar - Sebu La - Yumesamdong Complex	+	
IN-SK-11	Yumthang-Shingba Rhododendron Wildlife Sanctuary	+	+

Table 5A.7 Endemic Bird Area 130: Eastern Himalayas found in KL, India

Rusty-bellied Shortwing	*Brachypteryx hyperythra*
Hoary-throated Barwing	*Actinodura nipalensis*
White-naped Yuhina	*Yuhina bakeri*
Red-breasted Hill-Partridge	*Arborophila mandellii*
Black-browed Leaf-Warbler	*Phylloscopus cantator*
Ward's Trogon	*Harpactes wardii*
Rufous-throated Wren-Babbler	*Spelaeornis caudatus*
Wedge-billed Wren-Babbler	*Sphenocichla humei*
Broad-billed Flycatcher-Warbler	*Tickellia hodgsoni*
Giant Babax	*Babax waddelli*

Table 5A.8 Endemic Bird Area 133: Tibetan Plateau, found KL, India

Hoary-throated Barwing	*Actinodura nipalensis*
Broad-billed Flycatcher-Warbler	*Tickellia hodgsoni*

5A.14 Important Bird Areas

(a) BARSEY RHODODENDRON SANCTUARY: This is an important IBA on the southeast corner of Sikkim with Nepal as its western border and contiguity with KBR and Singalila, stretching from alpine meadows down to subtropical forests. Birds from biomes 5, 7, 8 and 9 have been recorded here including at least three globally threatened species, two restricted range species, five out of 48 Biome-5 species, 38 out of 112 Biome-7 species, 21 out of 96 Biome-8 species and three out of 19 Biome-9 species.

(b) DOMBANG VALLEY-LACHUNG-LEMA-TSUNGTHANG: The important birds of the valley are Himalayan Griffon *Gyps himalayensis*, Wood Snipe *Gallinago nemoricola*, Snow Pigeon *Columba leuconota*, Grandala *Grandala coelicolor*, Plain Mountain-Finch *Leucosticte nemoricola* and Hill Partridge *Arborophila torqueola*. A specimen of Tibetan Horned Owl (Eurasian Eagle-Owl) *Bubo bubo* from Lema was collected from a local of Lachung village and deposited with BNHS (Ganguli-Lachungpa, 2002).

(c) FAMBONG LHO WLS – HIMALAYAN ZOOLOGICAL PARK – RATEY CHU RESERVE FOREST COMPLEX: Over 281 species of birds have been reported from this area(Anonymous, 2002Within this very small geographical PA, 139 species of birds (25.36% of the species reported from Sikkim, as a whole) belonging to 28 families were recorded, which included two endemic species of Sikkim, *Actinodura nipalensis* and *Yuhina bakeri* (Basnet and Badola, 2012)

(d) KHANGCHENDZONGA NATIONAL PARK AND BIOSPHERE RESERVE: This isone of the richest biomea for avian diversity, besides other globally sensitive faunal elements (Badola and Subba, 2012). Some important birding habitats here are Dentam-Uttarey-Chitrey-Chewabhanjyang, the Rathong Chu Valley along the Yoksum-Dzongri-Goecha La trekking trail, Yambong-Singalila trail, Tashiding, Rabdentse, Dubdi, Khecheopalri all in West Sikkim; Tholung Valley-Kishong La in Dzongu, Tsungthang-Menshithang-Lachen-Thangu, the Muguthang-Green Lake route including the Zemu Glacier-Zemu Chu Valley, all in North Sikkim. Due to the size and altitude elevations in this IBA, birds recorded are from at least four biomes. Thus, this IBA has at least 127 bird species of conservation concern including 07 globally threatened and restricted range species, 24 species of Biome-5, 67 of Biome-7, 26 of Biome-8 and three listed in Biome-9. The provided lists are on the vulnerable and endemic birds and other important birds having global representation, of KBR (Appendix 5A.12).

(e) KYONGNOSLA ALPINE SANCTUARY – TSOMGO – TANZE-CHO LA COMPLEX: More than 230 species of birds have been identified. Outside Khangchendzonga National Park, this is the site where the State Bird of Sikkim, the Blood Pheasant *Ithaginis cruentus*, is found, and is not difficult to sight. Among the globally threatened species of this site, the most prominent one would be the Wood Snipe *Gallinago nemoricola*, as it possibly breeds here.).The site is located in the Eastern Himalayas Endemic Bird Area (EBA-130) where 21 species have been listed of which only one species, the Hoary-throated Barwing *Actinodura nipalensis*, has been found till now but more are likely to occur.

(f) LHONAK VALLEY: Lhonak Valley is the famed flyway of migratory waterfowl (Ali, 1962). Many Vulnerable and Biome-5 restricted species breed here such as Tibetan Snowcock *Tetraogallus tibetanus*, Black-necked Crane (unsuccessful nesting attempt at Tebleh Tso, Muguthang), Tibetan Sandgrouse *Syrrhaptes tibetanus*, Güldenstädt's Redstart *Phoenicurus erythrogaster*, Hume's Groundpecker *Pseudopodoces humilis*. Lesser Kestrel *Falco naumanni* has been infrequently recorded from this valley during the course of the Alpine Grassland Ecology Project of BNHS from 2000-2003.

(g) LOWLAND FORESTS OF SOUTH SIKKIM (MELLI-BAGUWA-KITAM-JORETHANG-NAMCHI-SOMBAREY: The lowland forests of Sikkim are home to several species identified as Near Threatened by BirdLife International (2001): Great Pied Hornbill *Buceros bicornis* now restricted to few sightings over tea estates, Red-breasted Partridge *Arborophila mandelli* (not recorded recently) and Ward's Trogon *Harpactes wardi*. Biome-5 species like Ibisbill *Ibidorhyncha struthersii* are regularly recorded in winter on the banks of the Great Rangit river; Wallcreeper *Tichodroma muraria* recorded from Trans-Himalayan Lhonak Valley (at Green Lake) and other high altitude sites is also recorded from this IBA.

(h) MAENAM WILDLIFE SANCTUARY – TENDONG RF: The site lies in the Eastern Himalayas Endemic Bird Area (EBA-130), in which Stattersfield *et al.,* (1998) have listed 21 restricted range species. Some areas of this IBA, especially in the valleys also show some faunal elements of Biome-9 (Indo-Chinese Tropical Moist Forest). Four species of this biome are also found here. This IBA has habitat contiguity with the Khangchendzonga Biosphere Reserve; therefore, both these IBAs together form a large habitat for the bird life of this small state.

(i) PANGOLAKHA WILDLIFE SANCTUARY – ZULUK – BEDANG TSO – NATU LA COMPLEX : The mountain passes of Natu La and Jelep La (La = Pass) form the routes for migratory waterbirds many of which stop over at the various wetlands in the area, especially Bedang Tso Lake. The Himalayan Monal *Lophophorus impejanus* (locally called as Feydong) used to be found here (Chezung Lachungpa pers. comm. 1996), hence the name Bedang Tso.

(j) TSO LHAMO PLATEAU – LASHAR – SEBU LA – YUMESAMDONG COMPLEX: Around 227 birds have been recorded from this c. 500 Km^2 area, including 4 globally threatened species, 3 Restricted Range species and 93 Biome-restricted species (Ganguli-Lachungpa and Rahmani, 2003). This site in the Eastern Himalayas Endemic Bird Area is the highest altitude eco-region in Sikkim spanning two biomes, Sino-Himalayan Temperate Forest (Biome-7) and Eurasian High Montane (Alpine and Tibetan) (Biome-5) as described by BirdLife International (undated).

(j) YUMTHANG – SHINGBA RHODODENDRON WLS: Not much information is available on the general bird life of this site, except for opportunistic observations. The globally threatened Wood Snipe *Gallinago nemoricola* is occasionally, seen in the Rhododendron-Fir forest of Shingba, Blood Pheasant *Ithaginis cruentus* and Himalayan Monal *Lophophorus impejanus* breed in the higher reaches of the Sanctuary while the Himalayan Griffon *Gyps himalayensis* is a resident of the cold desert to the north. In addition to above, 11 IBAs of Sikkim, Neora valley national park, Singalila national park and Mahananda wildlife sanctuary, in north Bengal are other rich important bird areas.

(k) NEORA VALLEY NATIONAL PARK: The Neora Valley National Park (27°52'03''-27°07'35''N, 80°45'-80°55' E) lies in the bio-geographic zone 2 and includes Dry mixed forest, Wet mixed forest, Lauraceous Forest, Buk-Oak Forest, High level oak Forest, Coniferous Forest, Himalayan Moist Temperate Forest and Rhododendron forest. The Park is contiguous with Sikkim and Bhutan at its northern and north-eastern boundaries,

respectively, and is an integral part of the KL. It links Pangolakha Wildlife sanctuary in Sikkim and the Torsa Strict Reserve of Bhutan. The southern boundaries of the Park adjoin the forests of Jalpaiguri district, which have connectivity with the Chapramari Wildlife Sanctuary and the Gorumara National Park. It is one of the few Important Bird Areas (IBA) of North Bengal, which fall, within the Restricted Range Species site – the Endemic Bird Area, Eastern Himalayas and the Restricted Assemblages Biomes, Sino Himalayan Temperate Forest and Sino Himalayan Subtropical Forest.

(l) SINGALILA NATIONAL PARK: The park and adjoining areas are one of the richest avifaunal zones of the world, with about 550 species of recorded. Of these, more than 50 % are passerine birds, the largest being the Timalinae (laughing thrushes, Babblers etc.) with 61 sp; A large number of birds are local migrants moving up and down the hills according to season. Others are passage migrants using the area for movement to the north in Siberia, Tibet, China and to the plains of India.

(m) MAHANANDA WILDLIFE SANCAUARY: The Sanctuary falls in the region east of the Mechi river, an area reputed to possess the richest variety of birds in India. Iit is assumed that well over 300 birds species can be found in the Sanctuary, particularly in winter. The Jaldapara national park (with 178 species and endemic birds) and Gorumara wildlife sanctuary (with 101 avian species and endemic birds, *Stachyris oglei*-Snowy-throated Babbler and *Paradoxornis flavirostris*-black breasted Parrotbill) in north Bengal are eligible IBAs.

5A.15 Conservation concern

5A.15.1 Endemic and rare plant species

Chatterjee (1939) observed the number of endemics in the Himalaya as 3165 out of 6850 endemics in India. Several endemic species have been collected from Khangchendzonga landscape (India), especially Sikkim. It is estimated that about 3 % of the plants known from Sikkim are endemic to the region. The genus like Brachycaulos is exclusively endemic to Sikkim. Some of the representative endemic flowering plant species are listed here as Table 5A.9

Table 5A.9 Flowering plants Endemic to Khangchendzonga landscape, India (Sikkim)

Acronema pseudotenera	Apiaceae
Anaphalis cavei	Asteraceae
Anaphalis hookeri	Asteraceae
Anemone demissa var. *monantha*	Ranunculaceae
Angelica nubigena	Apiaceae
Arenaria thangoensis	Caryophyllaceae
Astragalus zemuensis	Fabaceae
Berberis sikkimensis	Berberidaceae
Cacalia chola	Asteraceae
Calamus inermis	Arecaceae
Caragana spinifera	Fabaceae
Carex kingiana	Cyperaceae
Codonopsis affinis	Campanulaceae
Coelogyne treutleri	Orchidaceae

Cremanthodium palmatum subsp. *benthamii*	Asteraceae
Crepis atropappa	Asteraceae
Juncus sikkimensis	Juncaceae
Jurinea cooperi	Asteraceae
Ligularia kingiana	Asteraceae
Ligularia pachycarpa	Asteraceae
Ligularia yakla	Asteraceae
Mahonia sikkimensis	Berberidaceae
Podophyllum sikkimensis	Podophyllaceae
Ranunculus sikkimensis	Ranunculaceae
Rhdododendron sikkimense	Ericaceae
Uvaria lurida var. *sikkimensis*	Annonaceae

Besides, some endemics to Khangchendzonga landscape (India) include, *Cissus spectabilis* (Vitaceae), *Cotoneaster simonsi* (Rosaceae), *Rhododendron campanulatum* subsp. aeruginosum (Hook.f.) Chamb. (Ericaceae), *Rhododendron dalhousiae* subsp. tashi Pradhan and Lachungpa (Ericaceae), *Rhododendron sikkimense* (Ericaceae; endemci to Sikkim, *Rhynchospora rugosa* subsp. browni (Roem. and Schult.) T. Koyama (Cyperaceae), *Selliguea tricuspis* (Hook.f) Fras.-Jenk. (Polypodiaceae).

5A.15.2 Endemism in Bryophytes

In KL, India 130 mosses reported to be endemic to India, of which distributed as 82 species for Sikkim and 104 in Darjeeling, whereas, one species in Jalpaiguri; however, 63 endemic species have wider distribution to other places of India (Dandotiya *et al.,* 2011). Pylaisiadelphaceae (19 species) is the richest one amongst the endemic rich families (Figure 5A.9). For specific presence of endemic species, 11 species are found in Sikkim only, and 26 endemic exclusively to Darjeeling. Encouragingly, 67 species of mosses are endemic to KL, India, exclusively.

5A.15.3 Threatened Taxa

Threat to the world biota is a modern-day problem ushered in by two major factors, namely, global industrialization and the expanding populations all over the world. The KL, India, being a part of the designated Eastern Himalayan Hotspot region has its own share of threatened elements and most of it constitutes the plant species.

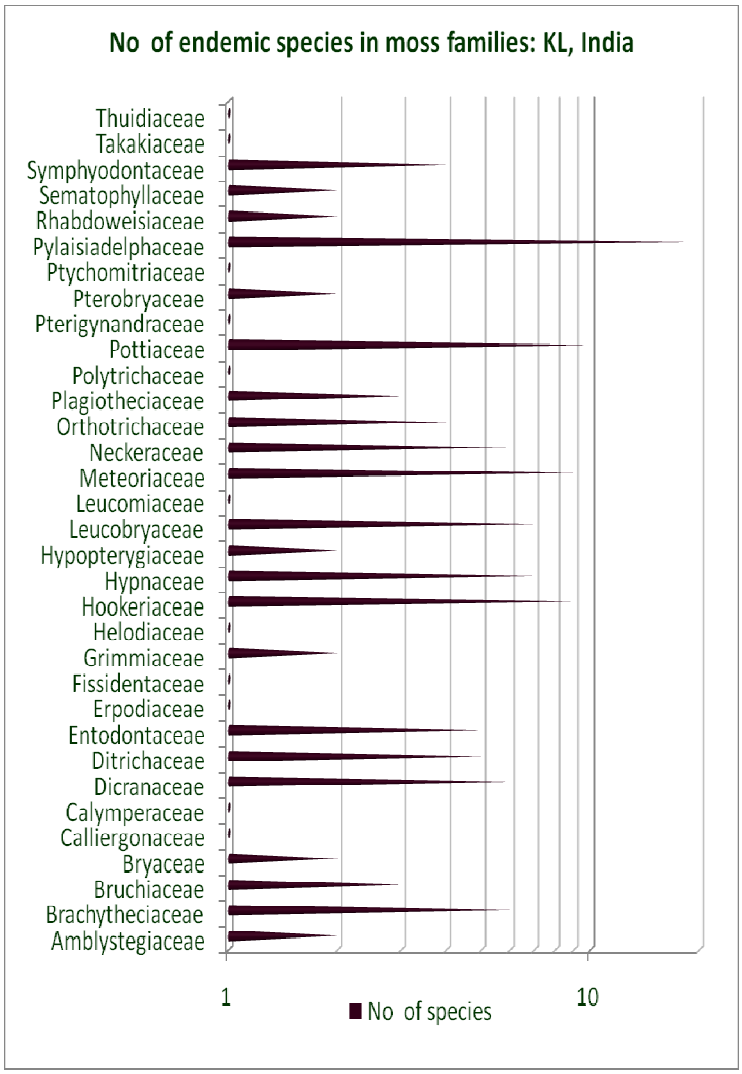


Figure 5A.9 Endemic moss diversity amongst families in Khangchendzonga landscape, India (Graphic representation is based on Dandotiya *et al.*, 2011), by GBPIHED

5A.15.4 Protected, rare and threatened plant species

Appendix 5A.13 provides some important 96 plant species with their conservation status, either for rarity, data deficiency (though sensitive for conservation), threatened status and possible risks; the species are also detailed out for their description especially in the context of KL, India. The documentation analysed 3 species for data deficient status, 11 species as endangered, 8 vulnerable, 46 rare, 8 endemic, 4 at risk, 2 monotypic, 01 highly localized, 01 natural hybrid, 01 questionable on rarity and endangerment, 01 possibly extinct, 01 vulnerable in IUCN Red List of Rhododendrons, 01 very scarce, etc.

5A.15.5 Threatened medicinal plants

Not only the anthropogenic factors, but also various natural enemies are also threaten medicinal plants; these include pathogens, herbivores and seed predators (Dhyani and Kala, 2005; Badola, 2013). Dhyani and Kala (2005) cited examples of faunal pressures in

wild on medicinal plants of high conservaiton concern, such as, the grazing of *Saussurea gossypiphora* (endangerd) flowers by Moschus chrysogaster (Himalayan musk deer) add to reducing plant population. Various forums have exercised assessing the conservation status of medicinal plants towards different threats in Indian Himalaya, that include various CAMP exercises using IUCN criteria (http://envis.frlht.org/medicinal-plants-conservation-concern-species.php) and using multi-dimensional matrix by international experts (Badola and Pal, 2003). Table 5A.10 provides a comparable picture of, hitherto, assessed 31 red listed medicinal plants of KL India.

Table 5A.10 Some threatened medicinal plants of Khangchendzonga landscape, India, comparing to other parts in Himalaya (based on various CAMP workshops)

		Red List Status of medicinal plants based on CAMP workshops**							
	Botanical Name	**Sikkim***	**North Bengal**	**Arunachal**	**J and K**	**Meghalaya**	**Uttaranchal**	**HP**	**Nepal**
1.	*Aconitum ferox* Wall. ex Seringe	EN	EN	EN					DD
2.	*Aconitum heterophyllum* Wall. ex Royle	EN, CR(G)		EN CR(G)	CR			CR	VU
3.	*Aconitum spicatum* (Bruhl) Stapf	VU	EN						VU
4.	*Bergenia ciliata* (Haw.) Sternb.	VU		VU		VU			
5.	*Cordyceps sinensis*	EN							
6.	*Dactylorhiza hatagirea* (Don.) Soo	EN			CR		CR	CR	EN
7.	*Dendrobium nobile* Lindl.	VU		VU		EN	EN		
8.	*Ephedra gerardiana* Wall.	DD			EN		EN	EN	
9.	*Fritillaria cirrhosa* D.Don	EN	EN	EN					VU
10.	*Gymnadenia orchides* Lindl.	VU		VU					
11.	*Gynocardia odorata* R.Br.		EN						
12.	*Mahonia napaulensis* DC.	VU		VU		VU	VU		
13.	*Nardostachys grandiflora* DC.	EN		EN				CR	VU
14.	*Oroxylum indicum* (L.) Vent.	VU		VU		VU	VU		
15.	*Panax pseudoginseng* Wall.	EN	CR						
16.	*Paris polyphylla* Smith	EN			EN			EN	VU
17.	*Picrorhiza kurrooa* Royle ex Benth.	EN		EN	EN				
18.	*Piper boehmeriaefolium* Wall. ex C.DC.	NT		VU		NT			
19.	*Pleione maculata* (Lindl.) Lindl. And Paxton	VU		EN		EN			
20.	*Podophyllum hexandrum* Royle	CR	CR	VU	EN		EN	EN	VU
21.	*Polygonatum cirrhifolium* Royle	EN						VU	
22.	*Polygonatum verticillatum* (L.) All.	VU		VU	VU			VU	

23.	*Rheum nobile* Hook.f. and Thoms	VU		NT					VU
24.	*Rheum spiciforme* Royle	DD			VU			VU	
25.	*Rhododendron anthopogon* D.Don	EN		VU	VU			NT	
26.	*Saussurea obvallata* (DC.) Edgew.	VU			VU		EN	CR	
27.	*Swertia chirayita* (Roxb. ex Flem.) Karst.	EN	CR	VU	CR	VU		EN	CR
28.	*Taxus wallichiana* Zucc.	EN	CR	EN	EN	CR		EN	EN
29.	*Valeriana hardwickii* Wall.	VU		VU		VU			
30.	*Valeriana jatamansi* Jones	EN			VU	VU	VU	VU	VU
31.	*Juniperus wallichiana* Hook.f. ex. Parl.	EN							

* modified based on personal observations (Badola HK and Rai LK; unpublished)
**http://envis.frlht.org/medicinal-plants-conservation-concern-species.php
Critically Endangered (CR), Endangered (EN), Vulnerable (VU) and Near Threatened (NT) and Data Deficient (DD), Global (G)

Swertia chirayita and Rheum nobile, the threatened species in Khangchenzonga landscape, India (Photo: HK Badola, and Dupden Lepcha)

5A.15.6 Threatened Fauna

5A.15.6.1 Conservation status of mammals and avian species in KL, India

The Khangchendzonga landscape in Indian part represents a large number of globally sensitive mammals for their conservation concern; IUCN has categorised over 10 species as threatened, i.e. either endangered or vulnerable (Table 5A.11). Some important threatened species, besides already mentioned earlier elsewhere in this chapter, are given in Table 5A.12).

Table 5A.11 Some important mammals of KL, India with their conservation status

Zoological name	Common name	CITES	IWPA	IUCN
Uncia uncia	Snow Leopard	I	I	Endangered
Panthera pardus	Common Leopard	I	I	Vulnerable
Elephas maximus	Asian Elephant			Endangered
Ursus thibetanus	Black bear, Asian		II Part II	Vulnerable
Pseudois nayaur	Blue sheep	LR	I	Low risk, Least concern
Moschus chrysogaster	Himalayan Musk deer	I	I	Endangered
Eitragus jemlahicus	Thar	NL	I	Vulnerable
Capricornis thar	Himalayan Serow	I	I	Vulnerable
Naemorhaedus goral	Goral	LR/nt	I	Vulnerable
Cuon alpinus	Wild dog.Dhole		I	Endangered
Ailurus fulgens fulgens	Red Panda		I	Endangered
Macaca assamensis	Macaque, Assamese		II Part I	Vulnerable
Hylopetes alboniger	Squirrel, flying		II Part II	Endangered

[**IUCN** – International Union for Conservation of Nature and Natural Resources; **IWPA** – Indian Wildlife (Protection) Act, 1972; **CITES** – Convention on International Trade in Endangered Species; VU- Vulnerable; LR- Low Risk]

Table 5A.12 Some important threatened avian species of Khangchendzonga landscape, India with their conservation status

Scientific name	Common name	IWPA 1972	IUCN
Lophophorus impejanus	Himalayan Monal	I	Least Concern
Sitta formosa	Nuthatch beautiful	II	Vulnerable
Arborophila mandellii	Partridge, Chestnust-breased	I	Vulnerable
Falco naumanni	Kastrel lesser	IV	Vulnerable
Brachypteryx hyperythra	Rusty-bellied Shortwing	IV	Vulnerable
Ithaginis cruentus	Blood Pheasant	I	Least Concern

[**IUCN** – International Union for Conservation of Nature and Natural Resources; **IWPA** – Indian Wildlife (Protection) Act, 1972;

5A.16 Invasive

5A.16.1 Alien, Invasive plant species

Claude White introduced many garden plants into KL, Indian part from many parts of the world. Exotic weeds like *Eupatorium* sp. seem to be seriously competing with *Artemisia* sp. and spreading into the forest as well as urban areas. *Cryptomeria japonica*, after clear felling in many places, was planted in KL, India in 1980s and now considered not a good species for the flourishment of biodiversity

Cryptomeria japonica- planted exotic in KL, India (Photo: HK Badola)

Other exotic weeds now well established include *Ageratum houstonianum*, *Bidens biternata, Erigeron karvinskianus, Galinsoga parviflora, Erichthites valerianiifolia* and *Calceolaria mexicana. Datura suaveolens* native of Mexico. In 1982 *Lantana camara* a tropical American plant was recorded as 'cultivated in only one Garden at Gangtok'. *Digitalis purpurea* introduced during the 1860s is seen as a garden species. An African grass *Panisetum clandestinum* was apparently air-seeded all over Sikkim. Now it is the commonest grass in Gangtok as well as at altitudes from 1200 – 2100 m.*Mikania micrantha* is virulently manifesting as the most dominant invasive in recent decades. Recently lowland invasive like *Parthenium hysterophorus* is there. Similarly, some animal pests have also begun to manifest their influence here, including The Giant African Snail. The Appendix 5A.14 provides some invasive alien plant species, with their nativity and mode of introduction and family, spread over different parts of KL, India.

5A.17 Weeds in KL, India

Due to forest lopping and extensive clearing for large cardamom cultivation, the ground flora is occupied by mainly weeds like *Ageratum conyzoides, Bidens bipinata, Eupatorium adenophorum, E. odoratum, Lantana camara,* etc. The weeds and pests have been slowly making its presence felt in high altitude areas of KL, India. . Newer weeds in the form of *Parthenium hysterophorus*, *Mikenia scandens*, *Cestrum aurantiacum* as well as a host of other exotic weeds are gradually making their presence felt in the region. Of the recorded ca. 35 weed plants from the region a few have crossed 2500 m asl mark and one has reached 3000 m asl in the recent past. Some important weeds of KL India are provided in Appendix 5A.15.

5A.18 Unique Biodiversity elements of KL, India

The KL India represents various unique elements of biodiversity; following are some important ones:

- The Tso Lhamo Cold Desert in northern Sikkim supports India's only population of Southern Kiang (*Equus kiang polygodon*), and also significant populations of the

Tibetan Gazelle (*Procarpa picticaudatsa*) and the Tibetan Argali (*Ovis ammon hodgsonii*) and Tibetan Gazelle (*Procapra picticaudata*).

- *Poorvi Botapa*, a primitive maize group that bears a close semblance to primitive wild maize so far found only in fossilized form has been discovered in northern Sikkim. Locally called as *Muralimakai* the plant actually has been found to be growing as two separate variants.
- The *Rhododendron nivale*, an alpine Sikkim Himalayan shrub, is the only species in the world with a shrub habit growing at and above 5,000 m elevations.
- Snow Toad *Scutiger sikkimensis*, found in Lhonak Valley (north Sikkim), is the only amphibian, which survives at 5,900 m asl. Lhonak valley is the only breeding ground in the Eastern Himalayan biome for very rare Black-necked Crane (*Grus nigricollis*).
- The KL India represents many conservation sensitive flagship species, viz. Snow Leopard (*Uncia uncia*), musk deer (*Moschus chrysogaster*), Himalayan black bear (*Ursus thibetanus*) and Tibetan Gazelle (*Procapra picticaudata*) in the high mountains, red panda (*Ailurus fulgens*), takin (*Budorcas taxicolor*) and clouded leopard in mid hills and Bengal tiger (*Panthera tigris*) and Asian Elephant (*Elephas maximus*), in the lowland areas. However, the rhododendron, especially R. niveum is one of the flagship species of the KL.

5A.19 Ecosystem Services

For the seven Himalayan states, Singh (2007) made a value evaluation of ecosystem services, which estimated 944.33 billion rupees in total, of which Sikkim state of KL, India assigned an ecosystem services value of Indian rupee of 14.02 billion. The features of Forest and Mountain Ecosystems and the peculiarities of the Himalaya characterize ecosystem services of Protected Areas of KL (India). NTFPs are important component of livelihood of people in north-east region and are being exploited for the reasons of food, employment, cash, and medicinal purposes (Karki 2001). Chettri *et al.,* (2005) quote 94 NTFPs in Khangchendzonga complex, 50 % of which are traded in periodic markets (haats) at minimum price). Nearly, 175 wild edibles are reported to exist in Sikkim-Darjeeling Himalaya (Chettri *et al.,* 2005, Sundriyal and Sundriyal 2003, Sundriyal and Rai 1996; Rai and Badola, 2009).

The rich biodiversity of this area, have led to development of a good heritage of ethno-medicinal traditions (Pradhan and Badola, 2008; Idrisi *et al.,* 2010; Badola and Pradhan, 2013), the folk medicine practices using them are quite common amongst the ethno-cultural groups of the region. Darjeeling area has 281 species used in the folk medicines (Chettri *et al.,* 2005). Bantawa and Rai (2009) have enumerated 41 medicinal plants used in traditional medicine; compilation for reference enclosed. Many varieties of Orchids and other plants of high ornamental value are also found in the protected areas and their vicinity (Kholia and Joshi, 2010). Forests supplement to needs of fuel, fodder, agricultural implements, and local handicrafts. Chettri and Sharma (2006, 2007) and Chettri *et al.,* (2007) have enumerated and prioritized the species used as firewood, fodder and timber which are being collected from different sources, viz., protected areas, community forests, and the agricultural lands in some tourist pockets along the trekking corridors in Yuksam-Dzongri areas of West Sikkim (Chettri *et al.,* 2007). Different

works suggest that Bamboo and Ringal species find wide application in local handicraft works (Chettri and Sharma, 2006).

5A.19.1 Rangelands and pastures-alpine and trans-Himalayan regions

In Himalaya, pastoralism is mostly characterized by changing composition and numbers of livestock grazed at high altitudes and the grazing impacts. In KL India, north of Sikkim is Trans-Himalayan with biota of Palaearctic affinity, as high-altitude cold desert in the rain-shadow of the main Himalayan range with typically Tibetan flora and fauna. This diversity and close-to-natural conditions is Sikkim's greatest gift to the world (Rodgers and Panwar, 2002) and emphasizes the significance of trans-Himalayan range. Botanically the KL, India has been well studied since 1858 by J. D. Hooker and other botanists. Butterfly fauna, bird fauna and large and small mammals have been, in general, recorded though status of most high-altitude species is considered to be endangered. For example, the Tibetan Wild Ass or Kiang, thought to be extinct in Sikkim, still exists, as does the Snow leopard, Eurasian Lynx, Pallas's Cat, Great Tibetan Sheep or Argali, Tibetan Gazelle, Tibetan Wolf, Tibetan Fox, Lammergeier, Tibetan Snowcock and Black-necked Crane. (Schedule I of the Indian Wildlife (Protection) Act 1972, amended upto 2009). The source of River Tista and the water bodies are used by migratory water bird species, which are accorded international protection under the Ramsar Convention. . It is also rich in medicinal plants and supports the only true alpine grasslands in the State.

In Sikkim based Khangchendzonga national park between 1975 and 2004 the livestock impact units (LIU) of the Yak and Urang in the oak and fir forests (between 2500 m to 3500 m) during winter, increased from 2 to 17 LU days ha^{-1} (192 to 1531 LU) (Tambe and Rawat, 2009). Change detection study in the 1977 to 2000 time series indicates that 25 % of these forests, having an extent of 48 km^2 show more than 15 % reduction in NDVI value. Contemporary geospatial studies in the Barsey Sanctuary by Kushwaha *et al.,* (2005) showed that out of the total area of 120 km^2, 63 km^2 had been disturbed. Areas impacted by cattle sheds (*Goth*) have been converted to degraded forests and scrub showing relatively high disturbance. In Sikkim, due to the apparent serious degradation of the rangelands the government has put on restriction on the practice of open grazing in the reserve forests from 1999. Selective enforcement of this ban in the greater Himalayan part of Khangchendzonga national park resulted in the eviction of about 300 agro pastoralists owning about 6000 cows from the reserve forests adjacent to KNP by 2002. However, the Yak population could not be fully reduced since the Yak herders were influential and also they accessed remote alpine pastures whose ecology and nature of their impacts was not studied. Consequent to the ban on rangelands the situation turned into conflicts between the Yak herders and the forest department (Tambe and Rawat, 2009).

5A.19.2 Spatial distribution of the pasturelands

The alpine zone of KNP, which broadly includes the areas between 4000 and 5000 m asl are the established rangeland. Physiognomically it starts from where the krummholz thickets end and the alpine scrub begins and extends up to the subnival vegetation. It consists of about 22 % of the park with an extent of 390 km^2 of grazing area. The winter pastures of the Yaks and their crossbreeds fall in the temperate subalpine forests

adjacent to the National Park between 2500-3500 m asl. This winter pastures of the Yaks are located largely outside KNP in the temperate and subalpine forests of Yambong and Barsay sanctuary. Unlike the summer pastures, only the Yaks and their crossbreeds use the winter pastures, since the sheep descend down to the farmers' fields in winter (Tambe and Rawat, 2009). Outside Wildlife Protected Areas (WLPAs) the only true pasturelands in KL, India can be found in the alpine and trans-Himalayan grasslands including the cold desert areas beyond Thangu at the head of Lachen Valley; and the Yumesamdong – Tembawa areas at the head of Lachung Valley all in North Sikkim.

5A.19.3 Transhumance system of animal rearing

In the beginning of the 20th century there was only one royal herd of about 50 yaks of the king (Chogyal) of Sikkim in the KNP. Gradually with increased opportunities in Sikkim, trans-border yak herders from eastern Nepal started migrating here with their herds. They paid grazing fees to the forest department and lead a nomadic life of transhumance. It was only in the latter half of the 20th century, they purchased land in the border villages of West Sikkim and shifted from pastoral nomadic to high altitude agro-pastoralism. Thus in the Greater Himalaya of KNP, sheep were traditionally grazed while the yak, cattle yak hybrids (urang) and the pack animals (dzo and horse) are recently introduced. The livestock composition and populations in the KNP have been rapidly changing over the last six decades. Current livestock composition includes sheep, cow, Yak, Yak-cow crossbreed and horse. Historical records (Hooker 1853, Risley 1894, Smith and Cave, 1911) indicate that while sheep and trans-Himalayan Yaks (Tibetan breed) were traditionally grazed in the alpine landscape of KNP, cows, buffaloes, Yaks (Nepalese breed), female Yak-cow crossbreeds (Urang or Dzomo) and horses in the greater Himalaya have arrived over the last 60 years. The livestock in KNP reduced from 11,010 in 1950 to 3710 in 2004, as larger sized livestock have mostly replaced sheep (Tambe and Rawat, 2009). The Barsay Rhododendron Sanctuary and Singalila National Park of KL, India are mainly dominated by private forests and agroforestry systems, while the remaining five corridors in India and Bhutan mainly have reserve forests under government ownership. The corridor in Bhutan linking the Torsa Strict Nature Reserve with the Jigme Dorji National Park is a part of biological conservation corridor network in Bhutan has 70-89 % of land area under the forest and had extensive pastureland.

5A.20 The Trend of Transhumance

In KL (India), the most important and highly practiced transhumance pastoral system was recorded from Sikkim. From the mid 20th century, trans-border Bhutia yak herders from eastern Nepal started migrating and settled in the border villages of West Sikkim adjacent to KNP. In 1975, with the merger of Sikkim with India, rapid development created new opportunities and markets. To meet the growing demand for dairy products, the herd size of the yak (Nepalese breed) and the female yak cow crossbreeds (Urang) started increasing. However, in the alpine regions of the KNP, the yak and urang pastoral systems have substantially influenced the oak and fir forests with bamboo understory. Comparatively the sheep, which descend down to the agricultural fields during winter and pack animals that are free ranging without an attendant herder have lesser impacts. Yak herding livelihood showed the highest inequity with benefits concentrated amongst a few followed by urang herding. Lower impacts and greater

equity in benefit sharing made the sheep and pack animal herding relatively more sustainable than the high impact and inequitable yak and cow yak crossbreeds pastoral systems. The overall livestock composition and population trend shows that the number of smaller sized sheep has reduced drastically while the number of heavier animals, mostly yaks, their crossbreeds, and horses, is on the rise (Tambe and Rawat, 2009). The long-distance migration of the sheep has been replaced by an altitudinal one of the yaks and their crossbreeds that do not descend to the permanent human habitations during winter. The result of this switch from sheep to yaks is the much higher winter effects on the temperate and subalpine forests. In Sikkim, pastoralism is known as '*gothwala*' system and here *goth* means cattle shed and the pastoralists are known as *gothwalas* or owners of the cattle shed. In Lachung (north Sikkim), also *gothwalas* practice a cyclical movement to maintain a balance between demand and supply of fodder.

During winter: At the beginning (November-December) the *goth* is shifted to lower altitude. Generally, the *Goths* are shifted from Lachung (around 8900 ft) to Lehma, Luiten, Khedum, (around 6000 ft). The village council or Dzumsa specifies the areas where each of the *gothwalas* is supposed to set up his *goth*.
During mid-winter: Again in mid-winter (January-February) the *gothwalas* move further down towards Tong, Naga (4000-4500 ft) from Lehma, Luiten, and Khedum. They settle there, till the second month of Lunar calendar (March-April).
During summer: After the onset of summer, *goths* are shifted back to higher altitude but certainly away from their residential areas. For example, in Lachung the *goths* may stay back for 15 days, thereafter it has to be shifted to Yumthang or Yumey-samdong, Yakshey and Singba (12000-14000 ft) which are at a higher altitude in comparison to Lachung. The whole cyclical movement of herdsmen along with their herd addresses the twin objectives of ensuring availability of grass as a fodder for the animals and allowing the grass to regenerate.

5A.21 Cultural services

5A.21.1 Wetlands and Ramsar Sites

In KL, India, the state of Sikkim has more than 227 wetlands spread mostly in the higher altitude. These wetlands have important biodiversity values apart from direct consumptive use value for human including tourism and have important regulatory role in soil and water conservation. Management and conservation of these lakes assumed importance under National Wetland Conservation Programme of the MoEFCC, Govt of India. Therefore, in order to steer and guide the programmes on the Conservation of Wetlands in Sikkim, the State Govt constituted a State Level Steering Committee in February 2007. Sikkim has only natural inland wetlands belonging to the category lakes/ponds. Majority of the wetlands are of glacial origin. The Sikkim Government under National Wetland Conservation Programme has identified 116 wetlands for Conservation, mostly glacial and snow-melt lakes have been proposed by Six have been recently included under the same: (i) 1. Khecheopalri Wetland (West Sikkim); (ii) 2. Tsomgo Wetland (East Sikkim); (iii) 3. Phedang Tso (Bedang Tso) Wetland Complex (East Sikkim); (iv) 4. Tamzey Wetland Complex (East Sikkim); (v) 5. Gurudongmar Lake (North Sikkim), and (vi) 6. Tembao Lake and Glacier Complex (North Sikkim)

Three Proposed Ramsar Sites (sites of international importance for migratory birds, especially water birds) in important wetland sites and forested catchment areas in Sikkim: Sikkim is an important flyway for migratory birds. As the whole of Sikkim lies directly along the East Asian migratory flyway, adjacent to the great Chumbi Valley of the Tibet Autonomous Region of China, all migratory birds use the numerous Himalayan mountain passes and high altitude wetlands along the northern and eastern parts of the State and along the different river valleys. They can be sighted here during the pre- and post-migration seasons in transit.

1. **Khecheopalri-Khangchendzonga-Lhonak Complex: comprising**
    a. Khecheopalri Lake and two Important Bird Areas namely:
    b. Khangchendzonga biosphere Reserve (KBR) (West and North Sikkim)
    c. Lhonak Valley (North Sikkim)

A wetland complex of India's highest altitude National Park and Biosphere Reserve, with Khecheopalri on the southern fringe, Lhonak Valley on its northern fringe and the Tista River Valley along its right flank

2. **Tsomgo-Bedang Tso Complex: comprising two IBAs**
    a. Kyongnosla Alpine Sanctuary–Tsomgo- Tamze-Chola Complex
    b. Pangolakha Wildlife Sanctuary–Zuluk-Bedang Tso Complex

Only wetland-forest complex with its main water body in Sikkim is draining out of the state into Bhutan.

3. **Tso Lhamo Plateau-Lashar-Yumesamdong-Tembao Complex: comprising**
    a. Tso Lhamo-Lashar-Sebu La-Yumesamdong Complex (IBA)
    b. Tembao Lake and Glacier Complex

The largest wetland complex forming the sources of the principal river of Sikkim, the Tista, originated in the cold desert and trans-Himalayas in the north Sikkim of KL, India.

5A.21.2 Sacred Forests, Sacred landscapes

Yuksom in KL is a sacred landscape and meeting place of *Lamas* Lhatsun Chempo, Gnadak Rinzing Chempo and Kathok Sempa Chempo who came to Sikkim from three different directions with an intention of establishing Buddhism. In KL, India, Sikkim is the only state with an Ecclesiastical Department in the state government, which is entrusted with the responsibility of the upkeep of the monasteries and other places of worship. Almost all the *gompas* (monasteries) and other religious institutions are responsible for a considerable degree of (unintentional) biodiversity conservation. Natural landscapes have been consecrated as sacred forests, sacred lakes, sacred boulders, stones and sacred spaces around these monasteries. Even lakes and mountains rocks and caves, springs and rivers here are considered holy because of which there is natural inhibition about polluting them.

5A.22 Biological resources – Traditional knowledge and use practices

5A.22.1 Review of ethno-biological knowledge

Indian tribal communities use over 7500 species in primary health care; that further estimate the use of about 50% plant species of a given ecosystem (Badola and Aitken, 2003). Historically, for example, the ancient tribe of Sikkim, the Lepchas have been known to practice nature-based lifestyle (Pradhan and Badola, 2008); hunting and gathering, hitherto a few decades back, was the key to their livelihood and survival.

Similarly, the traditionally very old tribe, Limboos (Badola and Pradhan, 2013) and other communities (Idrisi *et al.,* 2010) still sustain the strong traditional ethnobiological practices in KL. In Darjeeling district of west Bengal (Yonzone *et al.*, 2012) and Jalpaiguri (personal communication: Forest Department, West Bengal), other communities of KL, such as Nepalis, Limboos, Bhutia, etc have strong traditional use practices and dependency on natural resources. Many plant species such as *Pandanus nepalensis* in KL possesses multiple utility (Badola *et al.,* 2009) and offers opportunities for community people for better livelihood options practicing ex-situ cultivation. The traditional use of wild edibles and local marketing has been continued as one of the strong practice in different parts of Khangchendzonga landscape, India (Sundriyal *et al.,* 2004, Sundriyal and Sundriyal, 2004; Rai and Badola, 2009; Badola, 2010b, 2011; Subba and Badola, 2011).

In the Neora valley (Majumdar *et al.,* 1984), eighty-three medicinal, 59 edible, 18 ornamental, 21 poisonous (irritants and lethal) and 11 plants having fascinating assorted ethnic uses have also been identified (Rai and Das, 2004). For Gorumara National Park, 125 species of ethnomedicinal importance are highlighted (Das *et al.*, 2013). Yet another list for Jalpaiguri provides 143 plants of ethnomedicinal use (personal communication: Forest Department, West Bengal). Similarly, 218 plants used traditionally for curing various ailments in Darjeeling district is reported (Yonzone *et al.,* 2012). An exhaustive study on Dzongu landscape in Khangchendzonga Biosphere Reserve (north Sikkim) highlighted 118 ethnomedicinal plants (Pradhan and Badola, 2008). Whereas, in south-west part of KBR in Sikkim, 124 ethnomedicinal plants (Badola and Pradhan, 2013), and 45 ethnomedicinal plants in south Sikkim (Idrisi *et al.*, 2010) are assessed further for their use practices. For Sikkim and Darjeeling, 37 species of 28 families were documented in their use to treat diabetes, of which 81% species reported as hypoglycemic agents (Chhetri *et al.,* 2005). A study by Basu *et al.,* (2012) documented 44 ornamental fishes for Jalpaiguri district of which 40 fishes having distribution in Darjeeling district too, of west Bengal. Important ethnomedicinal plants of Khangchendzonga landscape, India- representative species use for Sikkim and north Bengal are listed in Appendix 5A.12.

5A.22.2 Traditional knowledge in healthcare practices in KL

For KL India, 05 studies, one each for Darjeeling (Yonzone *et al.*, 2012) and Jalpaiguri (Sood, VK; personal communication), and three from Sikkim, covering the plant use in healthcare practices by Lepcha in north Sikkim; Pradhan and Badola, 2008), Limbu tribe (in west Sikkim; Badola and Pradhan, 2013) and south Sikkim (Idrisi *et al.*, 2010) documented a total of 404 plant species. The species rich top families (Figure 5A.10) were, Asteraceae (20 species), Rubiaceae and Zingeberaceae (8 species each), and Euporbiaceae, Fabaceae and Liliaceae (7 species each). For the species rich genera, the Achyranthes emerged at the top with 21 species; whereas, the genus *Anthocephalus* (14 species), Aegle and Amomum (13 species each), and Datura and *Artocarpus* (12 species each) were amongst prominent (Figure 5A.11). Four species are used commonly amongst all five reviewed areas; whereas 258 species use practice limited to only one study area. However, 24 species are used commonly amongst four areas (Figure 5A.12). Maximum of 64 species commonness was recorded between Darjeeling and Jalpaiguri (with Alipurduar), and 62 species between north and west

Sikkim. Amongst two communities and highly different geographic setting, i.e. Dzongu in north Sikkim, a cooler region in remotest part of high altitude and the low land and culturally different part, i.e. Jalpaiguri, 31 species were documented. Limboos of west Sikkim has commonality of species use (26 species) with those of Jalpaiguri mixed community.

In recent years, however, owing to developmental activities govern changes in rural sectors, education, and lucrative migration of youth to townships, globalisation have vividly shown the declining interests of younger generation on taking up the noble profession of Ved (Medicine man) and on learning the traditional medicinal use practices (Badola and Pradhan, 2013). This is the reason that the documentation of traditional knowledge is vital.

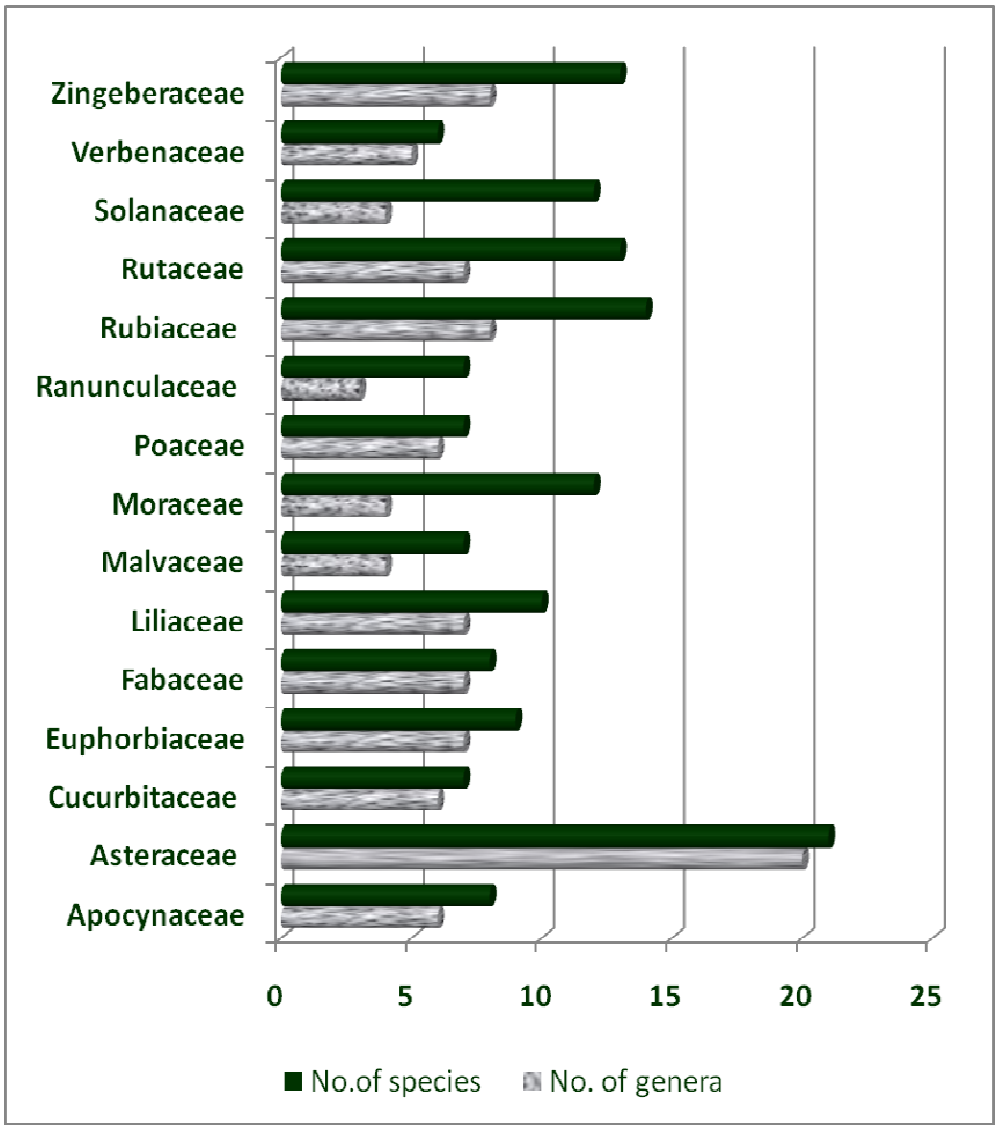


Figure 5A.10 Top species rich families of ethnomedicinal plants in Khangchendzonga landscape, India (Badola HK, unpublished)

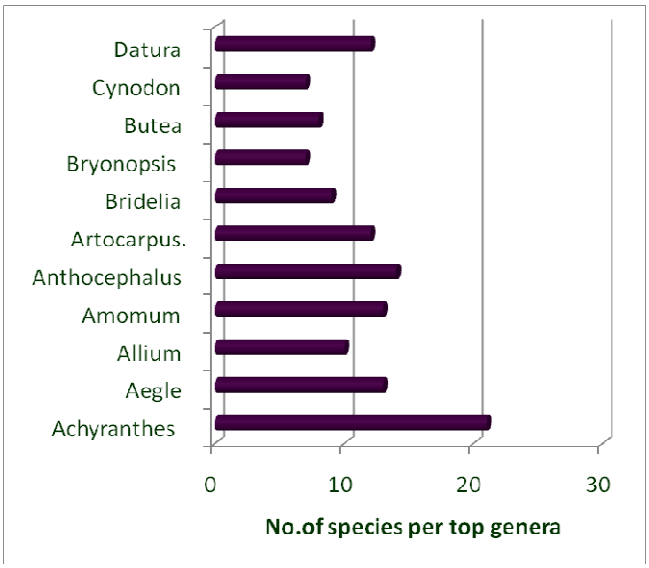


Figure 5A.11 Top species rich genera of ethnomedicinal plants in Khangchendzonga landscape, India (Badola HK, unpublished)

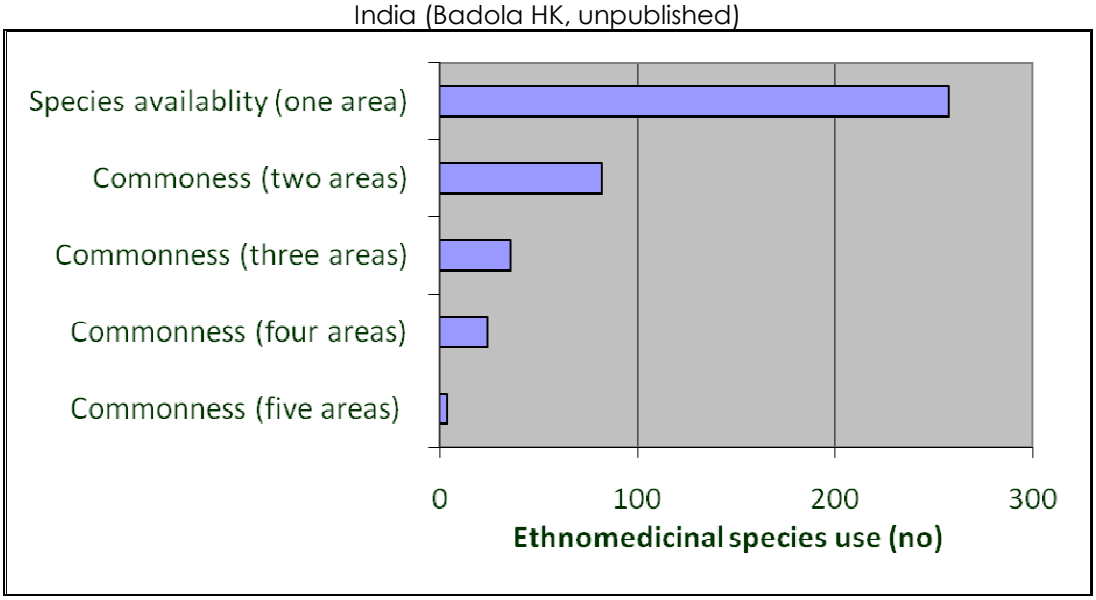


Figure 5A.12 Species commonness of ethnomedicinal plants in Khangchendzonga landscape, India (Badola HK, unpublished)

5A.22.3 High value medicinal plants

The KL (India) boost to support a variety of high value medicinal plants, majority is confined to higher altitudes. Some of these include with high market demand are: *Aconitum heterophyllum, Cordyceps sinensis*, *Picrorhiza kurrooa, Nardostachys jatamansi, Swertia chirayita*, etc. Alone 707 medicinal plant species are recorded for Sikkim-Darjeeling combined in KL. Policy support from government to growers and horticulturists in Sikkim has recently appeared while as in HP, successful cultivation demonstrations of *Dactylorhiza hatagirea* have proven lucrative for growers (IRs. 250,000 - 350,000/hectare) far exceeding revenues from wild harvesting (Butola and Badola,

2006). Similarly, very successful demonstrative ex-situ cultivation approach for community people is provided for endangered and highly commercially potential herb, *Swertia chirayita* for KL, India (Badola and Pradhan, 2011).

5A.22.4 Wild edible plants, an untapped bioresource

As per the available information, for the entire KL India, 251 wild edible plant species under 172 genera are reported (Appendix 5A.17 and Appendix 5A.18). In Sikkim alone, natives consume over 190 wild plant species and about 43 are sold in the market on a periodic basis. The fruit *Spondias axillaries* (Lapsi), eaten raw or used for making pickles especially in Sikkim (Rai and Badola, 2009) undergoes high marketing in KL, India. Amongst the lesser exploited wild edibles, the *Pandanus nepalensis* (Tarika), offers big commercial potential for making quality fruit jam/jelly/juices (Badola *et al.,* 2009). However, most of the wild edibles are locally marketed and largely exploited from the natural habitats, and exerting a pressure on the wild populations, cultivation efforts through developing suitable propagation and cultivation protocols and field trials need to be boost up (Subba and Badola, 2011). *Diplazium esculentum* (Lingra/Ningru) is one of the popular edible ferns which marginal people harvest and sell in local markets as a vegetable or as a pickle; large-scale entrepreneurship awaits this product if sustainable cultivation can be developed (Badola, 2010b). In KL, *Ficus roxhburghii* (Nibara) is a multipurpose fruit tree often ignored for its commercial scope. It has been confined to village-level uses, as is Kaphal, *Myrica esculenta* (Dhyani and Dhar, 1994).

5A.22.5 Mushrooms

Twenty percent of globally known 10,000 species of mushrooms are edible. At least, fewer than 25 species are accepted as food item and only about a dozen can be domesticated Borah and Rahman, 2011). Amongst commonly found species in natural habitats include, *Kaloongae cheaoe, Chiplae cheaoe, Kotuchae cheaoe, Chamrae cheaoe, Konnae cheaoe, Jharae cheaoe, Tuktuke cheaoe, Giddae cheaoe* etc; however, edible and medicinal value of about 200 such species have been in known (Das, 2010). In addition, there are most common species of mushrooms and their descriptions in the KL-India Appendix 5A.19.

5A.22.6 Orchids, as potential bioresource in KL, India

Sikkim is one of the richest hot spots for orchid diversity with 523 species, in Indian Himalaya (see Figure 2); whereas, comparatively, there are about 244 orchid species in Trans, north-west and west Himalayan regions (Lucksom 2007). Categorized as an endangered group, due to environmental degradation and habitat depletion, orchids have proven to be highly vulnerable to climate change (Lucksom 2007).

5A.23 Fuel wood resource

The huge rural sector and traditional life-style of KL, India make big space for using fuel wood from natural forests as well from the from agro-forestry fields and village landscape. Over 66 species of fuel wood species diversity has been reported with assessment of their energy value (Rai *et al.,* 2002) for KL, India. Figure 5A.13 provides some of the top quality fuel wood species from KL, India.

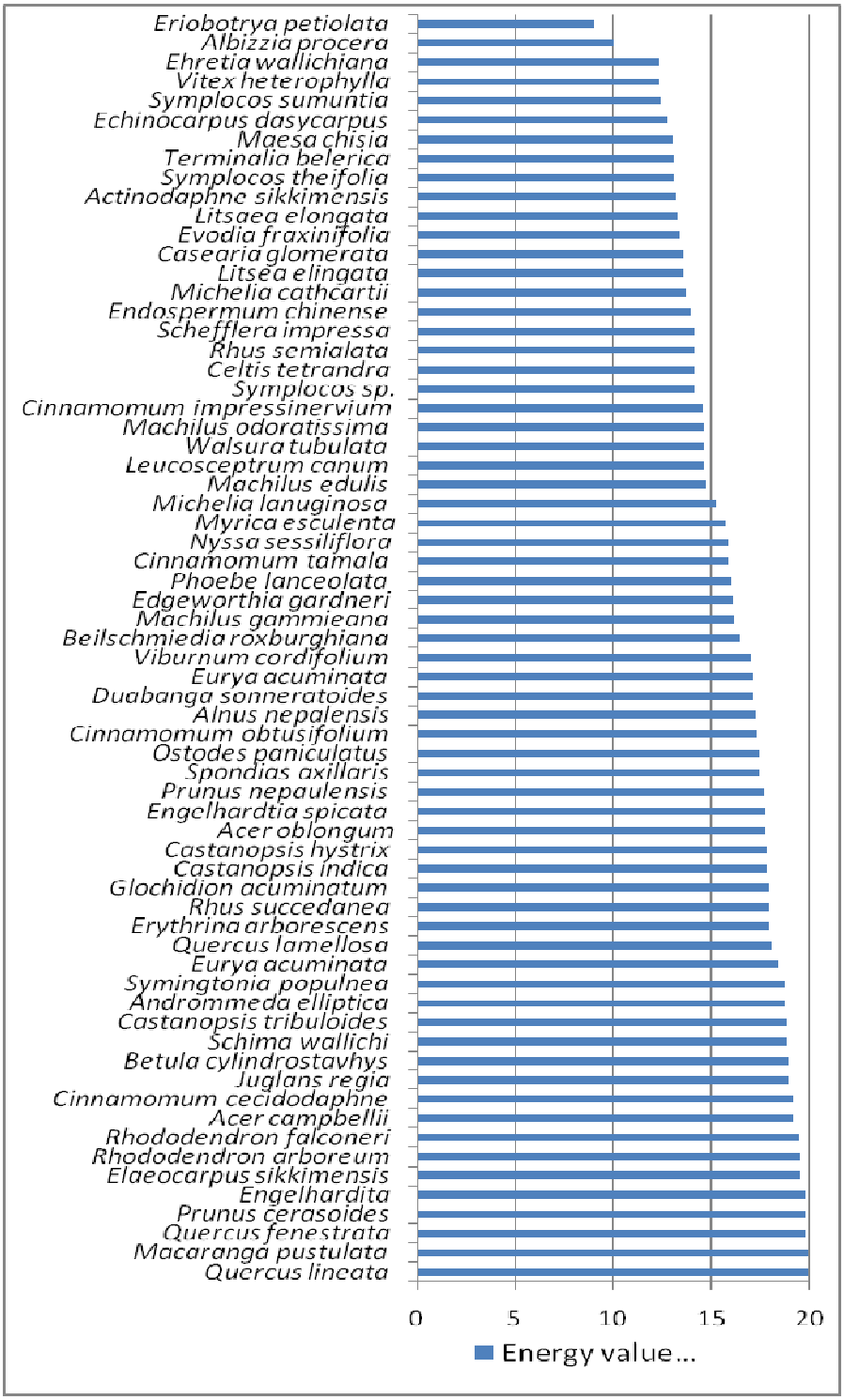


Figure 5A.13 Importatant fuel wood use species of Khangchendzonga landscape, India (Graphical representation, based on Rai YK *et al.*, 2002)

There are many other minor forest produce such as timber, fodder, fibre from KL, India, having excellent availability.

`

Chapter 5B: Biodiversity and ecosystem services

5B.1 Agro biodiversity in Khangchendzonga landscape, India

The evolution of agrobiodiversity is the result of mankinds' efforts over thousands of years applying adaptive management in the utilization and cultivation of biodiversity from wild to meet out food and livelihood securities (Brookfield *et al.*, 2003). The Food and Agricultural Organization (FAO) defined agrobiodiversity as the variety and variability of the biodiversity resources used directly or indirectly to meet the various daily necessecities including food, fodder, fibers, fuels, pharmaceuticals. In addition to providing the income, it also performs ecological services essential to human survival, such as nutrient cycling, pest and disease regulation and pollination. All over the world, farmers have been conserving a wide range of overall biodiversity of the region by sustaining agrobiodiversity in their agriculture fields or farmlands and their surroundings. Besides the soil factors and the climatic condition the cropping system of a particular region is determined by the guiding principles of potential productivity and monetary benefits of the farmers. In the current scenario, there are several widespread threats to agrobiodiversity, such as, habitat fragmentation and habitat loss, increasing human population, socio-economic transformation and consequent diversion of farmers, substitution of indigenous breeds and varieties to modified ones, growing demand for food security, rapid change in land use, etc. (Badola, 2009) further narrows down the decision to the choice of cropping system in any particular region. For Khangchendzonga landscape, India, many studies are focusing these different aspects. Traditional agricultural heritage systems are reviewed for Sikkim (Sharma and Dhakal, 2011), agrobiodiversity in Sikkim elaborated by Sharma *et al.* (1992), Pradhan *et al.* (2004), Badola (2009), Rahaman and Karuppaiyan (2011), and for West Bengal by Bhattacharya *et al.* (2008), etc. Crop diseases and management was highlighted for Sikkim (Srivastava, 1998).

5B.2 Land use systems in agriculture

KL -India offers varied agro-climatic conditions for sustaining a huge diversity of cropping along great altitudinal amplitudes. Out of total geographical area 14126.36 Km^2 of KL, India, the agricultural land use systems occupy varied space, i.e. for the Jalpaiguri- 622,700 ha; Darjeeling- 325,460 ha; and Sikkim- 709,600 ha. Total net area under cultivation in the landscape is approximately 575,130 ha (Jalpaiguri- 335,726 ha; Darjeeling- 160,140 ha; Sikkim- 63,250 ha) Figure 5B.1 shows the percentage of availability of cultivable land within the Landscape. In addition, the total operation land of approximately 784,750 ha contributes in the landscape for agricultural purposes and out of this the district Jalpaiguri (include the bifurcated part of district Alipurduar) area occupy maximum area i.e. 57 % as compared to Darjeeling (i.e. 28 %) and Sikkim (i.e. 15 %) (Figure 5B.2).

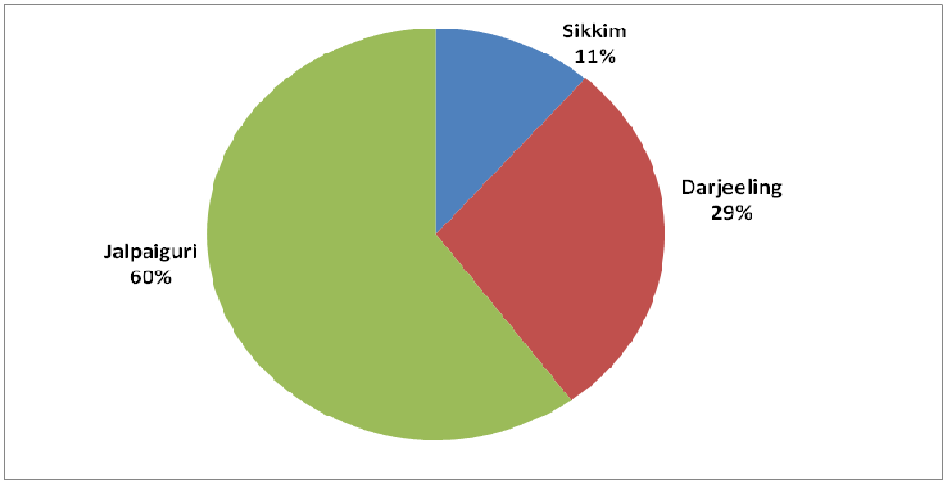


Figure 5B.1 Cultivated land under KL- India (Modified figure using data from Agricultural contingency plan for district Jalpaiguri and Darjeeling; Annual Progress Report 2009-10, Food Security and Agriculture Development Department, Government of Sikkim)

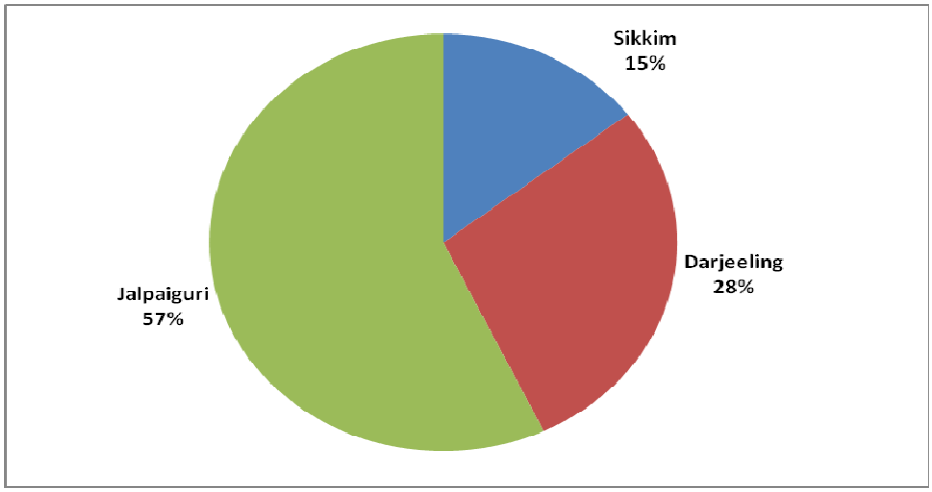


Figure 5B.2 Operational land under agricultural system in the KL-India (Modified figure using data from Agricultural contingency plan for district Jalpaiguri and Darjeeling; Annual Progress Report 2009-10, Food Security and Agriculture Development Department, Government of Sikkim)

5B. 3 Crop diversity

In KL-India, the two areas, i.e. Sikkim and Darjeeling of the Eastern Himalaya are the part of 22 agrobiodiversity hot-spots of India (http://www.plantauthority.gov.in/hotspots.htm, accessed on 27 January 2014). Agriculture is the main livelihood option to more than 64 % of population and contributes to around 11 % of the Gross State Domestic Product (IPR 2013). KL-India houses a diversity of agro ecosystems, farming cultures, agro climatic regimes, traditional landraces, and local livestock breeds, that gives rise to rich agro biodiversity. The local and indigenous communities in KL, India have been maintaining traditional tested and adapted innovative strategies for conserving and harnessing native agro biodiversity, primarily for food security, and for the improvement of their livelihoods The variation of crop diversity of the landscape is briefly provided in Table 5B.1

`

Table 5B.1 Crop diversity of Khangchendzonga landscape, India

Locations	Crop diversity
Jalpaiguri (with newly bifurcated district of Alipurduar)	• **Cereals-** Autumn rice (local), Autumn rice (HYV), Winter rice (local), Winter rice (HYV), Summer rice, Wheat Maize, etc. • **Oilseed**s- Rape and mustard, Sesamum, Linseed, Niger, Groundnut, Kalai, Lentil, etc. • **Pulses-** Moong, Arhar, etc. • **Jute** –Capsularis and Olitorius • **Vegetables**: Tomato, Tomato, Onoion, Chili, Cauliflower, Cabbage, Brinjal, Peas, Gourds, Cucumbers, Radish, Carrot, Green vegetables, etc. • **Species**- Turmeric, Ginger, etc. • **Fruits**- Coconut, Jackfruit, Arecanut, Litchi, Pineapple, Banana, Mango, etc.
Darjeeling	• **Cereals-** Rice, Wheat, Maize, Ragi, Barley, • **Psuedo-cereal** -Buckwheat • **Pulses**- Urd, Rajma, Mung, Rice Bean, etc • **Oilseeds-** Yellow Sarson, Brown Sarson, Toria, Rayo, Soybean, etc • **Vegetables**- Potato, Chili, Okra, Peas, Beans, Cowpea, Tomato, Cucumber, Squash, Radish, Pumpkin, Gourd, Bitter Gourd, Cabbage, Cauliflower, Broccoli, Tapioca, Sweet Potato, Fenugreek, Coriander, Palak, Onion, Garlic, etc • **Spices-**Large Cardamom, Ginger, Turmeric. • **Fruit**s-Mandarin, Pineapple, Jackfruits, Coconut, Banana, Mango, Litchi, and Temperate fruits. • **Ornamental plants**- Orchids, etc • **Medicinal plants**
Sikkim	• **Cereals-** Rice, Wheat, Maize, Ragi, Barley, etc • **Psuedo-cereal-** Buckwheat • **Pulses-**Urd, Rajma, Mung, Rice Bean, etc. • **Oilseeds-**Yellow Sarson, Brown Sarson, Toria, Rayo, soybean, etc. • **Vegetables**- Potato, Chili, Okra, Peas, Beans, Cowpea, Tomato, Cucumber, Squash, Radish, Pumpkin, Bitter Gourd, Cabbage, Cauliflower, Broccoli, Tapioca, Sweet Potato, Fenugreek, Coriander, Palak, Onion, Garlic, etc. • **Spices**-Large Cardamom, Ginger, Turmeric, etc. • **Fruits**- Banana, Mandarin, Citrus's fruits, Mango, Avocado, Pineapple, Temperate fruits, etc. • **Ornamental plants**- Orchids, flowering varieties, etc. • **Medicinal Plants**

The literatures like that of Bhattacharya (2008), has been important for the study of crop diversity of Darjeeling and Jalpaiguri with Alipurduar regarding the fruits cultivation as described in figure 5B4 and shown to have significant crop biodiversity.

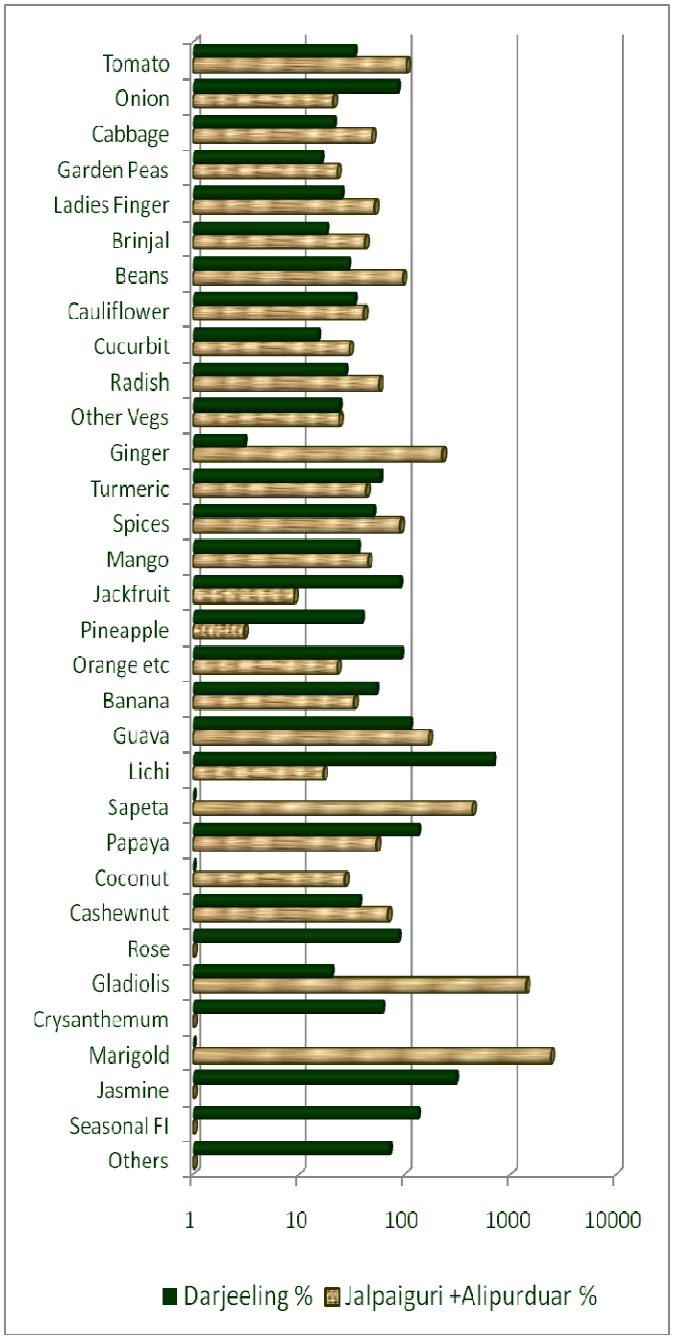


Figure 5B.3 Compound Growth rates (%) of area of high value crops of KL, India (district Darjeeling, and Jalpaiguri with Alipurduar) between 1997-98 to 2004-05 (Graphic representation by GBPIHED, unpublished: based on Bhattacharya, 2008)

Apart from these, information available from the another part of KL-India (i.e. Sikkim), of the total 5,580 plant species (flowering plants including orchids, bamboos, Rhododendrons, tree ferns, other ferns and fern allies, oaks), are obtained, around 550 species have food value, 50 % of which are cultivated species. The *in situ* agrobiodiversity houses a repository of gene pools in the farms that consists of around 130 landraces of cereals (including rice 76, maize 26, millets 8), 49 of vegetables, 40 species of fruits, 36 landraces of tubers/roots, and 22 spices/condiments. As many as 38 fruit tree species are commonly grown in the farms with >200 species of wild edibles naturally grown in the farm-based, forest-

based and cardamom-based agroforestry (Sharma G; personal communication). More than 119 species of multipurpose agroforestry trees (timber, fuel-wood, fibre, fodder, soil binder in terraces, minor construction material etc.) have been recorded. While 52 crop species are socio-culturally important and 69 species are essentially sacred to the indigenous communities.

A centre of agrobiodiversity at sang, East Sikkim Khangchendzonga landscape of India (Photo: G. Sharma)

The existence of □-diversity in several crops is high (maize, rice, millets etc.). There are over six sub-landraces of maize such as "*Pahenli-makai*" and "*Seti makai*" or three to four sub-landraces of traditional rice varieties, e.g. "*Ättay*" and "*Bacchhi*". These sub-landraces are agro climatically suited in the local conditions as regular crops and are exchanged among the farmers upstream and downstream. The agrodiversity houses a rich repository of protein banks with 14 Rajmah (Kidney Beans) landraces, 7 landraces of Rice Beans, 9 landraces of chillies, 9 landraces squashes, and 4 of ginger. The genetic diversity of large cardamom (*Amomum subulatum*) is high with 7 species (*A. linguiforme*, *A. kingii*, *A. aromaticum*, *A. corynostachyum*, *A. dealbatum*, *A. costatum* and *A. plauciflorum*), naturally occurring in the region. While, local cultivars developed by indigenous plant breeders are *Ramsai*, *Sawney*, *Madhusey, Bharlang* (cultivated >1500 m), *Chibey*, *Ramla, Ramnang* (1000−1500 m), and *Golsai* and *Seremna* (1000 m) (Sharma G; personal communication). The diversity of underutilize or lesser-known crops is very high (>250 species) in the KL-India and considered as poor-man's food at high elevational zones (Sharma G; unpublished). Sundriyal and Sundriyal (2003) have reported 190 food plants growing in the wild in part of landscape (Sikkim). Some lesser known crops such as finger millet, cow peas, perilla, yams, fox-tail millet, barnyard millet, amaranths, chenopods, gourds (bottle, ash, bitter, sweet, sponge) fenugreek, niger, sunflower, linseed, common legumes (black gram, broad bean, common French bean, cow pea, field pea, garden pea, green gram, horse gram, lentil, red gram, rice bean, soybean, urd), buckwheat (*Titey phapar*, *Mithey*) are commonly grown in the farms for a variety of reason such as the food, medicinal or cultural value (Sharma G; unpublished, Badola, 2009). Crop diversity under traditional farming system and landraces is quite feasible exclusively for the area (Darjeeling and Sikkim) of KL-India (Appendix 5B.3).

`

5B.3.1 High Yield Varieties of crops in KL, India: an approach to improve productivity

In recent years, various high yielding varieties of crops are introduced in KL, India; the Table 5B.2 provides some of the HYV of demand.

Table 5B.2 Some introduced HYV of crops in the traditional farming landscapes in Sikkim Himalaya (Sharma G 2014, personal communication)

Sl. No.	Crops	Hybrids, HYVs or Improved varieties introduced
1	Rice	Pant Rice-10, VL-85, VL-62, VL-82, VL-206, PD-10
2	Maize	Navjot, Aparanji Mixed, Suan Mixed, Devki Mixed, Shankar C-1415, Shankar C—1837
3	Wheat	Sonalika, UP-262, VL-738, HD-2687, PBW-343
4	Finger Millet	Endaph-9, VL-Mandua-146, Maski-5
5	Barley	VL-46, VL Barley-1
6	Buck Wheat	VL Unal-7, PRB9001
7	Rajmah	PDR-14 (Udaya), VL Rajmah-63, Kannauri, Jwala
8	Rice Bean	PRR-2
9	Mustard	Bold Agrani
10	Yellow Mustard (Sarsoon)	Sikkim Sasoon-1, B-9
11	Soybean	PK-1042, PK-1024
12	Pop-corn	Madhurai Queen, Golden, Amber, Amber Mixed
13	Masoon dal	Pant Masoori-4, VL Masoor-4, Sapna
14	ARhar dal	ICPH, Pusa-85
15	Moong Dal	K-851, PCM-11, Pragya

5B.4 Horticulture crop diversity

Horticulture is one of the major economic activities of the people in the entire landscape. Utilization of area under vegetable farming comprises 188,720 ha land in the entire Khangchendzonga landscape of India out of which the areas used for vegetable farming by different regions are shoen in figure 5B4.

5B.4.1 Ginger

Ginger (*Zingiber officinale* Rose), locally called 'Adua' is an important spice crop grown in entire landscape of Khangchendzonga India from 40 – 1500 m asl. The crop is a good source of income for small and occupying 10,457 ha total area under cultivation in the entire landscape and maximum area under cultivation comprises from Sikkim- 7,557 ha (72 %) and followed by Darjeeling- 2,200 (21 %) ha and Jalpaiguri-700 ha (7 %) (Figure 5B.5). The quantum of ginger going out of the state ranges from 18,422 tonnes to 22,600 tonnes about 40-50 % of the produce is retained as seed. The important markets dealing with ginger in the state are Naya Bazar-Reshi (3 %), Singtam (25 %), Jorethang-Namchi (20 %), Melli (15 %), Pakyong (3 %), Rangpo (3 %) and other (4 %).

Vegetables cultivation in the Khangchendzonga landscape, India (Photo: K Gaira)

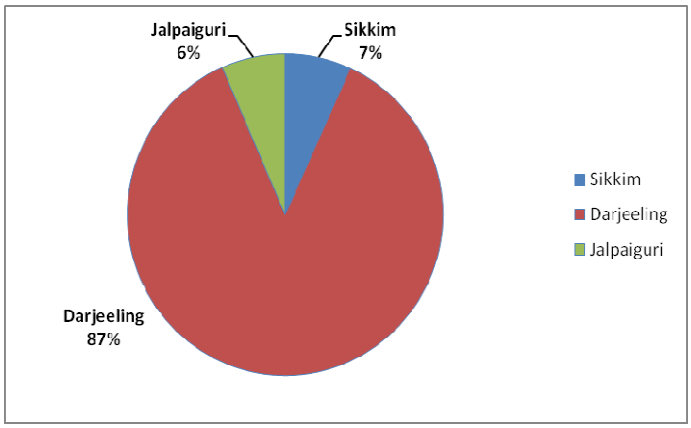


Figure 5B.4 Area under vegetable farming in the KL, India. Modified figure using data from Agricultural contingency plan for district Jalpaiguri and Darjeeling; Annual Progress Report 2009-10, Food Security and Agriculture Development Department, GOS)

There is a ready market for fresh ginger in Sikkim. The main marketing centres are Gangtok Pakyong, Singtam and Rangpo in the East district, Gyalshing, Reshi, Legship and Nayabazer in the West district Namchi, Jorethang and Melli in South district and Mangan and Dikchu in the North district of Sikkim. Delhi market is the major consumer of Sikkim ginger (70 %) followed by Punjab (10 %), Uttar Pradesh (10 %), West Bengal (5 %) and other (5 %). Most of the ginger coming to Delhi is further traded with other markets in other states.

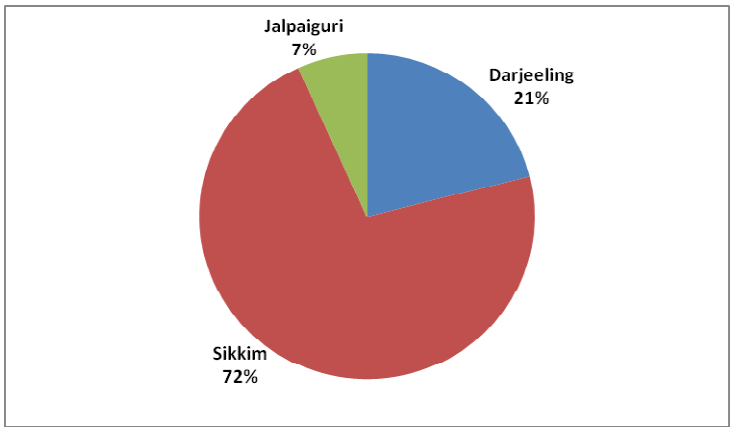


Figure 5B.5 Area under cultivation of ginger in the entire KL, India Modofied figure using data from Agricultural contingency plan for district Jalpaiguri and Darjeeling; Annual Progress Report 2009-10, Food Security and Agriculture Development Department, GOS)

5B.4.2 Floriculture

Khangchendzonga landscape of India is a paradise for flowers. *Gladioli, anthuriums, lilliums, primulas, rhododendrons, orchids* as well as many other floral species flourish here. Only Sikkim part of the landscape is home to an amazing 450 species of exotic orchids alone. The Khangchendzonga landscape Himalaya is the centre of origin of an important orchid species *Cymbidium*. Other valuable orchids of commercial importance available in the region are *Coelogyne, Dendrobium, Paphiopedilum, Pleione, Rhyncostylis* and *Vanda*. There is immense potential for developing floriculture on a commercial basis here, and the department of Horticulture is making concerted efforts to turn this sector into an export-oriented industry.

5B.4.3 Fruits

Khangchendzonga landscape of India is a rapture for fruit crops, it covers approximately total area 152,198 ha and maximum area under fruits comprises from Darjeeling (90 %), while other part occupy 10 % area (i.e. Sikkim- 7 % and Jalpaiguri- 3 %) (Figure 5B.6). Darjeeling district having a wider climatic gradient and covers Himalayan slope and terai land well as, is quit suited for both temperate and tropical fruit cultivation. Mainly, Darjeeling covers a large area under Pineapple, Coconut, Mandarin, etc. As considering tropical and sub-topical zone and comparatively, Jalpaiguri have less area under fruit, mainly it grows tropical fruits like Coconut, Arecanet, Jackfruit, and Papaya. Apart from these, Mandarin fruit is grown in Sikkim largely as compared to the Darjeeling and Jalpaiguri district of West Bengal in the lower elevation zone of the state.

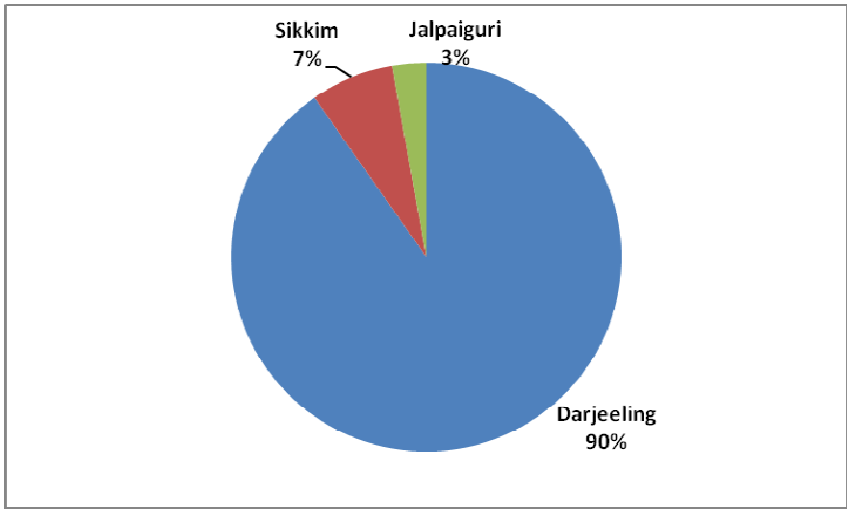


Figure 5B.6 Area under fruit in KL-India **(Source:** State contingency plan for Darjeeling and Jalpaiguri**;** GoS 2001; Achievement Report Achievement Report 1975-2010; DESME (2002, 2006-07); Annual Progress Report 2009-10, Food Security and Agriculture Development Department, GOS)

Amongst commercial fruit crops, Mandarin orange is a most important of the landscape especially in Himalayan part i.e. Darjeeling and Sikkim. Mandarin farming has been gradually progressed in the Sikkim, covering total area about 6,300 ha, having a total average annual production of about 10,479 tonnes, as compare to the Darjeeling area, where, it covers about 500 ha area. The main orange producing areas are the Tista and Rangit river valleys within the elevation range of 600 to 1500 m asl in the landscape. However, in recent years, emphasis is given on cropping

multiple varieties of horticultural crops including fruits and tubers in the home-gardens, which not only help sustaining the rural food supplements but a mean of economic earning to villagers. Appendix 5B.1 provides some of the important horticultural crops being grown in KL, India.

5B.4.4 Cash crop-Large cardamom

Large Cardamom (*Amomum subulatum* Roxb), a member of the family Zingiberaceae, is another main cash crop cultivated in the sub Himalayan part of the Khangchendzonga Landscape India. Mainly, the crop is cultivated under agroforestry system in Darjeeling and Sikkim area between 600-2000m elevations and cover 18,004 ha approximately total area under cultivation. Maximum area under cultivation comprises 73 % in Sikkim as compared to Darjeeling 27 % (Figure 5B.7). There are mainly six popular cultivars of large cardamom viz., Ramsey, Ramla, Sawney, Varlangey, Seremna and Golsey. Indian Cardamom Research Institute in the year 2004 released two high yielding varieties viz. ICRI Sikkim 1, ICRI Sikkim 2 for cultivation in Sikkim and Darjeeling. These varieties are selected from Sawney and now are mostly used in Tissue culture for planting material production. In Sikkim, large cardamom is cultivated in an area of about 13,204 ha, with a total average annual production of about 2,970 tonnes. In particular, Sikkim Himalayan state of India is contributed nearly 57 % of world's total production (Sharma *et al.,* 2000). In addition, large cardamom crop is considered as cost effective as compared to the other crops due to less labour-intensive and non-nutrients exhaustive (Singh *et al.,* 2005).

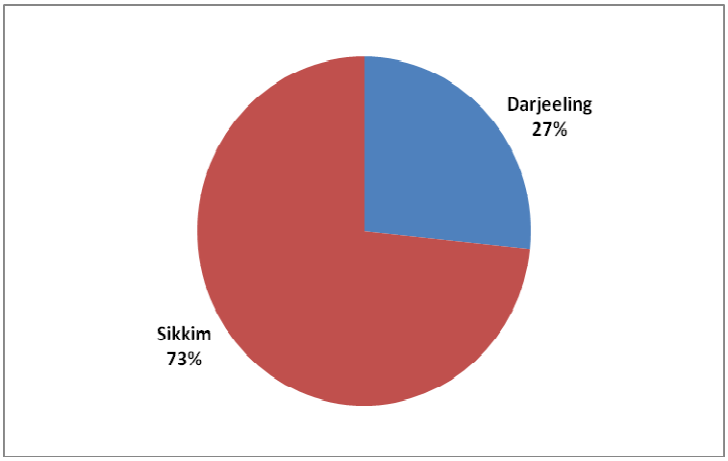


Figure 5B.7 Area under large cardamom in KL-India

5B.5 Major bottlenecks/problems in the Horticulture in KL, India

Having such a great potential in the horticulture sector still the landscape is not able to achieve its envisaged targets due to some constrain on both government as well as farmers part. Limited knowledge about the marketing and limited infrastructural faciloities. Non-flexibility among farmers/growers towards implementation of improved production practices has become one of the major problems for the government to deal with. The absence of a supply chain to link farmers with the market, has kept horticultural production at fairly low levels. The cultivation of cash crops also faces similar problems.

The review suggests following are some important recommendations on horticulture sustainability in Khangchendzonga landscape in India:

`

- The need of land use planning, clear demarcation of land for different uses
- Filling of gap between Scientists of research institutes of the region and the local farmers and the need to formulate policy to encourage the use of modern technology and more scientific techniques to transfer technologies from lab to land.
- Growing encouragement among farmers or youths to adopt the horticulture for their livelihood
- Development and distribution of good planting material development and strengthening post production infrastructure and facilities
- The need to review on policy on organic farming, in Sikkim especially towards implementation feasibilities at scientific level,

5B.6 Livestock diversity

The livestock is the principal source of farm economy to the farmers in the Khangchendzonga Landscape in India.. The local breeds of many domesticated animals are largely suited to the environment and geographical conditions of KL, India and support farmers/herders for their livelihoods (Appendix5B.2). Many progressive entrepreneurs rear crossbred cattle in the lower part of landscape. The community's reliance on a diversity of animal products and further conviction that the diversity helps overcoming any possible decline in productivity, has been the key of maintaining livestock diversity in traditional grazing systems (Coppock *et al.,* 1986; Brookfield *et al.,* 2003; Badola, 2009). In addition, yak rearing in high altitude and alpine zone of landscape is practiced wherein, two types of Yak (breed *Gargu*) i.e. big-bodied yak is called Bho and small-bodied yak is called Aho.

5B.6.1 Sericulture

In the KL India, due to its distinct climatic and geological features, Jalpaiguri and Alipurduar (north Bengal) has rich potential in sericulture development because the area is a potential supplier of seeds for mulberry cultivation to the other areas. As per the information available, area under mulberry cultivation is 158.4 ha. The average productivity of cocoon in the district is 750 kg/ha. The reasons for gap in the yield is inadequate inter culture operation, non-application of manure, lack of technical knowledge, etc. In addition, ericulture is another area which is practiced traditionally in the lower part of the landscape depending on its naturally growing castor plants by the poor tribal people. Systemic plantation has to be maintained to encourage the ericulture (**Source:** CDAP 207-12).

5B.7 Ecological zonation of agrodiversity in the KL-India

Agrodiversity of KL-India is categorized into four prominent agro-ecological zones, extending from 40 to 5500 m; (1) Pastoralism/agropastoralism in the Alpine and Trans Himalayan zones (4000–5500 m), (2) Mixed farming (subsistence agriculture) in the temperate zones (2500–4000 m), (3) Traditional agroforestry systems in the subtropical to warm temperate zones (600–2500 m), and, (4) Terrace rice cultivation-based mixed farming in the sub-tropical zone (below 300 m). For the agrobiodivesity management in KL, India, following agrobiodiversity systems are characterized with various attributes (Table 5B.3).

Table 5B.3 Adaptability of management systems and their attributes of agrodiversity in the Khangchendzonga landscape, India

Management Systems	Characteristics of the agrobiodiversity
Alpine/Trans-Himalayan agropastoralism (> 4000 m)	• Yak, sheep and goat grazing • Rotational grazing; sharing of grazing pastures, seasonal movement of animals as per resources availability • Forage production for lean season has been started • During non-snow seasons communities grow potato, cabbage, leafy vegetables, barley, medicinal and aromatic plants at Lhonak valley (Muguthang area), Dambuchey-Bamzey area, Thangu, Yumesamdong, Phadamchen-Jaluk, Hiley area in North Sikkim • A variety of animal products (alpine cheese, yak butter, meat, wool, traditional carpets, etc.)
Traditional agriculture practices (300-4000 m)	***Diversity of crops and associated species*** • Large number of landraces of rice, maize, buckwheat, beans, pulses, finger millets, yams and tubers, and ginger are grown in rotation • Inter-cropping (mandarin-based intercropping, ginger-maize, paddy-soybean, pulses-turmeric, maize-potato and vegetable crops are practiced as understory crops) • Incorporation and cultivation of high value cash crops e.g. large cardamom, mandarin orange, ginger and potato in the different agro-ecological zones under the integrated farming • Green manuring, and growing nitrogen fixing species (*Alnus nepalensis, Albizzia* spp., *Erythrina* spp., Legume crops).
	Agroforestry systems • Diversification of agroforestry systems such as farm based agroforestry, forest-based agroforestry, and high value cash crop-based agroforestry (large cardamom, mandarin orange, ginger, broom-grass) • Agroforestry ensures multiple production options and services
Irrigated/terai agriculture practices <300	***Diversity of crops and associated species*** • Monoculture practices i.e. Rice cultivation in three crop seasons; Jute cultivation • Large number of landraces of Rice, Potato, Mustard, Wheat, Vegetable are grown in rotation • Inter-cropping (Coconut-based intercropping, Arecanut, ginger-maize, paddy-soybean, pulses-turmeric, maize-potato and vegetable crops are practiced as understory crops)

5B.8 Indigenous soil and water conservation practice diversity

Mishra and Rai (2013) have studied the soil and water conservation practices in the KL India indicating the practice of several structural and biological land management practices by the farmers passed on to them by their ancestors. In which, different indigenous practices like; terrace cultivation, construction of retention walls, bunds, construction and maintenance of waterways, mixed cropping, crop rotation, mulching, agroforestry and use of farm yard manure are adopted in the landscape for conserving soil and water (Table 5B.4).

Table 5B.4. Brief description of Indigenous soil and water conservation practices diversity in agrodiversity in Himalayan part of KL-India.

Terminologies and measures		**Description**
Terminologies used in the context of hill farming system	Hill slope	Sloping land between valley floor and ridge
	Terrace riser	Steep slope between terrace of different altitude
	Farm edge	Farm boarder
	Goth	Makeshift livestock shed constructed in the farm terrace
	Slicing terrace riser	Thinly slicing of the slope between terrace by spade to remove weeds and grasses
	Panikhet	Irrigated rice field located in the valley floors and foothills
	Tarikhet	Rainfed rice field located in the hill slope
	Khet	Common local term for both *panikhet* and *tarikhet*
	Packo/Bari	Rainfed maize and millet field
	Gharbari	Homestead used for fruit, maize, wheat, millet and vegetable production
Measures of soil and water conservation	Terrace	Narrow strip of land carved out across the hill slopes of control water flow
	Terrace bund	An embankment at the outer edge of *khet* terrace made to control water flow
	Contour bund	An embankment built along the contour line to control soil erosion and siltation
	Waterway	Small canal at the inner toe of terraces made to convey runoff at a non-erosive point
	Retention wall	A reinforced wall constructed to protect terrace riser from being collapsed
	Alley cropping	Alternate rows of field crops and perennials grown in a contour pattern in sloping land
	Shrub formations in gullies	Bush formations, including bamboo, in gullies established to control gully expansion in the hill slopes.
	Vegetative measures of landslide control	Establishment of different shrubs and tree species with extensive root systems for rehabilitation and control of landslides
	Mulching	The practicing of covering the plowed land by crop residues and leaf litters for moisture and soil nutrients
	Farmyard manure	Dung mixed with leaf litter and crop residues used for fertilizing land
	Green manure	Plant species containing soil nutrients
	Compost	Decomposed mixture of organic materials, including manure, utilized for fertilizing land

(**Source**: Mishra and Rai, 2013)

5B.9 Agrodiversity and eco-system services in the KL-India

The agrodiversity of the landscape provides a number of goods and services that are of vital importance for humans and for the functioning of ecosystem (Badola, 2009). The land use systems provide the basis for the delivery of tangible benefits such as food, energy, water, air etc. and intangible use of non-use value to the

mountain societies (Sharma and Rai 2012). These services are divided into four categories (based on MEA, 2005), viz.,

1. *Supporting services*: The agrodiversity landscapes support primary and secondary production, biogeochemical cycling of nutrients, provision of habitats, and agro-biodiversity, which is necessary for sustaining the goods and services that mountain societies need and enjoy from these ecosystems for their well-being.
2. *Provisioning services*: The agrodiversity landscapes provide agriculture products such as food (crops, roots, tubers, seeds, nuts, fruits, tubers, fodder, spices, etc), construction materials (timber), energy (fuel woods), fiber (wood, textiles) and medicinal and aromatic plants.
3. *Regulating services*: The agrodiversity landscapes and forest ecosystems are critically important for carbon sequestration, water and climate regulation, pollination, protection from natural hazards such as floods, landslides, avalanches etc, water and air regulation, and disease and pest regulation.
4. *Cultural services*: For agrodiversity in the KL, India, the *Demazong* sacred landscape is the centre of spiritual, cultural and aesthetic importance. Traditional mountain societies conserve, preserve and protect these ecosystems for the present and future generations.

A diversity of ecosystem services is bestowed by the agrodiversity elements of Khangchendzonga landscape in India is given in Table 5B.5.

Table 5B.5 Range of ecosystem services bestowed by Traditional Agroecosystems in spatial scales (based on Sharma and Rai, 2012, after Kremen, 2005)

Ecosystem Services	**Spatial scale**		
	Farm Level (local)	**Khangchendzonga landscape**	**Himalaya** (regional)
Net Primary Production			
Food production, NTFPs, Lesser known/Underutilized crops, medicinal plants etc.			
Timber, fuel wood, litter			
Disease and pest control			
Pollination and seed dispersal			
Soil fertility maintenance and enrichment			
Control of soil degradation, stabilization and erosion			
Fresh/clean water			
Flood control and flood mitigation			
Fresh/clean air			
Carbon sink, carbon sequestration in diverse land use			
Biodiversity (hot-spot)			
Sacred landscape (aesthetic/cultural/spiritual value)			

5B.10 Agrobiodiversity Assessment and Factors to Work Upon

For sustainable use and conservation of biodiversity for long term basis, assessment of agrobiodiversity resources is pre-requisite, which needs to be addressed at four fundamental level for any region, *i.e.* genetic level, species level, ecosystem, and very importantly the landscape as a unit. For that, prioritization of agrobiodiversity components is necessary. Assessment of existing agrobiodiversity resources for quality and quantum availability, their use and socio-economic dimension, and

current threats towards genetic erosion, and monitoring are vital. Documenting and analyzing causes/consequences on extinction or under extinction of crops, varieties and/or landraces, and the genetic loss in faunal genetic resources would immensely be helpful to conservation management and planning of agrobiodiversity (Badola, 2009). Gene conservation at *in-situ* as well as *ex-situ* level is the parallel line of execution of planning. Community level demonstrations are crucial in helping farmers to get confidence on adopting scientific-based and tested technologies and approaches. It depicts factors addressing to animal as well as plant genetic resources. There are not many wild relatives possessing genetic variations between individuals, within breeds and between breeds in case of animal genetic resources; in small populations, inbreeding and random genetic drift can be observed commonly, as vital factor in maintaining their sufficient population size, as here, the *ex-situ* conservation is difficult, relatively.

Chapter 6: Resource Management Systems

6.0 Background

In recent decades, assessment of forests, wildlife and their interaction with human being has emerged as one of the critical areas of research. There are, however, many gaps in interactions between them, which comprise issues like depletion of forested areas, loss of habitat of wildlife, human-wildlife conflicts (HWC) etc. Nonetheless, several Acts as well as Statutory Rules and Regulations are in force at all parts and regions of India for regulation, protection and management of environment. The Environment Protection Act, 1986 is encompassing all central Acts dealing with environmental regulation in the States. To deal with the protection, restoration and conservation of forests the Forest (Conservation) Act, 1980 is the main statute. Likewise, for dealing with issues concerning the prevention, cure reduction and removal of water and air pollutants, the Water (Prevention and Control of Pollution) Act, 1974 and the Air (Prevention and Control of Pollution) Act, 1981 are in place. The Wild Life (Protection) Act, 1972 deals with the protection of the wildlife from depletion and harm due to human activities. For providing clearances by the Forest department of any state to a project(s), which is undertaken, that might interferes with or pass through a forest land, the Forest (Conservation) Rules 1981 deals with the same.

Most of the Rules and Regulations that are enacted under the legislations within the central government statues are applicable in the State. Hence, most of the Rules made under The Environment Protection Act, 1986 are applicable in either states of KL, India. These Rules address and resolve the issues like management of hazardous wastes and substances, trans-boundary movement of waste, bio-medical waste, etc. In addition, the Rules made under the specialized statutes dealing with air, water, etc. deal with the regulation of pollutants, standards of emission of effluents and air particulates, efficient discharge of sewage and hazardous wastes/pollutants, etc. In addition to above, the Executive Notifications and Orders in exercise of Delegated Legislation also are applicable relative to its requirement for and at any states in India. With the help of notices, office orders, etc., environmental regulation is also undertaken whereby the special powers given to different authorities under the laws function. By exercising these powers, most of the State specific initiatives in the protection of the environment and promotion of environmentalism are undertaken. Concerning KL, India, until date, the Sikkim state has initiated many programmes and projects in the promotion of environmentalism and creation of awareness on the protection of the environment. The Sikkim Green Mission, Paryavaran Mahotsav, Ten Minutes to Earth Tree plantation drives and National Environment Awareness Campaigns with various subthemes related to the environment amongst several important initiatives of the state government.

From time to time, several conflicts and disapproval have come up in regard to the execution of Acts/Rules at some parts of the country, which have paved way for elimination of discrepancies in the Statutory Regime and decisions of Courts and Tribunals. Usually, there are but few inconsistencies in the operation of laws, rules and regulations as central laws relating to the environment operate in the State without the requirement of any State amendments. However, in the case of land and rights to the environment of the Scheduled Tribes, many conflicts arise when there are differences in the operation of the laws. The operation of Article 371F which gives primacy to the rights of the Schedule Tribe and their local and customary laws, that

also mean the conflicts and inconsistencies arises in the statutory regime and consequently the decisions of the Courts. These local and customary laws and their conflict with the centrally legislated laws have been seen in cases of use of land resources, forest rights, natural resources and cultural and social notions in the idea of the environment and its relevance.
How the resources are shared and managed is the pedestal over which resource governance system stands. Varied management regimes that have strength in influencing human behavior to achieve agreed-upon goals, durability over time, and a robust capacity to survive the destabilizing forces are required for the effective governance. The main scheme of such system should fit appropriately with ecological and institutional factors as because what works at one setting may be not be suitable for other situations. Often, resource management has been found to be scale-dependent as what works at one level (local) may not be effectual at higher (country, region or global) level.

6.1 Forest management

For the effective functioning of territorial division, forest management and protection are two main functions. The governments of either state (Sikkim and West Bengal) in Khangchendzonga landscape (India) have addressed these vital issues in recent years in view of creating and ensuring a motivated field staff, sound legal enactment, efficient and effective transport and communication, accommodation facilities, self-defense and uniforms, etc. In KL, India, the Sikkim government has brought about vital amendments in the present forest, water courses and road reserve (Preservation and Protection) Act, 1988 (Amendment 2000) to make the specified clause more stringent and harsh in enforcement. The illegal felling of trees, encroachment and grazing in the Reserve Forest have been made non-bailable offences; in which, provision is available for formally implement various national Acts and rules. Additionally, in respect of natural resource management and biodiversity conservation the Sikkim state posses some of its own law and rules, viz. The Sikkim Fisheries Act 1980, The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act 1988, The Sikkim Forests Rules 1998, Sikkim State Biological Diversity Rules, 2006). The state has recently come up with a very comprehensively drafted having prioritization of issues and identifying potential institutions to take up desired tasks, the Sikkim Biodiversity Action Plan (2012). Earlier, a strategy and action plan for biodiversity conservation, the Sikkim Biodiversity Strategy and Action Plan (SBSAP) [Planning Commission, 2008] was available.

Concerning North Bengal part of the landscape, the west Bengal state has been very active in implementing Biological Diversity Act 2002 and Rules 2004 through West Bengal Biodiversity Board. So far the Board have constituted 4 Biodiversity Management Committees (BMCs) in Darjeeling and 2 BMCs in Jalpaiguri (including Alipurduar) district at Panchayat Samiti, Municipality and Block level and have completed preparation of Peoples' Biodiversity Register (PBR) in total 6 BMCs in Darjeeling, Jalpaiguri (and Alipurduar) districts (wbbb.gov.in/bmc.html; accessed on 16-03-2014). The forests of north Bengal provide shelter and protection to various species of wildlife included in the Red Data Book (RDB) and appendices of CITES (Convention on International Trade in Endangered Species of Wild Flora and Fauna).

The status of the forest conservation and management approaches in KL, India include the current position of the forest and suggests further review in the current scenario. With the aim of conserving and governing the rich biological diversity, 23.6

% of the total geographical area of the KL-India (14126.36 km^2) has been brought under protected area network in Sikkim. Wherein, there are 1 Biosphere Reserve (Khangchendzonga BR- 2931.12 Km^2, including transition zone in 2010 (Badola and Subba, 2012) and 7 wildlife sanctuaries. In north Bengal, Jalpaiguri and Alipurduar districts encompasses 7.5 % total area under protected in respect to total geographical area KL-India having 2 national parks, 1 Wildlife sanctuary (Chapramari WS) and 1 Tiger Reserve). District Darjeeling represents only 3.1 % area under PA network of total geographical land of KL-India and have 2 national parks and 3 wildlife sanctuaries.. Of the total PA cover for entire KL, India, i.e. 4,832.2 Km^2, distribution wise, Sikkim shares very large contribution of 69 % (Figure 6.1).

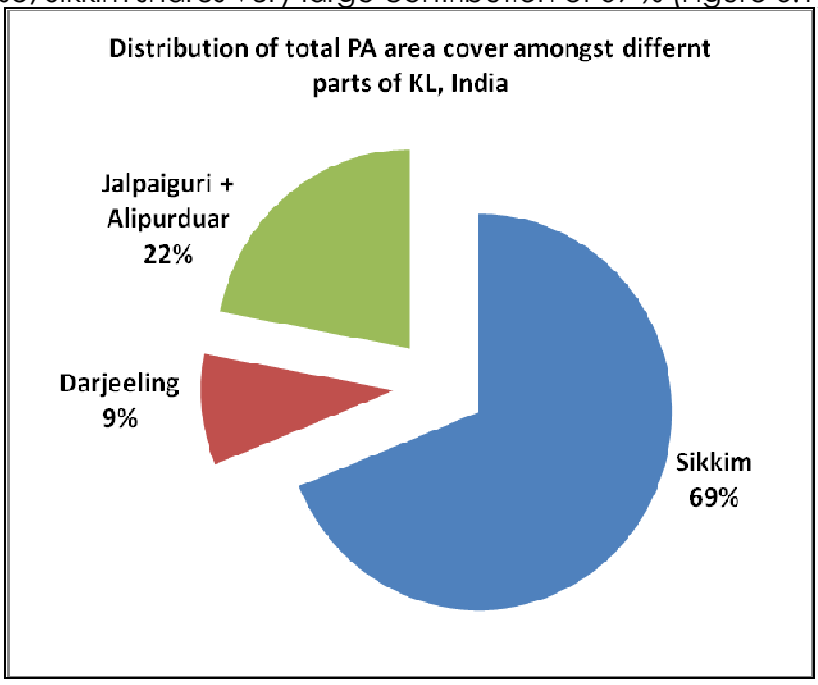


Figure 6.1. Distribution of total protected area cover amongst different part of Khangchendzonga landscape-India (out of total PA cover of 4,729.3 Km^2)

The cumulative PA cover exhibits an increasing trend across years for KL, India, which started with 126 Km^2 in the year 1984 when three sanctuaries in Sikkim were notified, with big expansion in the year 1997. Mainly due to notification of Khangchendzonga National Park (KNP) by the addition of 1784 Km^2 area, that reached to cumulative PA cover of 2872.04 Km^2. Again in the year 2000, keeping KNP as core zone, the Khangchendzonga Biosphere Reserve was notified adding buffer zones (835.92 Km^2), which resulted to expanded area of 4284.14 Km^2. In the year 2010, when an additional area of 311.20 Km^2 was added as transition zone to KBR. (Badola and Subba, 2012), the KL, India final coverage for PA networks reached to 4729.34 Km^2 (Figure 6.2). Again, an area of Neora valley national park was expanded to 158.89 Km^2 in the year 2013, and the cumulative PA cover of KL, India reached to 4832.2 Km^2.

6.1.1 Eastern Duars Elephant Reserve and management

In KL, India, the lower belt of north Bengal, the human-elephant conflict is much pronounced for decades, mainly due to severe habitat fragmentation; of about 529 elephants count in 2010 census, about 250 are concentrated in the protected area of Buxa an Jaldapara. In view of long term conservation and scientific management of elephant populations, a Eastern Duars Elephant Reserve, comprising of Buxa Tiger Reserve and the forests of wildlife division III (Coochbehar) in which the Jaldapara

national park is the major component, within 25^0 58'' N and 26^0 57'' N and 89^0 80'' E and 89^0 51' E, along 400 m to 1000 m asl (977.51 Km^2), was notified by the government of west Bengal. An area of 484 Km^2 is managed as core area, comprising 369 Km^2 of Buxa Tiger reserve and 115 Km^2 of Jaldapara national park. Crop loss through elephant depredation is a major concern to the local people. The other management challenge is the fragmented forest patches due to approximately 170 tea gardens in the area, which elephants use as corridors.

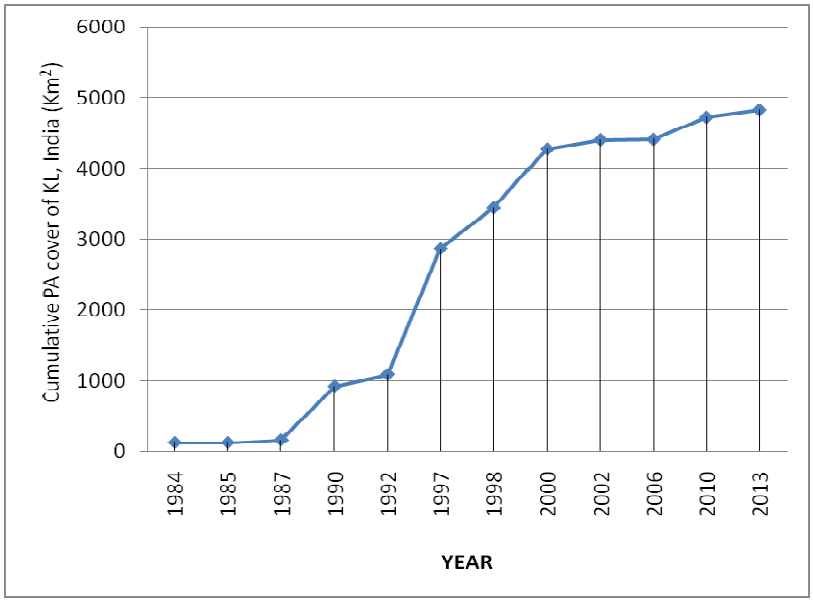


Figure 6.2 Cumulative growth of PA covers across the years in Khangchendzonga landscape-India

Elephants in Jaldapara national park, a major component of eastern duars elephant reserve In Khangchendzonga landscape, India

Important Elephant Corridors: In KL, India, for elephant movement, the existing corridors are not in continuum in the forest tracts along large habitats, but fragmented with tea gardens or village areas, having no control from forest department. Whereas, management has identified two elephant corridors, extensively used by the elephants, viz.,(i) *Bhutri-Dalsingpara - Titi Corridor*, , measuring about 9 Km and (ii) *Mendabari - Nimati Corridor,* averaging 3 Km length. The wildlife management of north Bengal has identified 11 important corridors in the

zone of influence and contemplated for future action. As per personal communicaiton fron CCF wildlife (north), the wildlife trust of India has highlighted 14 corridors for elephants in north Bengal, viz. Mahananda, Panighata, Mechi; Apalchand-Mahananda, Tista Chaur; Apalchand-Gorumara-via Barodighi; Apalchand-Bhutta Bari-via Sylee T.G; Apalchand-Kalimpong-via Meenglass T.G.; Bhutlsbari-Chapramari; Chapramari-Gorumara; Rehli-Central Diana; Rhili-Moraghat; Dhumchi-Rhiti; Titi-Dumchi; Buxa-Titi-via Torsa T.E.; Buxa-Titi-via Beech and Bhannabari T.E.; and Sankosh-Buxa, Assam. The elephant population increased from 152 in the year 1986 to 529 in the year 2010.

Captive Elephant Population and habitat improvement: There are Departmental elephants in West Bengal, stationed in the protected areas, which are mostly used for patrolling as the area is largely inaccessible by vehicle.
The management of the area has been making efforts in many type of on-going activities for habitat improvement, viz. Plantation of indigenous species, fodder species, grasses and bamboos, Canopy opening, Replacement of monoculture by mixed plantation of indigenous species, Grass Fodder plantation for Herbivores, Bamboo Plantation, Cut Back in grasslands, Weed Eradication, Plantation in blank areas, Construction of Wallow Pools and Water reservoirs for Wild animals. The Sikkim Government has made vital amendments in the present Sikkim Forest Water Courses and Road Reserve (Preservation and Protection) Act, 1988 (Amendment in 2000) thus made the specified clause which emerged more stringent and harsh when enforced in field. In Reserve Forests, the offences such as illegal felling of trees, encroachment and grazing in the Reserve Forest have been made non-bailable. Additionally, management and protection of forestlands further intensified by improved patrolling, building effective forest check posts, monitoring and curbing the illegal extraction and on the transit of forest produce, recording and reporting of all offences in the forest area and other vital information sharing to headquarter control room and division control rooms. Also, efforts were made to ensure registration of forest cases, checking on leakage of forest revenue and further improvement in systems of communications.

6.1.2 Forest Fire Management

Loss of habitat because of forest fires is another serious threat both in reserve forests and in all the protected area in KL, India. In north Bengal part, this is a regular feature during the hot and dry season from March to April. To check the forest fires become extremely difficult particularly in the hills because of the difficult terrain and the inaccessibility. There have been instances of raging forest fires in Singalila areas when extensive areas over 25 Km^2 have been affected.

In KL-India the forest fire management policy has been developed to enable the government focusing on fire prevention aspects and to coordinate efforts by various agencies towards this important function. Modern fire fighting approaches with community-based fire fighting strategies are integrated in the policy and are devised to preserve the unique biodiversity of the forests of the both States (Sikkim and West Bengal) especially those of the lower altitudes. Provisions are placed in the policy for zoning of the forests based on their vulnerability, assessed ecological impacts and intrinsic value so that different treatments can be congregate out to the different zones. Between the years 2000-04 for Sikkim and 2011-12 for North West Bengal, the forest fires events are presented (Table 6.1) and forest fire incidences

indicate an arming signal towards strengthening the management practices for forest fire and in the landscape at high level.

Table 6.1 Forest fires incidences year wise and types in KL-India

Year	Year	Area affected by fire (ha)	No of incidents	Loss due to fire	Type of fire	Reasons
Sikkim	2000	680	53	Ground flora, natural regeneration, plantations/ saplings and some of the trees including the wildlife habitat have been damaged and affected	Human-made/ incidental	All ground fire
	2001	33	9			
	2002	45	14			
	2003	37	18			
	2004	185	25			
North Bengal	2011-2012	621.46	68	Estimated forest loss as Rs. 60.00 lakhs	Accidental	All ground fire

(**Source**: Forest Environment and Wildlife Management Department, Government of Sikkim; State Forest Report, West Bengal, 2011- 2012)

6.1.3 Grazing and control

In north Bengal part of KL India, with the number of livestock ranging from 20,000 to 50,000 and above entering many of the PAs and the surrounding forests every day result extensive domestic livestock grazing. Livestock grazing in Singhalila and Neora Valley NP is a serious threat to habitat degradation and loss. Neora Valley NP was once having many cowsheds known locally as "Kharka" as many of the localities suggests. With the area being declared as NP, all these cowsheds were dismantled, however, they have established just outside the PA and which have been exerting pressure in the PA and its surrounding forest areas. The species rich sub alpine meadows of Singalila NP have been severely overgrazed by the domesticated yaks from the Nepal areas and have been replaced by *Berberis, Rosa, Euphorbia, Primula*, etc.

In Sikkim, the Government have imposed a ban on grazing within the Reserve forest, plantation areas and water sources areas with a view to encourage regeneration of forest resources, augment rural water supplies and develop degraded lands. The beneficial effects of this policy are already manifested in the form of improved supplies of water in the villages bordering the Forest areas, regeneration of degraded forest land and enhancement if overall natural resources status. In recent years, a number of *Goths* and cattle have been removed from most of the protected areas and reserve forests, and the cattle have been impounded and fined along with the wide publicity and awareness. The case of Khangchendzonga national park and Barsey wildlife sanctuary are some of the most effective management initiatives in KL, India. These are, the members of Eco-development Committees (EDCs), Joint Forest Management Committees (JFMCs), FDA, SSB personnel, local police personnel, Himal Rakshaks and others of the adjacent and transition zone areas, etc., and led by the officials of KNP and territorial division (in 2006 and 2007, etc) of the Sikkim state forest department. However, in the north Bengal part of KL, heavy cattle population and much wider open areas even in many of the PAs the grazing has posed serious problems for the area management.

6.1.4 Survey and Demarcation

Historically, in the first half of the 20th century, the forest areas in Sikkim were surveyed and demarcated into Reserves, Khasmal and Gorucharan forests. By erecting loose stone mounds the forest boundaries were demarcated, which over the time were vanished subsequently due to the burgeoning population leading to sizable forest area encroachment, and suggests newer surveys.

6.1.5 Forest restoration

In India, the National Afforestation Programme (NAP) was formulated by the inclusion of four 9 Plan national sponsored schemes of the Ministry of Environment and Forests (MoEF) i.e. Integrated Afforestation and Eco-development Project (IAEDP), Area Oriented fuel wood and Fodder Project (AOFFP), Conservation and development of Non-Timber Forest Produce Scheme (NTFP) including medicinal plants scheme. In addition, Association of Scheduled Tribes and Rural Poor in Regeneration of Degraded Forest (ASERP), with a view to reducing multiplicity of schemes with forest restoration objectives, ensure uniformity for funding pattern and implementation through institutionalization of peoples' participation. The scheme is being operated through Forest Development Agencies of various states, with funding support from the National Afforestation and Eco-Development Board, MoEF, Government of India, as a 100% centrally sponsored scheme. The forest restoration programmes are one of the important priorities of both the state governments. In West Bengal, following guideline of the National Forest Policy 1988, high priority has been given to the conservation of Forests with specially emphasizing the need of firewood and fodder development on available wastelands by involving the community people

Historically, in Sikkim, in the year 1914 the then Maharajah of Sikkim, Sidkeong Tulku, initiated the demarcation of the forest areas of the then Kingdom of Sikkim. Forests that were vital to the life support system and required full protection were set apart as Reserve Forests. These forests were to be left in their natural state and heavy penalties were imposed for illegal activities in these areas. Other forest areas that could be worked on a small scale in order to meet the timber and fuel-wood requirements of the local populace were carved out near villages. To meet the wood requirements forests were set apart as Khasmal Forests and those left aside as grazing grounds for cattle, were termed Goucharan Forests. During this period, forest rules and regulations were first instituted. Consequently, the system of exploitation of forests by selective felling leaving the mother stock intact was adopted. Contracts for lifting of forest produce from mature forests were given and extracted timber was exported with a view to generate revenue to meet the increasing expenditure on administration and to aid natural regeneration. This was supplemented by undertaking plantation work on a limited scale in marginal forests through the Taungyadar system. In 1975 when Sikkim was merged in the Indian Union, developmental activities accelerated. Aided by Central assistance, construction activities got a boost, and the lifestyle of the people improved considerably. The increasing population, coupled with the timber intensive lifestyle, mounted pressure on the forest areas, and the requirement of forest produce for internal consumption increased considerably. Forest department undertakes national afforestation program under wildlife sector, various activities such as, added natural regeneration, artificial regeneration, pasture development and silvi pasture. Bamboo plantation, sea buckthorn plantation, mixed MFP plantation, regeneration of perennial herbs and shrubs, awareness generation, micro-planning, fencing, value addition and marketing of forest produce with emphasis on improved technology are carried out

time to time. Under the 20-point programme, which was launched by the Govt. of India, an appreciable afforestation work carried out in government lands (Figure 6.3).

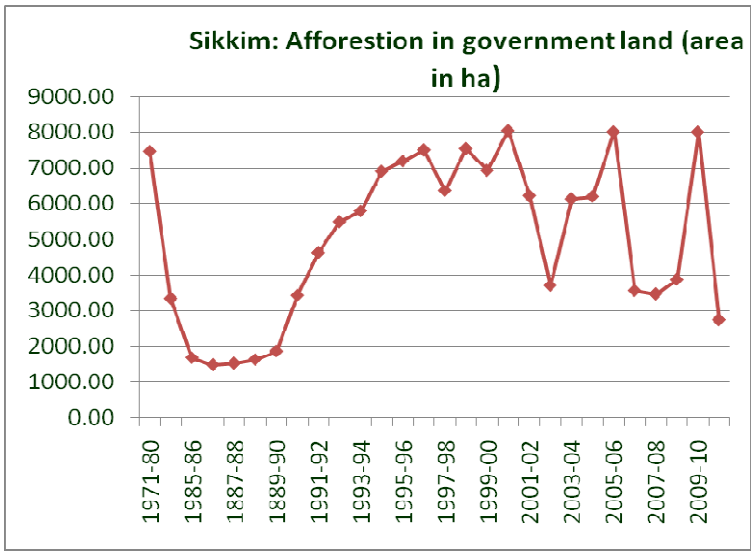


Figure 6.3 Afforestation under 20 point programme in government land in Sikkim over 1971-80 to 2009-10 (Graphic representation based on Annual Administrative Report, 2010-11, by GBPIHED)

Ten minutes to Earth', an afforestation drive under green mission (Sikkim) in Khangchendzonga landscape, India (Photo: HK Badola)

6.2 Agroforestry in forest management

Trees on farms yield food, fuel wood, fodder, timber and medicines, and they replenish organic matter and nutrient levels in soils and help control erosion and conserve water, thus offer both products and services. For example, the Himalayan alder (*Alnus nepalensis*) based agroforestry is particularly useful for supplying nutrients and accepted intervention by villagers in KL (India), with having cropping cover of 4800 ha and 13204 ha in Darjeeling and Sikkim, respectively. However, owing to severe viral diseases, Cardamom farming experienced setbacks in recent years, resulting which farmers have been finding other alternative source of income such as, horticulture and vegetables, besides tourism sector in KL, India (Badola,

2009). In Sikkim and Darjeeling the agroforestry can be viewed under four kinds of practices, viz., Mandarin Orange-Ginger agroforestry, Alder-cardamom agroforestry, and mixed forest-cardamom agroforestry. Amongst the same, Alder-cardamom is considered the best performer in relation to crop productivity and economic returns. A high value *Piper oblongum*-mixed forest agroforestry was also experimented once at the Darjeeling hills but the reports have not come up so far. Cultivation of high value medicinal plants under agroforestry system is one of the beneficial interventions and seen as lucrative commercially and successfully demonstrated for KL, India (Badola and Pradhan, 2011).

6.3 Forest utilization and management

Minor forest products, besides timber, are utilized and managed worldwide. Excessive logging and transport roads, construction of facilities for logging camps or for recreational activities in the forests and waste accumulation cause direct or indirect negative impacts on forest plant and animal resources on ecological functions of forests such as the conservation of biological diversity. In the forest of KL-India, a huge diversity of wild edible plants is found both in the wild and private lands offering both nutritive and commercial benefits to people (Badola and Aitken, 2010; Chettri and Sharma, 2010). Among wild edible species, many are utilized for their medicinal value. Some of them are also source of medicines (Pradhan and Badola, 2008; Badola and Pradhan, 2013). Utilization of *Juglans regia* for multiple uses including timber is known in KL, India (Subba and Badola, 2011). Local folks not only use these forest produce but have practice of managing resources by planting in their territories is well appreciated. There are many edible varieties of mushrooms are in the area; the fern like *Diplazium esculentum* is not only used as highly popular delicacy but a good nutritive source (Badola, 2010b). Inhabitants in the landscape use traditionally many medicinal plants and in commercial practice in general (Rai and Sharma, 1994; Pradhan and Badola, 2012For Sikkim, the utilization circle is the commercial wing of the forest department; which execute and manage the extraction of Wind-fallen trees, trees from project sites where forest land is diverted to the user agencies, extraction of poles from thinning of old plantations and conversion into timber, firewood and charcoal and sale. Figure 6.4 depicts the timber extraction trend by the utilization circle over the years.

Despite the profound economic value of NTFPs of region, till date, very limited scientific work is done in these plants. Following the modified resolution of West Bengal Protected Forest Rules 1956, No. 4461 – For D/1S-16/88 in the year 1989, wherein forest dwellers are allowed to collect some NTFPs free of charge for their household needs. They can also collect a limited amount of products to sell at the local market. With the collection of leaves, flowers, fruits, seeds and brushwood, each family can also collect one pole per annum for making a plough and three poles for house construction after every five years. However, to get these advantages, forest dwellers have to prove that they have been living in the forest area for at least 75 years or so (Forest Survey of India, Eastern Zone, 1985, p. 20). Presently JFM policy is used by every state government in India. Following the JFM resolution or policy, state governments decide the NTFPs harvesting strategy. It was NAEB's initiative that Government of India introduced the JFM resolution in the year of 2003 and to implement it NAEB has arranged series of discussions with the Panchayat Raj Institution (the rural governing body), FPC members and forest officers. In Sikkim biodiversity action Plan (2012), as a topic sustainable utilization of

biodiversity resources has been included in the plan and recommended specific actions.

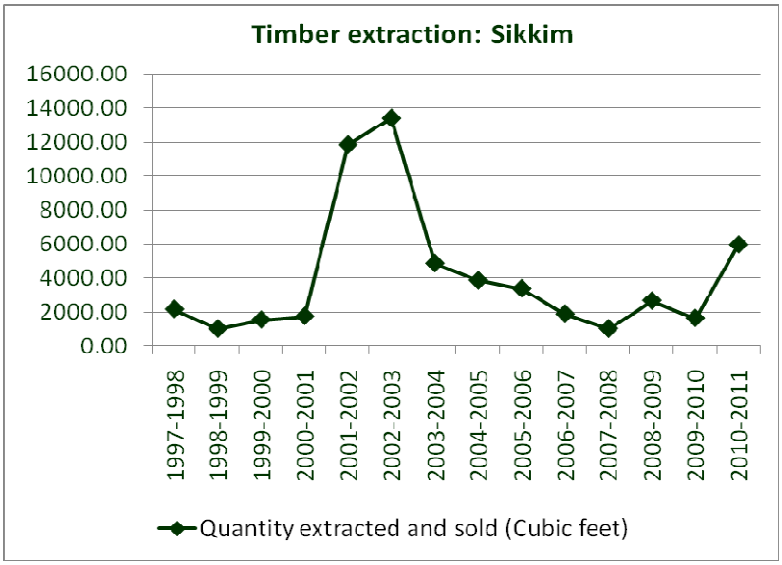


Figure 6.4 Timber extracted and sold by the utilization circle of Sikkim state forest department during 1997-2011 (Graphic representation based on Annual Administrative Report, 2010-11, by GBPIHED)

6.4 Intensification of forest management scheme (IFMS)

While aiming to expand forest cover in the country, it is equally important to improve the state of existing forests and protect them against various threats. MoEF, GOI has sponsored a scheme entailed 'Intensification of Forest Management Scheme' (IFMS) which aims at strengthening forest protection machinery of the States Governments and providing support for area-specific forest management interventions. The financial assistance is provided on cost share basis. All the North Eastern States including Sikkim and special categories States, namely, Jammu and Kashmir, Himachal Pradesh and Uttarakhand share 10 % of the cost while 25 % share of West Bengal. The major components of the scheme include: Forest fire control and management, Strengthening of infrastructure, Survey, demarcation and working plan preparation, Protection and conservation of sacred groves, Conservation and restoration of unique vegetation and ecosystems, Control and eradication of forest invasive species, and Preparedness for meeting challenges of bamboo flowering and improving management of bamboo forests. The overall management of forest land and forestry resources have been intensified by better patrolling, effective forest check posts, checks on illegal extraction and transit of forest produce, reporting and recording of all forests offences and other information at Headquarters control room and Division control rooms, registration of forest cases, check on leakage of forest revenue and better communication system. Apart from these, some centrally sponsored schemes in the proposed landscape have been implemented and monitored by central government while some schemes are sponsored by state heads and monitored by its own level (Appendix 6.1).

6.5 Wildlife management

The wildlife management tries ensuring balancing the needs of wildlife with the requirements of people using the best available technical knowledge, which includes habitat protection, conservation, control human-wildlife conflicts and pest control. Cntinued fragmentation of important wildlife habitats and intensifying human-wildlife conflict, especially in the north Bengal part, are the major concern in

the region. With these concerns, poaching of wildlife is a major issue and Govt. of West Bengal has taken up initiatives in this concern as an incentive paid to informers on any planned poaching activities under (GoWB, 2002-03; 2005-06) poaching of Schedule I animals between 1999 and 2005-06. The information revealed that 37 elephants, 17 leopards, 4 tigers and 3 each of rhinoceros and bison have been killed in recent years (report of Tiger Task Force; August 2005). A total of 74 Km of railway line in the prime forest area of north Bengal has caused serious concern for the protection of wildlife; as many as 67 wild animals which include 1 Tiger, 53 elephants, 2 leopards and 11 Indian Guars elephants have been killed due to train accident in the last 11 years. The expansion of National Highway through prime wildlife area in north Bengal is also a major issue. In a most recent study report prepared by Expert Team from the MoEF, GOI, it is mentioned that proposed alignment for East-West Corridor, if built, would cut through some of the finest forests in north Bengal and pose a threat to its wildlife (Planning Commission, GOI, New Delhi, 2010). A highway to be built by the National Highway Authority of India (NHAI) is to connect north Bengal to Assam. The expert team after seeking the view of local community, forest department and other stakeholders, an alternate route, passing alongside the state highway is proposed through Fulbari near Siliguri, Jalpaiguri, Dhupguri, Manegarm Falakata,Pundibari and Tufanganj.

In Sikkim wildlife, snow leopard deliver few live damages at the high altitude Himalayan region, from habitat degradation, loss of kill, the trade in pelts, animal parts and live animals, and conflict with humans, primarily the pastoralists. As a 'flagship' and 'umbrella' species, the snow leopard can be a unifying biological feature to raise awareness of its plight and the need for conservation, which will benefit other facets of Himalayan biodiversity as well. There are black bear and human conflicts in recent years emerged profoundly, and considered high priority by the government of Sikkim to mitigate the problem. Cases were registered in recent past on poaching instances, illegal collection of butterflies and insects from protected areas and exploitation and trade of *Cordyceps sinensis*, etc. One of the most innovative management initiative has been the deployment of the "Himal Rakshaks" (those who once were the hunters and shepherds) for the protection and monitoring of wildlife and its offences by the Govt. of Sikkim. The wildlife management cell of the state forest department in either states have poured high investments in mitigating the problems and efforts are there through various schemes and management approaches for improved management.

6.5.1 Human-wildlife conflicts and management

In KL (India), like any other parts of the region, is common and widespread; the growing populations, over use of natural resources, encroachment in the territory of the animals by humans are some of the main reasons of the same. In Sikkim as well as north Bengal parts, the human-wildlife conflict consists of direct encounters and human casualties as well as damage to crop and livestock; however, the killing of animals is much more pronounced in the north Bengal part. From crop depredation and human casualties by Himalayan black bear to crop damage by wild boar, porcupine, monkey, peafowl, deer etc. have been reported time to time, and documented during field investigations by WII (Sathyakumar *et al*., 2012) and GBPIEHD (unpublished) in Sikkim.

The human-black bear conflict was not very new; only in the absence of communications, such reports were not highlighted in the past. In Sikkim, one study

reported 65 conflict cases during 2011-12, in which, most involved wildlife species in conflicts with local people was Asiatic black Bear (70.76 %), followed by jackal (7.69 %), wild pig (6.17 %), Himalayan crestless porcupine (7.69%) and yellow-throated marten (4.61%). Such conflicts were mostly relating to crop damage and livestock depredation except two cases on human attacks (Sathyakumar *et al*., 2012).

6.5.2 Management in human-bear conflicts in Sikkim

In recent years, increasing conflicts have posed serious problems before wildlife management departments in KL, India. In north Bengal Elephants, Tigers and other animals are increasingly coming in conflict with human. The report further tried to know the perception of people regarding the efficacy of different control measures applied for different wild animals, damage by wild animals, preferred crop and peak season(s) of their attack (Sathyakumar *et al*., 2012a). For protecting their crops from species such as the black bear and wild pig the villager used bamboo fences, however, these fences were not sufficient in case of small mammals. The wildlife management department(s) of state government used to provide compensation to victimized families for such losses, as per norms, besides trying capturing problem wild animal through tranquilizers. In either state, Himalayan zoological parks are showing excellent progress on captive breeding and conservation programme in KL, India. The Sikkim forest wildlife department gave compensation ranging from Rs 900 to Rs 2000 and also Rs 5000 to individuals suffered with attacks of black bear for meeting out medicinal treatments during 2008-12, and sometimes, other land departments and village EDCs and public helped them (Sathyakumar *et al*., 2012b). During 2010-11, wildlife offences such as illegal possession of pangolin hide claded scale, Harra, barra and Amla, jungle moss , Yarchagompa, Antelope horn in Kubenday reserve forest, and illicit felling within Barsey Rhododendron sanctuary were occurred (Annual Administrative Report, 2010-11). On the human-wildlife conflicts, one case in north Sikkim, 10 case each in east and west Sikkim, respectively, were registered (Annual Administrative Report, 2010-11). Some of the highly problematic human-wildlife conflicts and their management interventions in KL, India are detailed below (the information relating to north Bengal is based on the various report drafts and personal communications /inputs of Dr V. Sood, CCF, Wildlife-N, and West Bengal):

6.5.3 Elephant (Elephas maximus) human conflicts

In Khangchendzonga landscape (India), Elephants move in an extensive home ranges, characteristically within a fragmented habitats and/or to traditional migration path along 100 to 1000 km^2, naturally result to numerous human-elephant conflicts, which caused harm to agricultural crops, property, household and injury and mortality to both humans and elephants. The Elephants in KL, India migrate from Assam to eastern Nepal; use the routes passing through the plains of Darjeeling and Jalpaiguri –Alipurduar districts searching for food and shelter. However, Darjeeling Wildlife Division- Kurseong, Forest Division and Mahananda Wildlife Sanctuary lie in the migration route of the elephants (http://westbengalforest.gov.in). Kurseong forest divisions are contiguous with the Mechi River on the eastern border of Nepal with tropical broad leaf forest where the elephants migrate to Nepal. Bahundangi Jhapa district of Nepal is their nodal point of entry. Because the migration corridors are fragmented and used for human settlements and agricultural purposes these elephants in movement, cause much damage to property and life. Consequently, elephants are killed; crops damaged and human lives are lost.

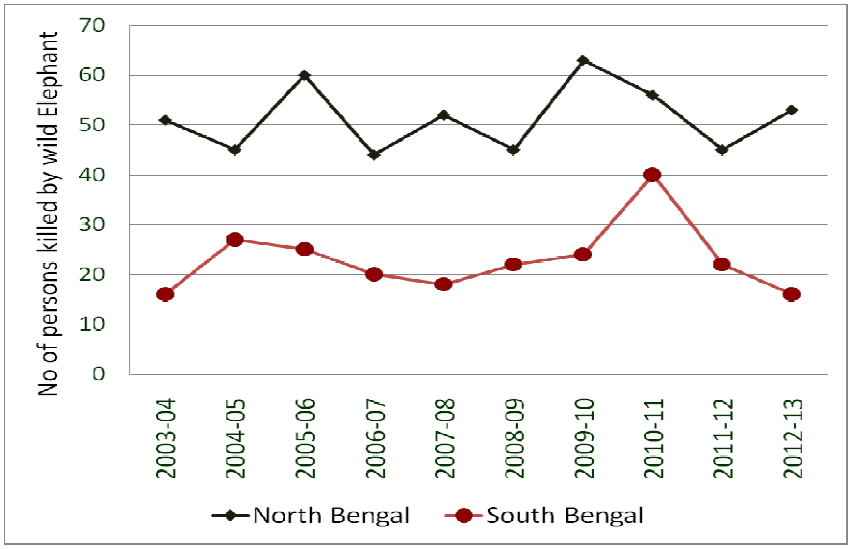


Figure 6.5 Number of human causalities by wild Elephant in north Bengal, comparing to south Bengal in Khangchendzonga landscape, India (graphic representation by GBPIHED, based on Directorate of Forest Annual Report 2012-13)

Human-elephant conflicts are widely documented in the northern West Bengal in KL, India, which is one of the highest levels of human-elephant conflict zones in Asia (Manoj et al. 2013). Besides damaging large agriculture crop areas Elephants kill on an average 50 people each year (http://www.asiannature.org/....elephant-conflict-mitigation-pr-2; accessed on 13.02.2013 2013). A news paper report highlighted, the Elephants trampled over 230 people over the past decade (A Threat to North Bengal Animals, The Times of India, Kolkata, India, 7 February, 2013). The forest department of west Bengal reports that there has been a consistent trend of human causalities in wild Elephants in north Bengal (Figure 6.5; in KL, India), totaling to 515 numbers between 2003 and 2013, comparing to 230 human killing in south Bengal. For the survival of Elephants, mitigation management is crucial. ANCF undertakes several projects to tackle this conservation issue (http://www.asiannature.org/our-programmes/asian-elephant-research-and-conservation-aerc/human-elephant-conflict-mitigation-pr-6; accessed on 30 June, 2014)
The Directorate of Forests, Govt of West Bengal in northern part in KL, India, has taken up mitigation measures.

Causes of human-elephant conflicts: During the last one decade, wildlife attacks resulted to over 430 Human deaths and 1000 persons' injuries. Annually approx. 800 ha crop is damaged and about 600 residential huts damaged by wild animals mainly elephants. More than Rs 150 Lakhs is annually spent for payment in entire area as Ex-gratia towards death to Human life/ injury, crop/livestock and hut damages. Area towards western Duars under zone of influence of Eastern Duars Elephant reserve shows maximum Human-Elephant conflict mainly because of many reasons: *Highly fragmented forests, Lot of Human Settlements, High Population Density, Extensive Agriculture, Tea Gardens in traditional Corridors, Development projects like Roads and Railways, Frequent Army / Air force establishments & artillery firing in elephant corridors, Constraint on resources, Increase in Wildlife Population, Illegal cultivation of Paddy/Maize in fallow land within Tea Garden, Manufacture and storage of country liquors in labor lines, Absence of proper illumination in labour lines during night, Unplanned construction of residential huts by illegal labor inside tea garden, Close Proximity of Human Habitats to Wildlife Habitat, Availability of food in the human habitats result in depredation by wildlife,*

Human death, Wild Animals death through poisoning, gunshots, electrocution, train accidents etc, and *Conflict in Indo-Nepal boarder.*

At irregular time intervals, every day mostly during night about 25-30 pairs of train pass through Elephant habitats. So far, approximately 33 elephants have been killed due to accidents from running trains in last 10 years. During the growing season, crop-raids by elephants in paddy, maize, banana, jack-fruit fields, and trampling of tea bushes emerged as a major problem. The Kurseong, Baikunthpur and Jalpaiguri division habitats are highly fragmented the food sources with relatively limited food value due to conversion of natural forests in to tea plantations, experience high level of crop raids by elephants; the cultivation pressure is very high population due to growing population. Consistently, between 2002-03 and 2012-13, a range of 16 to 39 elephant deaths is in record.

6.5.4 Conflict management

At present, funds received under Project Elephant, State Plan Schemes and Non Plan schemes are used for conservation of elephant population by improvement of existing habitat, creation of new habitat and management of Human – Elephant conflict. Major activities currently undertaken are:

- Habitat improvement works like creation and maintenance of fodder tree/grass plantation
- Improvement of water regime by creating/ maintaining water holes
- Maintenance and strengthening of existing wild life Squads at Bagdogra, Belacoba, Mal, Khunia, Ramsai, Binnaguri , Dalgaon and Madarihat
- Prevention of illegal paddy/maize cultivation inside tea garden and vacant Railway land
- Energized Fencing around affected villages and labor lines within tea Garden
- Publicity and awareness among the general public through meetings , workshops, nature education, documentaries, press and media
- Reward and recognition of all those who have given exemplary services towards conservation of wildlife
- Timely ex-gratia payments for human death/injury/hut damage/crop damage

Eco development activities like, alternate crops for protecting crops from depredation by elephants; incentives for Mushroom cultivation, strawberry cultivation, capsicum, etc. are carried out and promoted livelihood based activities for EDC members- jute carpets, handicrafts items, toy making, etc. In addition, income generation under ecotourism activities are processed under joint participation and shared income from eco cottages, running of kitchen for tourists, organizing tribal dance shows for tourists etc. In spite of all, direct employment through tourist guides, rural infrastructure development like improvement of village roads, repair and new construction of houses for economically weaker section and forest villagers, drinking water supply, rural electrification, construction of school buildings, community halls, and rural sanitation- toilets for forest villagers, etc. were promoted.

Habitat management by enriching water sources in north Bengal part of KL, India (Photo: VK Sood)

***Road map for Future*:** The management has been giving good emphasis on the elephant conservation programme for future, which should include the improvement in the quality of life of Elephants, rather than to increase their number by the important steps: By habitat improvement, Unrestricted corridors for movement, Minimum conflict with the people, Good veterinary support, Larger financial inputs, Larger research inputs, Conservation oriented Development, and Encouraging Alternative cropping

6.5.5 Bison (Bos gaurus) human conflict

In the past decade, the Bison population in North Bengal has multiplied many folds and that resulted damaging of huge fodder plantations growth of grassland in Gorumara National Park, Chapramari Wildlife Sanctuary, Buxa Tiger Reserve and Jaldapara National Park by population of Bison around 500-600 during 1990s. The census data of 2009-10 for Gorumara National Park and Chapramari Wildlife Sanctuary alone report more than 901 numbers of Bison. In 2010 the Bison population in North Bengal was 2000 in 2010 and that increased double fold (up to 4000) in 2012. Owing to increasing population, it has resulted in quite a few straying to forest fringe villages and into tea gardens and caused a large number of human injuries. On the other part, the Bisons are often scared when villagers and tea garden workers make huge crowds around straying bison/bisons. The wildlife management department of north Bengal has taken this problem as one of the big challenges, especially for Jalpaiguri region.

Gaur (*Bos gaurus*) looking for a safe refuge in north Bengal part of KL, India (Photo: Animesh Bose)

6.5.6 Leopard (Panthera pardus fusca) human conflict

Limited to forests of foothills in district Darjeeling and the forests of Jalpaiguri and Alipurduar districts of KL, India, the Leopard-human conflict often witnessed and challenged for the management. By using tea gardens adjoining forest as breeding areas, the Leopards come into direct conflict with tea garden workers when they enter the work area, resulting human deaths and serious injuries. Incidents of leopard lifting poultry, goats and calves of bovines in fringe forest villages are there. On human part, for being more aggressive than the original ethnic inhabitants and migrants of the area, the labourers in tea gardens sometime indulge in counteracting, which result death of leopards by beating or poisoning. In north Bengal, during 2003-13, a total of 236 cases of human killing or injuries due to attacks of Leopards are recorded (Forest Annual Repot 2012-13, DoWB), in which 10 as killing and 226 for human injuries appeared (Figure 6.6).

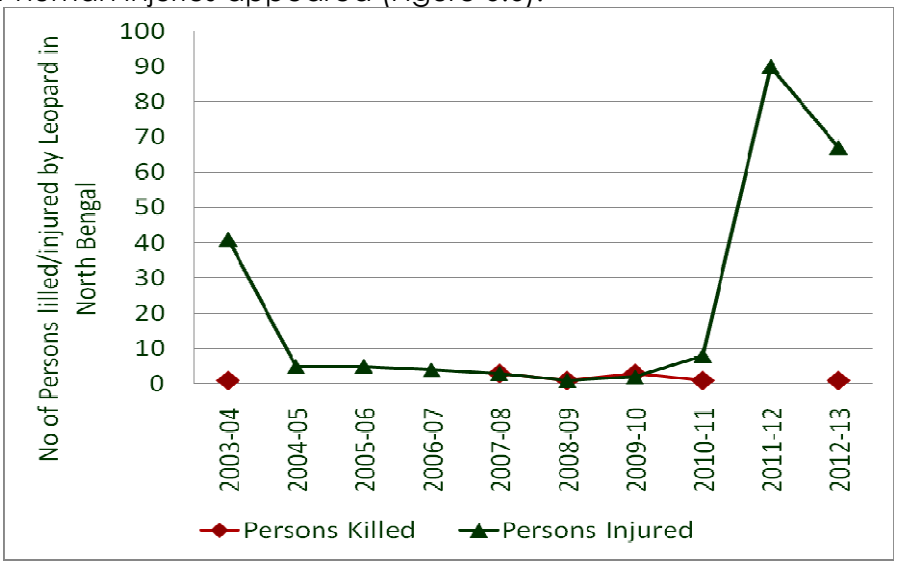


Figure 6.6 Number of persons killed/injured by Leopard attacks in north Bengal part of Khangchendzonga landscape, India (graphic representation by GBPIHED, based on Directorate of Forest Annual Report 2012-13)

6.5.7 Rhinoceros (Rhinoceros unicornis) human conflict

Few incidents have been reported from North Bengal region of KL-India where rhinoceros have left the PAs and strayed into human inhabited areas due to infighting among the rhinoceros population. Their drifting into human population results more of snooping accumulate of people following it and making it scared, confused and disoriented. Despite its huge increase in Gorumara National Park and Jaldapara National Park of the proposed landscape. Some human casualties have happened due to its occasional aggressive behavior. HWC in the form of crop-raiding and attack by wild animals has become integral part for communities located at the borders of protected areas. The management looked into this problem with care and trying best to reduce the same. In national parks the last poaching was recorded in 1992 when a rhino strayed out of the protected area. The population in Jaldapara PA good management retrieved the rhino population to 108 in 2005 from a pathetic low in the year 1975. In 1997 the rhino population in Gorumara national park was 14 which rose to 27 in 2005, a good management effort witnessed, which not undermining the chances of any relaxation as the international marketing for rhino horns is lucrative.

Many constraints are there being faced by the management. These include: i) large interface between the forest and villages due to irregular shape of PA; ii) close proximity of the international border with Bhutan and Bangladesh; iii) insufficient trained and competent patrolling staff; iv) inadequacy of suitable fire arms and insufficiency of patrolling vehicles/departmental elephants; v) inadequate inter-departmental coordination amongst various enforcement agencies; vi) existence of unauthorized fire arms in the fringe villages and vii) lack of conservation awareness amongst people living in the forest villages. In addition, limited grasslands, livestock grazing along fringe villages, advancement of woodland into grasslands, timber collection through illicit felling, leaching of pesticide from tea gardens, dolomite poisoning in PA, rhino inbreeding, small size of Gorumara national park and presence of tea gardens, rapid growing human population, accompanied by transboundary problems, etc are other limiting factors to conservation management of rhino.

Rhinoceros in Jaldapara national park in Khangchendzonga landscape, India (Photo: Animesh Bose)

6.6 Some other human-wildlife conflicts

At mid and high elevation ranges of the landscape some other important human-conflicts (i.e. Snow leopard, Red Panda, Bear, and Monkey) have been emerged. Snow leopard-human conflict has been observed during mountain expiation programme causing some casualties of human live. Red Panda case, it has been observed apparently during tourist visits in forest area. In the entire landscape with growing population of Monkeys, the human-Monkey conflicts has been occurred frequently and resulting human injuries at large scale and heavily damaged agricultural crops. Some incidences also, have emerged nearby Kitam Birds sanctuary, wherein, crops damaged by birds have been reported. Realizing the above concern, Govt of India and state Government s have launched several schemes related to the wildlife management separately and landscape has benefited a few. These initiatives are encouraging source of the community and stakeholders as well as more important for wildlife management. Some related schemes are functional in the landscape, which are sponsored by central and state government separately (Appendix 6.2).

6.7 Agrobiodiversity management

The Geographical Indications of Goods (Registration and Protection) Act 1999, Protection of Plant Varieties and Farmer's Rights Act, 2001, the Indian Biological Diversity Act, 2002 (Rules 2004) and the Patent Act, 1970 (Patent Rules 2003, amended in 2006), National Bureau of Plant Genetic Resources (NBPGR), National Bureau of Animal Genetic Resources (NBAGR) and Indian Council of Agricultural Research (ICAR) govern and guide the conservation, protection and promotion of biodiversity as well as agrobiodiversity elements and products in majority of the Indian states including north Bengal and Sikkim part of KL, India. Sikkim and West Bengal have framed their own Biological Diversity Rules to ensure conservation and protection of traditional Knowledge (TK) and genetic resources (GRs) arising within their territories. Because of these national legal frameworks, institutional infrastructure was established for conservation, sustainable use, and equitable sharing of benefits arising out of the GRs and associated TK.

The Govt of Sikkim has initiated the Indo-German climate change adaptation project, through Rural Management and Development Department, taking into consideration the cultivated systems as a component. The Sikkim Biodiversity Action Plan (2012) has categorically highlighted strategies recommended for agrobiodiversity conservation, protection and promotion. It identifies potential research and development agencies (i.e. GBPIHED, ICAR, NABARD, NBPGR, NBA, DARE and NBAGR) including Agriculture/Horticulture /Animal Husbandry Department of Govt of Sikkim as responsible institutions outlining different time frames (short term, midterm and long term basis) to ensure markets to organically farmed local crop varieties with certification and preservation of local germplasm of field and horticultural crops by screening them for desirable characters, identification of agrobiodiversity hot-spots and cropping systems, and promotion of on-farm conservation through training programs and incentives. The declaration of Sikkim as an "Organic State" in 2003 by the State Government and the initiation of *Sikkim Organic Mission* invariably initiated organic certification of farmers' fields, promoted the agriculture production systems through incentives and provided capacity building to rural farmers. Several programmes viz., Integrated Crop Development Programmes (ICDP), Integrated Nutrient Management (INM), Natural Resource Management (NRM), and Rastriya Krishi Vigyan Yojana (RVKY) are also,

implemented mostly towards redefining management practices of agrobiodiversity in the region.

In North Bengal, some programmes are functional to strengthen the agrobiodiversity in the region. Integrated Pest Management (IPM) has started to minimize the excessive use of insecticides in the crops. For promoting organic farming in the area, as short but effective initiative has been attempted for the promotion of organic farming and training in a bio village module by the state agricultural department (WB). Many programs are implemented and promoted by Krishi Vigyan Kendra (KVKs) operating in all district of the state.

6.8 Wetland management

Numerous existing legislations onrelated to wetland conservation include Indian Forest Act, 1927; Forest (Conservation) Act, 1980; the Wildlife (Protection) Act, 1972; the Air (Prevention and Control of Pollution) Act, 1974; the Water Cess Act, 1977 and the umbrella provision of Environment (Protection) Act, 1986. Nevertheless, there is no specific legal framework for conservation of wetlands and its biodiversity available. Although there is strict ban on grazing vis-à-vis management restrictions, unauthorized entry of people makes wise use of the wetlands virtually impossible in the wildlife sanctuary or national parks. Since 1985–86 National Wetlands Conservation Programme (NWCP) is operational, under this MoEF, for conservation and management interventions, has identified 115 wetlands across different states. In 1993, the National Lake Conservation Plan was carved out of NWCP to focus on lakes, particularly those located in urban areas, which are subjected to anthropogenic pressures. In spite of recognized value of wetlands, formal system of Wetland Regulation is yet to be existed; the National Environment Policy 2006, as approved by the Cabinet in May 2006 envisioned setting up a legally enforceable regulatory mechanism for the identified valuable wetlands to prevent their degradation and enhance their conservation, apart from routine inventory. In pursuance of the policy resolution, a Multi-Disciplinary Expert Group held a series of meetings to formulate a regulatory framework for the wetlands that gave forth the Regulatory Framework for Wetlands Conservation and has been published in the Gazette of India, Part-II, Section-3, Sub-section-II, in 1971. As far as the KL-India is concerned, the wetlands management plan has been covered under protected areas and only need further strengthening and amendment in the management approach and policy. In addition, some initiative has been taken up in this direction; Sikkim Government has identified the total wetlands and included it is in the National list.

Laxmipokhri lake in Khangchendzonga national park in Khangchendzonga landscape, India (Photo courtesy: JB Subba)

In notification of 2001 by Sate Govt Sikkim, conservation of unique terrestrial and aquatic eco-system of wetlands/lakes by prohibiting the commercial activities to preserve the Heritage and fragile ecology was given high priority. However, in many of the lake areas, a large number of tourist visit each year; for example, during 2006 and 2007, a total of 399715 and 333929 tourists visited the Tsomgo lake in east Sikkim.

6.9 Solid waste management (SWM)

For the development of a proper management and disposal system for the major wastes like hazardous waste, bio-medical waste, municipal solid waste and plastic waste, the MoEF (Govt of India) has notified various rules under the provisions of the Environment (Protection) Act, 1986. These include the Hazardous Waste (Management and Handling) Rules, 1989, as amended in 2000 and2003; The Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989; The Bio-Medical Waste (Management and Handling) Rules, 1998, as amended in 2003; The Recycled Plastics Manufacture and Usage Rules, 1999, as amended in 2003; The Municipal Solid Waste (Management and Handling) Rules, 2000; The Batteries (Management and Handling) Rules, 2002; and The Public Liability Insurance Act, 1991, as amended in 1999 and Rules to be taken up by the state government in controlling and managing its waste materials. There are functional set up and management of municipalities at Darjeeling, Kalimpong, Kurseong, Alipurduar, Jaigaon areas of north Bengal. In West Bengal subsequent to above, the responsibilities of implementing the provisions of these Rules have been entrusted to the West Bengal Pollution Control Board (WBPCB). In Dooars region of KL-India there are two municipal bodies, namely Siliguri Municipal Corporation and Jalpaiguri Municipality situated within the planning area of Siliguri Jalpaiguri Development Authority (SJDA). The WBPCB has extended the existing ban order (prohibiting entry, use and sale of plastic carry bags) in the Darjeeling hills to the entire Siliguri Subdivision and the area under the Siliguri Municipal Corporation, which lies in Jalpaiguri District. This direction came into force on September 15, 2003. Moreover, the use of plastic carry bags, cups and containers less than four inches in height and 40 microns in thickness have been banned in all government buildings in West Bengal. Issued by the State Department of Environment, this order came into force on March 4, 2004.

The Sikkim state of KL-India is witnessing a rapid growth of urban population and increase in tourist influx and due to these features; a proportionate increase in the quantum of garbage and wastage in the town and bazaar areas is in the rise. In the capital town of Gangtok close to 26 MT of solid waste is produced daily. Namchi town, the headquarters of South District produces around 10 MT of solid waste daily and similar figures are gathered for other major townships. For handling the solid wastes, a land measuring around 15 acres has been acquired where the garbage coming from South and West districts and peripheral areas are dumped. In Sikkim for proper working of solid waste management, there are regulations such as the Sikkim Non-Biodegradable Garbage (Control) Act, 1997 and The Sikkim Non-Biodegradable Garbage (Control) Rules, 2001. Any one violating the law is punishable with the imprisonment for term which may extend to six months or with fine up to Rs. 5,000/- or with both. From the year 2000, the Sanitation Rules for Towns of Sikkim has been extended to whole of Sikkim vide notification No. 104 (181)/ UD and HD/ 1986- 2000, date 17.6.2000). Despite the enormous effort put in by the state

government, the garbage tends to get the upper hand when the management process reaches the final stage.

6.10 Trans-boundary forest conservation and management

. Trans-boundary areas encompass various issues pertaining to over grazing, declining agroforestry system, change in farming pattern, degradation in dairy enterprises, deforestation, degradation of bio-resources, etc. Besides, the major concern related to illegal trade of medicinal plants and harvests of the crop, timber, poaching of wild animals, smuggling, etc. are the challenging issues. The KL-India has broad trans-boundary areas touching around four international boundaries, which face lots of problems and challenges to handle these issues at national level, especially along the partner countries Bhutan and Nepal. A cooperation between the countries should be needed at broad level for conservation and management of biodiversity within the trans-boundary area and minimize the illegal trades.

6.11 Pasture management and transboundary cooperation

In trans-boundary zones of KL, India, the constant pressure of population and developmental activities especially in the fragile alpine regions, grazing by sheep and yak and developmental activities like road construction and settlements are some constraints. The cold deserts of KL, India along trans-boundary ranges, though biodiversity rich, but not excluded from constant grazing pressures (Sekar and Badola, 2013). For owing to serious degradation, the government of Sikkim has banned the practice of open grazing in the reserve forests from the year 1999. In the greater Himalayan part of KNP particularly, the selective enforcement of governmental ban resulted in the eviction of about 300 agro-pastoralists owning about 6000 cattle from the reserve forests adjacent to KNP by 2002. Because the yak herders were influential and accessed remote alpine pastures, the yak population could not be reduced in early years. This had led to a 3-way conflict between the agro-pastoralists who had been evicted, the yak herders, and the forest department (Tambe and Rawat, 2009). As well as in Barsey rhododendron sanctuary, eviction efforts were greatly fruitful in significantly reducing the grazing pressures. In the north of Sikkim part of KL, India a different set of problem persists, where extensive pastureland exists, for having age-old pastoral lands. It is of much interest, that outside of Wildlife Protected Areas in north Sikkim, the only true pasturelands are found along these alpine and trans-Himalayan grasslands including the cold desert areas beyond Thangu at the head of Lachen Valley and the Yumaysamdong-Tembawa areas at the head of Lachung Valley, which are in constant use from centuries.

Trans-boundary cooperation mechanism is a prime issue for the neighboring countries of KL-India because each country suffered from the same situations. Trans-boundary illegal activity issue is growing concern of the landscape, wherein several smuggling activities are operating. Recently, the Indio- China border along the mountainous corridor of the Nathu La in the East Sikkim has emerged as a new cross-border smuggling route with the seizure of 160 kg of white sandalwood at Siliguri by West Bengal custom officials and consignment evaluated around Rs.20-22 lakhs (Sikkim express, 7 July 2014). Moreover, Sikkim police had seized earlier back a large consignment of sandalwood in Bojoghari area of Gangtok. Such evidences are sufficient to point towards several other trans-boundary smuggling and other illegal activities. In this concern, there is a need to resolve such illegal activities. Apart from

these, several other illegal activities i.e. animal parts, high value and endangered medicinal plants and insects were observed in the trans-boundary region.

6.12 Institutional arrangements for resource governance

In the Central Government the Ministry of Environment and Forests (MoEF) is the nodal agency for overseeing the implementation of India's environment and forest policies and programmes relating to conservation of the natural resources including lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals and prevention and abatement of pollution in the country. The MoEF is responsible to approve and implement the plan and programmes through the state Directorate/ Department of Forests (DoF) and other associated government agencies. With these, state has its own generated management plans, which are depend upon the regional forest management concerns and/or welfare of the state. Considering KL-India, the biodiversity conservation and management activities are monitored by district-level forest officers with the help of other functioning organizations and a significant include the PA conservation programmes. Some research and development agencies, which have proven record for significant expertise and experience in the field of biodiversity and conservation and management, are given in Appendix 6.3.

6.13 Local Traditional Institutions in resource governance and community based organizations

The Dzumsa system of natural resource governance in Lachen and Lachung villages in north Sikkim and adjacent landscape is one the most effective age-old traditional institutional mechanisms in KL in India and widely admired. Another local institution, Na Zong Nyo is also recommended for it indigenous knowledge and sustainable natural resources use practices among the Lepchas (Jha, 2002) and strong ethics for landscape level conservation among Sikkimese Buddhists (Ramakrishnan, 1996) are some of the effective traditional conservation measures that were seen to address "sustainability" of resources in the higher altitudes of KL-India. Earlier to 1965 (i.e., before the Sino-Indian war) herders had open cross border movements from these valleys into Tibet and back through Nyima La or Naku La pass. Consequent to Indo-China relationship turned more stringent, owing to shrinkage of pasture grazing rules were to be followed to sustain grazing in the high mountains, and to this the contribution of Dzumsa is much commendable. The coexistence between biotic resource and human being and sustainability in the highlands of KL-India largely may be attributed to the management skill and wisdom of Dzumsa. Adapting to the harsh climatic conditions over several centuries, Dzumsa and the Dokpas in northern part of KL, India in Sikkim have indigenously regulated and managed the grazing regimes of the Greater Himalaya, transition zones and in the trans-Himalayan meadows. Dzumsa has established self-regulating systems of natural resource management. It controls the rotational grazing, rangeland management and regeneration. Grazing regimes are chosen for the next move depending upon the forage availability pasture area, number of grazing animals, snowfall events and appropriate seasons (TMI India 2010). The Muguthang, Lhonak Valley, Tso-Lhamu Plateau and Lashar Valley of the trans-Himalayan region have been home to the agropastoralist Dokpas for centuries. It has been noted that these practices are fading slowly due to various driving forces leading to numerous conservation challenges (Murphy, 2005, Yonzon, 2005). An appropriate boost for revitalization of such practices might help to regain the cultural values and contribute to the location-specific conservation goals.

6.14 Joint Forest Management (JFM) and ecotourism

The National Forest Policy, 1988 envisages it as one of the essentials of forest management that the forest communities should be motivated to identify themselves with the development and protection of forests from which they derive benefits. National Forest Policy 1988 also recognizes the symbiotic relationship between the tribal people and forests, and implores to associate the tribal people closely in the protection, regeneration and development of forests..

In Sikkim, JFM programme was initiated in 1998 and till now, state has formed over 155 JFMCs, 59 Eco-Development Committees and 7 Forest Development Agencies as functional forces (Environmental Sustainability Index 2011).

In supersession of the north Bengal department's resolution No. 2340 for dated 14 July 2004, 2731 for dated 16 August 2004 and 2756 for dated 17 August 2004, the Governor was pleased to decide that Joint Forest Management Committees shall be constituted for the purpose of development of degraded forests and forests prone to forces of degradation. At present (2014) north Bengal has 491 JFMCs (389 FPCs & 102 EDCs). This movement of JFM had its genesis at Arabari in Midnapur District of West Bengal where 618 families of 11 villages were motivated in early 70's to rejuvenate 1,186 ha. of degraded sal forest by roping in their participation through a set of activities of employment generation and sharing of NTFP from such forests. This was followed by the adoption of the Govt.'s decision in 1989 to share 25% of usufructs and net profit of the intermediate and final yield respectively. As on March, 2006, there are 4,079 FPCs in the State (3,631 in South West Bengal; 389 in North Bengal) comprising of total number of 5,62,628 members (64000 families protecting 2250 Km^2 of forest areas under KL in north Bengal) protecting the total forest areas over 5,42,0057.217 ha. The total number of EDCs in the State are 102 (88 in North Bengal) comprising of 20,233 members protecting 85,748 ha of Protected Areas. In all FPCs and EDCs, the spouses are joint members. The process of formation and subsequent consolidation of JFM led to reckonable success in rejuvenating the degraded forests and bringing about economic upliftment of fringe population constituting the FPCs and EDCs through series of measures including implementation of people oriented development programmes.

The key issues for consolidation of JFM and its sustenance include:

- Motivation and training of stakeholders FD-staff and FPC members
- Carrying on the process of reorientation of the mind-set of forestry professionals at different levels
- JFM-Support activities
- Gender sensitization to ensure participation of women groups.
- Sharing of Usufructs
- Reorganization of the Forest Directorate
- A strong marketing initiative

In north Bengal, since 1991 participatory protected area management programme was initiated in the fringe villages of Jaldapara and Mahananda WLS and gradually the eco-development programme extended to all PAs. Until now, there are 115 EDCs in the entire state comprising of 65,136 members protecting about 1754 Km^2 of protected areas. However, for the north Bengal part, the management has successfully motivated 4298 EDCs and, who protected about 480 Km^2 area within protected areas. In all FPCs and EDCs, the spouses are joint members. Details about EDC functioning under the jurisdiction of Wild life north Circle is provided in Table 6.2.

Table 6.2 Status of eco-development committee in protected areas of north Bengal in Khangchendzonga landscape, India

Name of PA	Area (Km²)	No. of EDCs	Area Protected (Km²)	No of S.C.	No of S.T.	Total Members
Singalila N.P.	78.60	3	0.92	0	35	113
Neora Valley N.P.	159.89	6	55.94	46	1000	2944
Gorumara N.P.	79.45	9	55.92	429	461	1546
Senchel WLS	38.88	13	32.68	51	128	1229
Mahananda WLS	158	16	109.54	217	627	2238
Chapramari WLS	9.60	1	9.60	4	8	48
Jaldapara WLS	216.51	26	216.51	3551	3902	9813
TOTAL	**740.93**	**74**	**480.11**	**4298**	**6161**	**17931**

Source: Directorate of Forests, Wildlife (N), Govt of West Bengal (personal communication by V Sood, CCF,WL-N)

The north Bengal wildlife department through support of EDCs, achieved increasing population of rhino in both Gorumara national park (18 in 1998 to 35 in 2010) and Jaldapara (55 in 1998 to 155 rhino in 2010). Amongst other major achievements, infrastructural activity like road, culvert, hut making, ring well & agricultural input like irrigation channel, dug well, pond, water structure helping socioeconomic development; immunization minimized the cattle diseases in fringe village; awareness, people involvement as nature guide, and protecting forests.

6.14.1 Empowerment of JFMC , Gender Issue and ecotourism in north Bengal

Forest dependent and fringe people were made sufficiently empowered with their involved in participatory planning through micro planning in the matter of protection and improvement of forest and wildlife as well as socio-economic upliftment of local population to minimize their dependence on forestry resources, by mostly involving women. The north Bengal tourism is forest centric. The Figure 6.7 provides the tourist flow in different protected areas across the years, which indicate the Jaldapara and Gorumara protected area have been attracting higher number of tourist flow over the years. While the Department of Tourism is spread over the entire area, the Department of Forests also created various ecotourism centres at important locations. These centres have become a big attraction for the tourists. At present, below mentioned spots within the jurisdiction of wildlife wing function as ecotourism centres.

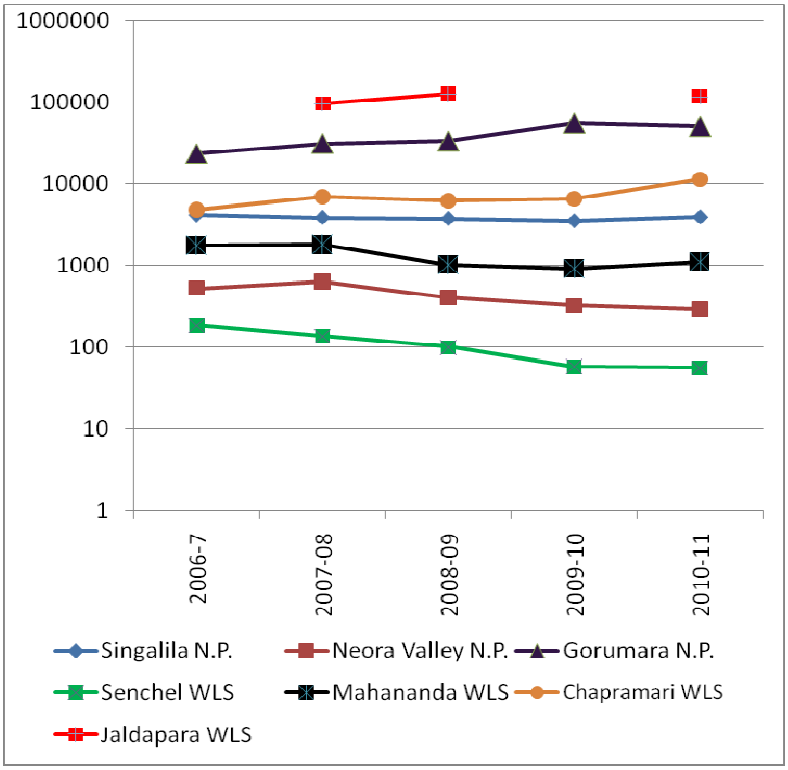


Figure 6.7 Tourism flow in differnt protected areas in north Bengal of KL, India

The case of women participation gave good results in Gorumara National Park, as a case study (Table 6.3), where forest department initiated ecotourism concept. The Gorumara national park is anthropogenically influenced by 70 villages (1,24,690 people); 13 EDC villages with 9 EDCs comprise 8548 EDC population. Besides, surrounding with 70 villages on three sides, the park is under pressure with 60 tea gardens on another side, for fuel wood collection and other resources. The wildlife management adopted fur strategies to improve overall infrastructure for the ecotourism development, viz. *1) Improvement of Facilities for Day Tourists; 2) Infrastructure Development; Involvement of Local Population in Ecotourism; and 4) organizing awareness and training camps.*

The JFM through ecotourism had an immense effect on the offence status in the Protected Area. A comparative statement shows that the felling of trees got reduced from 145 to 19 in four years. The unproductive cattle population was discarded and hence illicit grazing by cattle diminished from 138 to 7, i.e. a reduction of 95%. The earning of folk groups and EDC guides were also enhanced through above management interventions. Furthermore, the population of Gaur (Indian Bison) was increasing every year; similar positive results appeared for all other major animals and birds. About 25% earning from ecotourism went to EDC common fund, which could be utilized independently by the EDC members. The Figure 6.8 Indicates the increasing revenue generation from ecotourism, shared to EDC and government. In addition, in Gorumara NP, the local economy also enhanced through eco-tourism activities.

Gorumara Elephant camp, Dhupijhora, north Bengal in KL, India (Photo: VK Sood)

Meeting of park management with stakeholders in Gurumara, north Bengal in Khangchendzonga landscape, India (Photo: VK Sood)

Table 6.3 Status of gender participation in socio-economic activities in Gorumara national park north Bengal of Khangchendzonga landscape, India

Activity (gender involved)	Female	Male
Guide	0	60
Cottage Industries	105	0
Folk dance	81	44
Labour	8	62
Cart/Boat	0	10

6.14.2 Ecotourism Management in Sikkim

In KL (India), Sikkim has proposed to form an Ecotourism Council as an autonomous body to monitor the activities related to eco-tourism in the state. Ecotourism Council will have an executing arm, which is the Ecotourism Directorate (ED) working under the Forest, Environment and Wildlife Management Department (FEWMD). The Council will have a local village level operational system which incorporates various Community-Based Organizations (CBO) working in tandem with Panchayat, Non

Governmental Organization, Tourism Development Committee (TDC), Self-help Groups (SHGs) and other local people's representative groups.

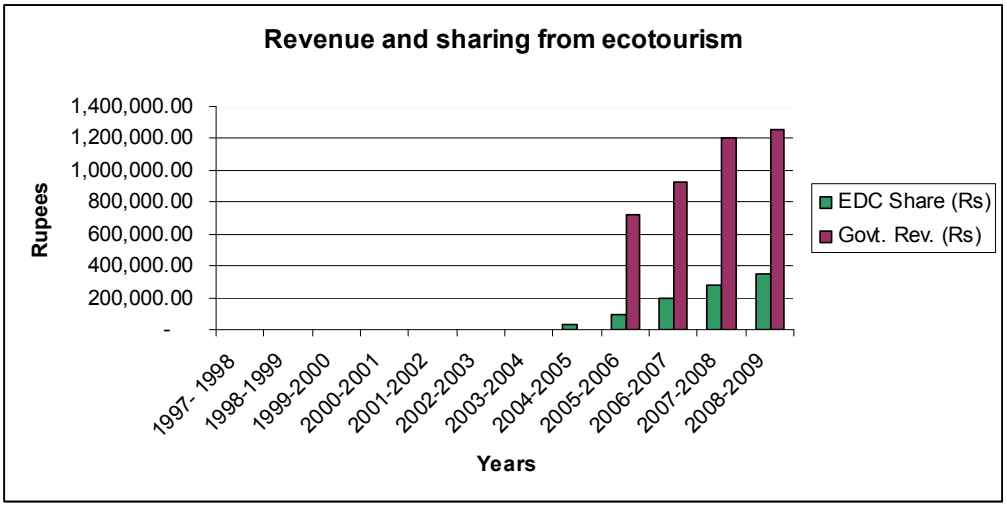


Figure 6.8 Revenue sharing from ecotourism in north Bengal part of KL, India

6.15 Dependency and roles of women in forest and biodiversity management

Forests and protected areas tend to be the main source of living for the majority of rural population in KL India. For example, around 82.31 % of the total geographical area in Sikkim is under ownership of the government. Around 15.69 % of the area is available for farming (Sharma and Tanak n.d). Therefore, forests are main sources for poor households to draw forest productsCase studies from Sikkim reveal that women are playing primary roles in the conservation of *in-situ* genetic resources and agrobiodiversity. They grow a variety of plant species and contribute significantly to maintaining biodiversity in the agricultural ecosystem. As gatekeepers of seed management, they have sound indigenous knowledge of seed selection, processing, and preservation (Dhakal, 2012a). Women make *kinema* out of soyabean and sell it in local market (Dhakal, 2012b). Women collect wild edible plants and sell them in markets (Sharma and Tanak n.d). In addition, the Self-Help Group led by women is contributing to plant and sell seedlings that have medicinal and economic values. Women's roles are also equally important in forest protection and sustainable use. For example, their involvement in non-timber forest products gathering, processing and marketing is higher than men's (Table 6.4).

Table 6.4 Gender roles (% of total time invested) in the Non-Timber Forest Products activities, West Bengal, India

NTFP activities	Men	Women
Collection	25	75
Processing	0	100
Marketing	33	67
Utilization	50	50

Source: Directorate of Forest, Government of West Bengal in Sarker and Das (2002: 4408)

6.15.1 Some gender issues related to forest management

6.15.2 Low representation of women in forestry institutions

Inclusion of women in JFMCs is less than 10 % of the total membership in the committee (Table 6.5). Even if women are included in the committee, they don't have voice and influence in planning and decisions related to forest management (KL India: Stakeholder meeting, 27 Feb 2014, Sukhana, Darjeeling).

Table 6.5 Gender Inclusion (% of total members) in the Forest Protection Committee, West Bengal, India

District	Forest Division	No. of FPC	Men	Women
Jalpaiguri	Baikunthapur	55	96.02	3.98
Darjeeling	Darjeeling	41	91.21	8.79
	Kalimpong	35	94.17	5.83

Source: Adapted from Sarker and Das (2002, p 4409)

6.16 Factors affecting gender equity in forest management and biodiversity conservation

Traditional socio-cultural norms, values, beliefs and institutional practices, and lack of organizational support hinder women to participate meaningfully in forest management and biodiversity conservation programme. As an example, membership criteria of forest users in the joint forest management tend to be gender bias. Since the head of households is considered as the unit of forest user, women's identity as forest users has been marginalized because men is often considered the head of household (Sarin, 1995). As membership is entitled to access to forest benefits, it is not surprising to say that women are losing the benefits. Preference of men forest users by the men staff of the forest department who facilitate JFM processes is another issue contributing to women's exclusion from participation and benefit sharing in forestry activities at the grassroots level. Moreover, dominance of men and limited opportunity for women to voice and be listened during JFM's meetings discourage women to take part in the executive committees. Even if women are included in the executive committee of JFM, they have limited awareness of JFM process and roles (Sarin, 1995). In context of involvement of women in forest management programmes, they have limited opportunity to familiar with formal procedures of forest management and strengthen their capacity on organizational management due to unaware about the institution. Forest management programme planning and implementation processes of the forestry department also less recognize gender differences in terms of dependence on forests, benefits sharing and decision making (Sarin, 1995). Women's role tends to be important in biodiversity conservation (Dhakal, 2012a, 2012b), but gender agenda receive low priority in policy level discussions and decision making related to biodiversity conservation. In many policy forums and training/knowledge exchange programme, women's presence is nominal. Therefore, gender sensitization in forest institutions at all levels and engaging men in empowering women in forestry are vital.

6.17 Initiatives towards conservation and management

There have been much progress in approaches, initiation and implementation of various programmes on conservation and management of biodiversity and associated areas in Khangchendzonga landscape in India over time. In case of environment and wildlife management in KL, India a long history of achievements is in record; the Appendix 6.4 offers many milestones, out of numerous.

Chapter 7: Climate Change and Environment hazards

The environment and climate change are highly pronounced alarming issues globally, threatening the natural resources and not limited to any political administrative boundary. Warming temperatures, more frequent extreme weather events and patterns of rainfall and drought govern the climatic variations, which affect the overall ecosystems regulating the development of patterns associated with biotic and abiotic elements (Fitter and Fitter, 2002; Walther *et al.,* 2002; Parmesan and Yohe, 2003). Inter-governmental Panel on Climate Change (IPCC) reported that the global surface temperature has risen by 0.74 °C between 1906 and 2005, and predicted to increase up to 1.8 - 4.0 °C by the end of a century. In Indian subcontinent, the maximum temperature may increase up to 2-4 °C, and minimum temperature may touch the 4°C during the 2050s and it is projected that the rainy days will decrease over a major part of the country (NATCOM, 2004). In the South-Asian sub-region, the Himalayan ecological system especially is the most sensitive to climate change and global warming. Himalaya includes 33,000 Km^2 of melting glaciers, which are considered vulnerable to global warming. For the Himalayan region, several studies suggested that the warming in the Himalayas projected much greater than the global average of 0.74 °C over the last 100 years (IPCC 2007). Study from the other part of Himalaya, i.e. Nepal showed warming trends and estimated 0.6 °C temperature rise per decade between 1977 and 2000 (Shrestha *et al*., 1999).

7.1 Climate change signal

KL-India is considered unique for its bio-geo-climatic gradients (tropical to alpine) wherein, several regression model has been applied to estimate and predict the changing phenomenon using long-time series data (1350 m asl), as a representative case for KL, India. Climatic data on different parameters (i.e. minimum and maximum temperature, rainfall, relative humidity, evaporation and sunshine hours) are utilized to estimate climatic change across the years (1981 to 2010). Linear regression model estimates that on an average 0.85-0.99 °C minimum temperature increased per decade significantly ($p<0.001$). Annual mean temperature indicates warming signal per decade (0.42-0.58 °C) ($p<0.001$) (Figure 7.1). While, annual rainfall does not show significant trend (Figure 7.2). Mean annual relative humidity estimates increasing signal (i.e. 0.53-1.21%) per 10 years significantly ($p<0.02$). Also, on an average 13.86-25.08 mm annual evaporation increased over per 10 years significantly ($p<0.002$). However, sunshine hours indicates declining (i.e. 220-283hrs) result over each 10 years significantly ($p<0.001$).

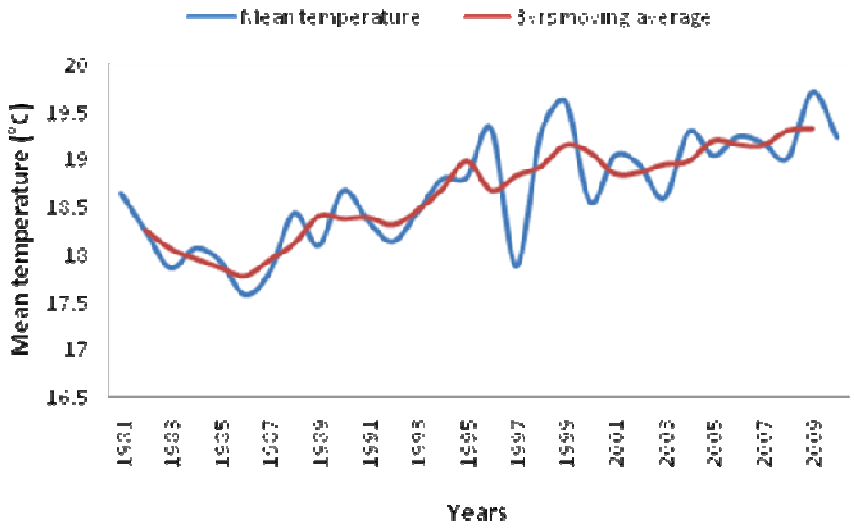


Figure 7.1 Three years' moving average trend of temperature across the years from 1981-2010 (Statistical and Graphic representation by GBPIHED, using base data from Rahman *et al*., 2012)

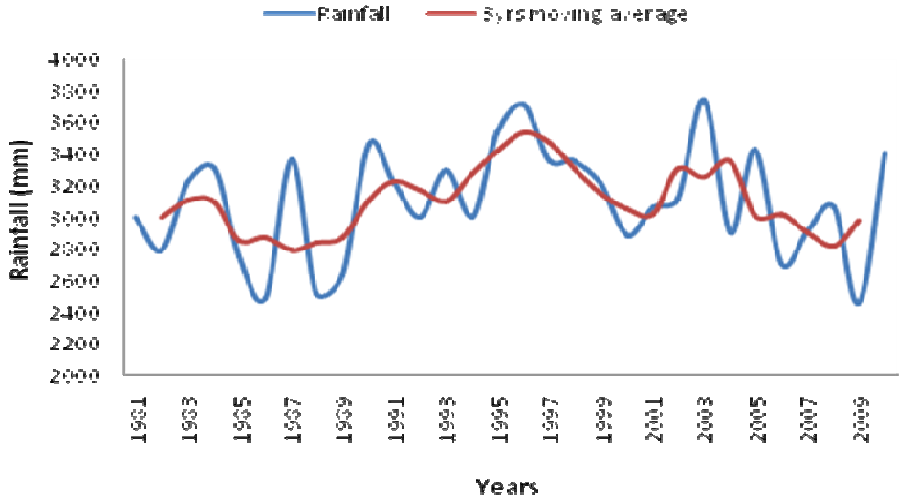


Figure 7.2 Three years' moving average trend of rainfall across the years from 1981-2010 (Statistical and Graphic representation by GBPIHED, using base data from Rahman *et al*., 2012)

Climate change indications has also, been estimated in the KL-India, using long time series data (Kumar, 2012) and resulted that the mean annual minimum temperature increased over the last 10 years i.e. 0.2 °C, wherein winter and summer season projected warming signal. An increasing indication in annual rainfall has been observed (i.e. 49.6mm) over a past decade while, decreasing (0.7mm) in winter season. Based on such consequences, the Himalaya considered as a sensitive towards climate change. Rhododendrons in Himalaya have indicated vivid sensitivity towards climatic variations (Badola and Paliwal, 1987; Vetaas, 2000). From central Himalaya, reported impact of climate change on the flowering of *Rhododendron arboretum* (Gaira *et al.,* 2014). A recent study on assessment of impact of climate change on rhododendrons in Sikkim part of KL-India using Maxent model has concluded a reduction in distribution pattern due to climatic change (Kumar, 2012).

7.2 Impact of Climate change

7.2.1 Biodiversity

Along the environmental gradients in time and space, biodiversity characteristics are subject to change for being interrelated and each influences the other. The threats to biodiversity and the impact of global climate change are two major environmental concerns affecting the mankind in a myriad ways. With the passage of time, these concerns are progressively growing. A linkage has been established between biodiversity threats and climate change (Chettri *et al.,* 2012) through extrapolated data of vulnerability from Tse-ring *et al.* (2010) for the seven administrative units in the KL. It shows higher vulnerability ranking for Darjeeling, followed by Sikkim and eastern Nepal (Table 7.1). The least vulnerable areas, as per the analysis, indicate in the administrative units of Bhutan. Such threats may be considered due to high sensitivity of some of the microclimatic habitats in the landscape such as alpine meadows, alpine scrub slopes, alpine dry and moist scrub, old growth fir forest, birch-rhododendron forests, Juniper forests, bamboo undergrowth, cloud forests, Juniper-rhododendron scrub, hemlock-spruce, larch forest, willow scrub to climate related stresses.

Table 7.1 Administrative units of the KL with indicators of vulnerability and vulnerability ranking

KL Countries	Countries administrative units within KL	Vulnerability ranking within KL	Vulnerability ranking within EH	Adaptive capacity index	Exposure index	Sensitivity index	Vulnerability
India	Darjeeling	1	14	0.334	0.486	0.449	0.534
	Sikkim	2	51	0.441	0.434	0.304	0.452
Nepal	Taplejung	3	55	0.454	0.490	0.299	0.445
	Ilam	4	59	0.525	0.474	0.360	0.436
	Panchthar	5	61	0.511	0.452	0.337	0.426
Bhutan	Paro	6	81	0.562	0.472	0.295	0.401
	Haa	7	89	0.693	0.463	0.303	0.358

(Source: Tse-ring *et al.,* 2010, taken from Chettri *et al.,* 2012)

7.2.2 Climate driven species range shifting

Species range shifts is an important component with respect to climate change and observed worldwide. Considering such indications in the part of KL-India, Acharya and Chettri (2012) have compared their observations with Ali (1962) on birds; they have observed that Blood Pheasant has been occurred above 3300 m elevation limits, while earlier report indicates the occurrence of species as low as 1500 m (Ali 1962). Furthermore, they have mentioned snow Pigeon currently occurs in the sub-alpine and alpine zones (common at 3000 m), far exceeding its historical lower limits of 1600 m. Rusty- bellied Short-wing has shown shift of its habitat from temperate broad-leaved evergreen forests (upper limit 2900 m) to temperate coniferous forest (3600 m) in the landscape. Above all evidences are sufficient to indicate an elevation range expansion of species (Acharya and Vijayan, 2007). In addition, white-winged Redstart occurs in the Tibetan Plateau above 4000 m but earlier it was recorded as low as around 1700 m by Loke-Salim Ali expedition in Sikkim in 1950s. Recent study in the landscape resulted reduction in distribution pattern of *Rhododendron* species (Kumar, 2012). The case of alpine flora reaching greater heights have been of real concern (Telwala, 2012) in the alpine area of KL-India,

especially for the associated faunal component who have to accommodate themselves in the changed environment. In the last decade the common Himalayan Alder (*Alnus nepalensis*) which is a temperate species (900-1800 m asl) has reached up to 2400 m asl and is still observed to be gaining higher elevations for establishment. Similarly, the major food crops, e.g., maize, paddy as well as the mandarin are marking higher altitude range than before. High levels of impact from climatic change has also been observed for wheat, oil seeds, cardamom, ginger, drinking water sources and springs and fodder trees in the region. However, the changing climate regime in Sikkim is positively affecting the farming sector (Sharma and Rai, 2012), hitherto, this appeared appropriate but in the longer run suitable adaptive mechanism has to be find out. Lucksom (2011) has recorded that there are cases of orchids shifting to higher altitude in KL, India.

7.2.3 Phenological changes

One of the most preferred indicators of climate change, phenology is the discipline of the timing of recurring biological events, influenced by seasonal environmental factors such as temperature and precipitation, etc. (Badola, 1994). Phenology offers a high-temporal resolution of on-going changes using their date-wise records (Menzel *et al.,* 2006; Badola, 2010a). Several evidences have indicated that global climate change is affecting biological systems all across the world and phenology recognized as a potential indicator of climate change (Badola, 2010a; Gaira *et al*., 2012). Amongst Himalayan woody taxa, rhododendrons show much sensitivity towards climatic variability, especially including the *Rhododendron arboreum*, which is widely distributed in Himalayan range (Badola and Paliwal, 1987). A recent study from Indian Himalayan Region (IHR) has assessed the impact of climate change on flowering of *Rhododendron* in the central Himalaya (Gaira *et al.,* 2014) and estimated 88-97 days early flowering with increasing annual maximum temperature. The entire KL- India, a most conspicuous elevation gradient having high sensitivity to climatic perturbation, is amongst data deficient regions from phenology study point of view especially relating to climate change. A casual observations of the rhododendron flowering time taking in the primary and secondary data has revealed that the regional rhododendrons are getting ahead in respect of its flowering season (Table 7.2; Gurung *et al.,* 2011, Unpublished poster, GBPIHED, Sikkim). More or less similar observations of the year 2010 on half a dozen rhododendron species in Khangchendzonga National Park, on the flowering dates were compared with the record of Pradhan and Lachungpa (Badola and Pradhan; unpublished results). It may be clear if the other species follow this trend in the rhododendron group.

Table 7.2 Climate change impact on rhododendron flowering time

Species	Hooker (1849)	Pradhan and Lachungpa (1990)	Observations (2008-2010)
R. arboreum	Mar	Mar	Feb
R. campylocarpum	Jun	May-Jun	Apr-May
R. decipiens	May	May-Jun	Apr-May
R. edgeworthi	May-Jun	May-Jun	Apr-May
R. pendulum	May	Apr-May	Apr-May
R. thomsoni	Jun	May-Jun	Apr-mid May
R. wighti	Jun	May-Jun	Apr-May

In monitoring climate change, for KL, India, an action plan with wider application using rhododendron phenology by establishing permanent monitoring stations along five altitudinal zones, viz., Zone- 1 (1600-2100m). Zone- 2 (2100- 2600 m), Zone- 3 (2600-3100m), Zone- 4 (3100-3600m), and Zone- 5 (3600-4100 m) have been recommended (Badola, 2010a).

7.2.4 Pollination and climate change

Valuable report has been documented that 87 world's leading food crops depend upon animal pollination, representing 35% of global food production (Klein *et al.,* 2007). Bees and other pollinating animals provide a valuable input to agricultural production, increasing both the variety and quality of harvests, especially for orchard, oilseed crop, horticultural and forage crops and production of seed for many root and fiber crops. Therefore, pollination service is partially or impartially affected by climatic variability. Pollination services may be hampered due to changing in any component of plant viz-a-viz pollinator by changing in climatic variables. Both the pollination agents i.e. flowering plants and animal pollinators, are interrelated to each other. In the KL-India, there are several cross-pollinated crops, which are depended on pollination services for quantity and quantity of harvests.

7.2.5 Effect of rainfall on cardamom crop

Large Cardamom is one of the main perennial cash crops in KL-India (600-2000m). The crop is cultivated in the agro-forestry system contributing to the mitigation of climate change due to its higher primary productivity rates and carbon fixation rates in the region as high value and low volume crop. Moreover, the crop prefers growing under *Alnus nepalensis* is more profitable in terms of fertility enhancement of crop field (Sharma *et al.,* 2009; Singh, 2008). The crop is generally, sensitive to climatic conditions requiring limiting temperature of 6 °C (Dec-Jan); 30 °C (Jun-Jul), high humidity and annual rainfall between 2000-3500 mm. Crop normally does not require irrigation but situation in the region is showing certain signs of altering this natural design and this is most visible in the form of cardamom crop. The rain dependent cardamom production has been greatly affected by less rain in the past few years bringing about lesser yield and economic returns (Gaira *et al.,* 2010).

7.2.6 Weeds, pests and diseases

The weeds and pests have been slowly making its presence felt in KL-India by way of - (i) new entrants in the region, and (ii) resident weeds/pests making inroads into newer territories, mostly towards higher zones. Apart from the above incidences, it has been noted that plant diseases are found to be entering newer locations as well as new diseases are also recorded in the region. The incursion of weeds and pests in the region and especially in farming environment has dire consequences to the economy. Newer weeds in the form of *Parthenium hysterophorus*, *Mikenia scandens*, *Cestrum aurantiacum* as well as a host of other exotic weeds are gradually making their vivid presence in the region and that needs study on its negative impact and coping measures. Of the recorded ca. 35 weed plants from the region a few have crossed 2500 m asl mark and one has reached 3000 m asl in the recent past.

7.2.7 Economic and ecological burn out of cardamom, ginger and mandarin crops

The ginger and mandarin along with the cardamom comprise important cash crops cultivated in the Darjeeling and Sikkim part of the KL-India and incidentally these are affected to changes in climatic variables mostly in the form of temperature

changes, which have brought about increased disease incidence affecting the produce. Temperature being a factor in greening disease and *Phytopthora* infestation in mandarin orange was reported long ago (Ghosh, 1992). It was reported over 50 % of cardamom field have been decimated in the last few decades taking a massive toll on the state's economy. With the declining crop cover its ecological fallout cannot simply be wished away especially in regard to its ecosystem services in the form of water balance, land erosion and habitat loss to the particular biota that thrives on these crop system.

7.2.8 Shrinking ice cover

Global climate change had a significant impact on glaciers and glacial environments during the twentieth century (Govindha *et al.,* 2013). The lakes are increasing in a real amount and water storage capacity due to increase in the rate of melting of the glaciers. Sudden discharge of large volumes of water and debris from these lakes is defined as glacial lake outburst flood (GLOF) which can cause extensive damage to the natural environment and human property. Among the many glaciers, the major ones are found to be shrinking from the last few decades representing nival zone to decrease and the alpine zone to increasing in its extent and South Lhonak glacier is expand up to 1.9 km due to glacier retreat from 1962-2008 (Govindha *et al.,* 2013). However, the fastest shrinking rate has been reported for Jongsang glacier at 38.20 m per year (Raina, 2009). Another study by Luitel *et al.* (2012) on East-Rathong glacier in West-Sikkim indicates that the retreat of the glacier from 1976 to 2009 (i.e. 33 years) is around 460 meters, while during from1997 to 2009 (12 years), it observed to be 234 m. The retreat of glacier was measured along the centerline and highlight that the glacier showed a retreating trend and the rate of retreat is 19.5 m/year during the last 12 years. Such evidences on retreat and shrinking of glaciers of the KL-India are indicative of change in climatic events like rising temperature, extreme rainfall and uneven sunshine hours.

7.2.9 Indicators of climate change impacts on agrobiodiversity

Himalayan farmers of the landscape (KL-India) have, over the years, observed alteration of crop seasons due to unseasonal rainfall events, or erratic rainfall, unusual temperature, new diseases and pests in the major agricultural and horticultural crops, prolonged dry periods etc. As a result, these events are affecting the suitability and adaptability of the crops in the agroecosystems. While mountain farmers have initiated to overcome such challenges by establishing agroforestry. Agroforestry is an increasingly important adaptation strategy for enhancing resilience to adverse impacts of rainfall variability, shifting weather patterns, reduced water availability and soil erosion. The diversity of multipurpose species grown in the agroforestry systems or naturally growing in the forest areas have tolerance to wind, high temperature, or drought and are becoming increasingly important to communities. Rice, maize, wheat are important staple crops for the marginal farmers that are most vulnerable in the changing situation of Sikkim (Table 7.3). Similarly, among the high value cash crop large cardamom is the most vulnerable after ginger and broom grass in the traditional farming systems of the Sikkim Himalayas. Some naturalized exotics such as *Ageratum houstonianum*, *Erigeron karvinskianus*, *Galinasoga parviflora*, *Erichthites valarianiifolia* and *Gleolaria maxicana* have been observed profusely colonizing in agrobiodiversity systems in KL, India.

Table 7.3 Some indicators of climate change impacts on agrobiodiversity

Crops	Indicators of change
Cereals and pulses	Several traditional varieties of rice disappeared from the systems such as *Punaro Kanchi Attey, Kagey Tulasi, Thulo Attey, Ghaiyya Dhan, Sanu Tulashi, Seto Tulashi, Thulo Marshi, Tauli Dhan, Baghey Tulashi*. The roots are infected by termites when the rice is in fruiting stage. In maize pest infestation, Kalipokey not seen in maize in last 10 years. In the subtropical belts, ginger cannot be cultivated due to stem rot and blights.
Large cardamom	The major threats to large cardamom have been the spread of fungal disease *Colletotrichum* blight that appears in the advent of pre-monsoon showers (April-May) and progresses rapidly during the rainy season (June-August). The emergence of viral diseases commonly called chirke and foorkey disease since early eighties have drastically reduced the production (up to 60%) and plantation area (almost 50%).
Ginger	The biggest challenge for ginger cultivation has been to control the soil borne diseases, soft rot, dry rot, bacterial wilt and so on. At the same time production of enough manure, manpower for cultivation, and marketing at the time when market fetches high price are other challenges.
Chayote	Shrinking leaves, blights etc. has been observed in the last five years
Broom grass	Broom grass is a multipurpose agroforestry species in the mountain farming systems all along the Himalayas. In the last 10 years this grass has developed yellowing of leaves and leaf blights. During winter especially after October, the broom grass bushes develop this disease and dry out. Thus, this fodder species remains non- palatable to farm animals.
Orange	Recently, the productivity drastically declined after 2008 owing to weak management of old diseased trees where potential fruit bearing potency is lost. In addition to this, the old plantations have lost the vigor and majority of them are reeling under viral and other disease infestations.
Fodder species	In the recent years, farmers have witnessed that tree fodder production has significantly declined. One of the reasons is pests eating up all the leaves before they mature for harvesting especially during lean season. Some of these preferred trees are *Artocarpus lakoocha* (Badar), *Ficus cunia* (Khasreto), *Ficus benghlensis* (Pate Bar), *Ficus ruxborgii* (Nibaro), *Ficus lacor* (Kabro), *Ficus semicordata* (Khanew), *Ficus nemoralis* (Dudilo),*Ficus hispida* (Khasreto), *Morus alba* (Kimbo), *Bauhinia ascicula* (Koiralo), *Ficus hirta* (Khasre Khanew), *Ficus clavata* (Lute Khanew), *Bauhinia purpurea* (Tanki), *Litsea monopetala* (Kutmero), *Saurauia roxburghii* (Auley gogun), (Chuletro), *Saurauia asciculate* (Gogun), *S. griffithi* (Tatey gogun), *S. nepaulensis* (gogun), *S. punduana* (Auley gogun),
Grass fodder	Colonisation of invasive species ; the common fodder species such as *Digitaria sanguinalis* (Ghogey Banso), *Paspalum conjugatum* (Chitre Bnaso), *Panicum repens* (Phurkey), *Thysanolena agrostis* (Amliso) are declining.
Emergence of weeds in cultivated farms	Some of the common weeds of maize are *Eleusine indica*, *Setaria galuca* etc. Similarly, common weeds of rice are *Cyperus eragrotis*, *Hydrodoctyle helplansis*, *Paspalum pasploides*, *Echinocloa crusgalli*, *Echinocloa colonum*, *Cyperus rotundus*, *Cynodon dactylon*, *Ageratum conyziodes* etc. The common weeds of wheat are *Chenopodium album*, *Amaranthus* sp., *Cynodon dactylon*, *Polygonum capitata* etc. Potato and mustard are common winter crops. They are mostly infested by common weeds such as *Polygonum capitata*, *Cyperus rotandus*, *Cyperus iria*, *Cynodon dactylon*, *Drymaria cordata*, *Spilanthus paniculata*, *Sida rhimbifolia*, *Gnaphalium affine* etc.

7.3 Local level evidences/issues in relation to climate change

Local people are the major source of information because, they are directly associated with natural resources. Therefore, it is important to include their perceptions and views in various environmental issues at local level. Realizing their importance, people's perception based programme was conducted in three Wild Life Sanctuary (WLS) (i.e. Fambonglho WLS, Kyangnosla WLS and Pangolakha WLS) in the KL-India, as the case of representation. People's perception on global warming and climate change was gathered and over 80 % consent beset on increasing pollution, snow area decrease in snow-bound areas, increase in temperature, climate getting warmer, unpredictability of weather, rise in risk of crop failure, increased garbage load and increasing incident of forest fires. Out of these the event of rising temperature observe with 95 % consent score which is followed by increased pollution (92 %) in the past one decade. In regard to the people's perception on rainfall, temperature and wind velocity at three different wildlife sanctuaries (Fambonglho WLS, Kyangnosla WLS and Pangolakha WLS) appraisal, 83.88 % consents had emerged on changing temperature and followed by rainfall (i.e. 69.33 %), and wind velocity (i.e. 62.77 %) (Figure 7.3). Fambonglho WLS recorded the highest values because of the extremities of climatic variables, which location experiences due to its proximity to Mt. Khangchendzonga and for being situated on the ravines of rivers Tista and Rongnichu.

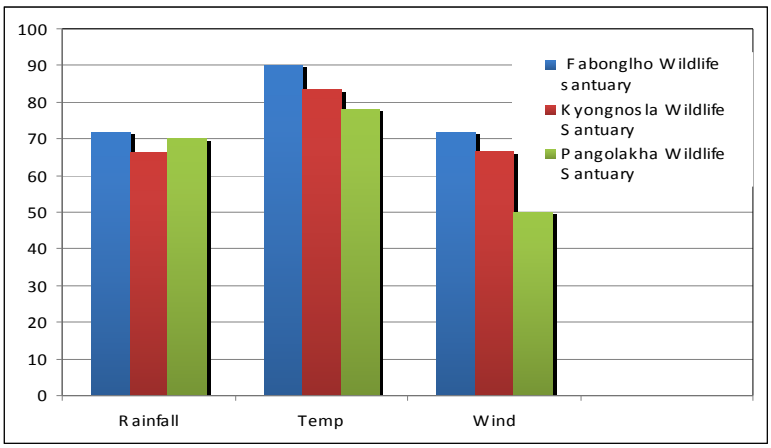


Figure 7.3 People's perception on climate change in Khangchendzonga landscape, India (approval in %; source: BCTL Report 2010)

7.4 Environmental hazards

7.4.1 Earthquakes

The KL-India includes wider geo-bio-climatologically variations comprising various kinds of natural calamities. Darjeeling–Sikkim Himalayan (DSH) region lies between the Nepal–India border to the west and the Bhutan Himalaya to the east is prone to earthquakes (and the Darjeeling–Sikkim–Tibet Himalayan wedge is the most appropriate region to explore the first- order kinematic behaviour of the active Himalayan wedge (Mukul, 2010; Gansser, 1983). In continuation, Mukul *et al.* (2014) have been studied seismo-tectonic implications of strike–slip earthquakes in the Darjeeling–Sikkim Himalaya and listed focal mechanisms of the moderate earthquakes in the Darjeeling–Sikkim Himalaya (Table 7.4). Table exhibits that prominent thrust earthquakes in the region include the 14 February 2006 Sikkim earthquake of magnitude 5.3 *(Mw)*. While Significant strike–slip earthquakes include the 19 November 1980 Sikkim earthquake of *Mb* 6.2, the 12 February 2001 earthquake of *Mw* 4.8, the 20 May 2007 earthquake of *Mw* 4.9 and the 18

September 2011, *Mw* 6.9 earthquake close to the Nepal–Sikkim border. This shows that both strike–slip and thrust seismo-tectonics are operational in Darjeeling–Sikkim Himalaya.

Table 7.4 Focal mechanisms of the moderate earthquakes in the Darjeeling–Sikkim Himalaya in Khangchendzonga landscape, India

Reference	Date	Latitude (°N)	Longitude (°E)	Depth (km)	Magnitude	Focal mechanism	Strike	Dip	Rake
1a	19/11/1980	27.39	88.75	17	6.2	Strike–slip	209	51	-2
2a	26/03/2005	28.08	87.95	69.6	4.7	Strike–slip	200	89	28
3a	14/02/2006	27.22	88.64	19.2	5.3	Thrust	287	27	127
4a	20/05/2007	27.23	88.56	13.6	4.9	Strike–slip	204	58	-4
527b	12/2/2001	27.34	88.31	22	4.8	Strike–slip	182	16	
6c,62	12/01/1965	27.40	87.84	23	6.1	Strike–slip	90	75	90
7d,a	05/04/1982	27.38	88.83	9.0	5.1	Strike–slip	206	48	-30
8d,e	18/09/2011	27.74	88.11	35	6.9	Strike–slip	220	78	0

[(a- http://www.isc.ac.uk, Thatcham , 20011; b-de la Torre et al., 2007; c- Crouch and Starfield, 1983; d-Pradhan, et al., 2013; e- http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usc0005-wg6/neic_c0005wg6_cmt.php); Source: Mukul et al. 2014]

7.4.2 Landslides

Landslide is affected by very heavy rainfall in KL-India with different magnitude and intensity causing several damages. Landslides are frequent in the landscape especially in the mountain part. Extreme rainfall events are the major cause of landslide. Earlier in 2013, first exceptionally heavy rainfall event after a large earthquake in mountainous areas causes very large numbers of very damaging landslides, with a high cost in lives and damage. There is some major landslide of the landscape (KL-India) listed in the Table 7.5. Considering entire Darjeeling hills, 40 major landslides have been occurred claiming 27 lives beyond 2 persons who are still untraced (Darjeeling Times, 2009; Govt. of W. B., 2009). The total damage of dwelling houses caused by this storm-induced landslide was Rs 888.67 million, approximately 542.989 hectares of agricultural lands have been reported to be damaged. All major 5 roads connecting Darjeeling to Siliguri and Kalimpong faced 15 to 20 landslides in each stretch (Govt. of W. B., 2009). Pictorial representation of landslides prone areas of Darjeeling has been placed (Figure 7.4).

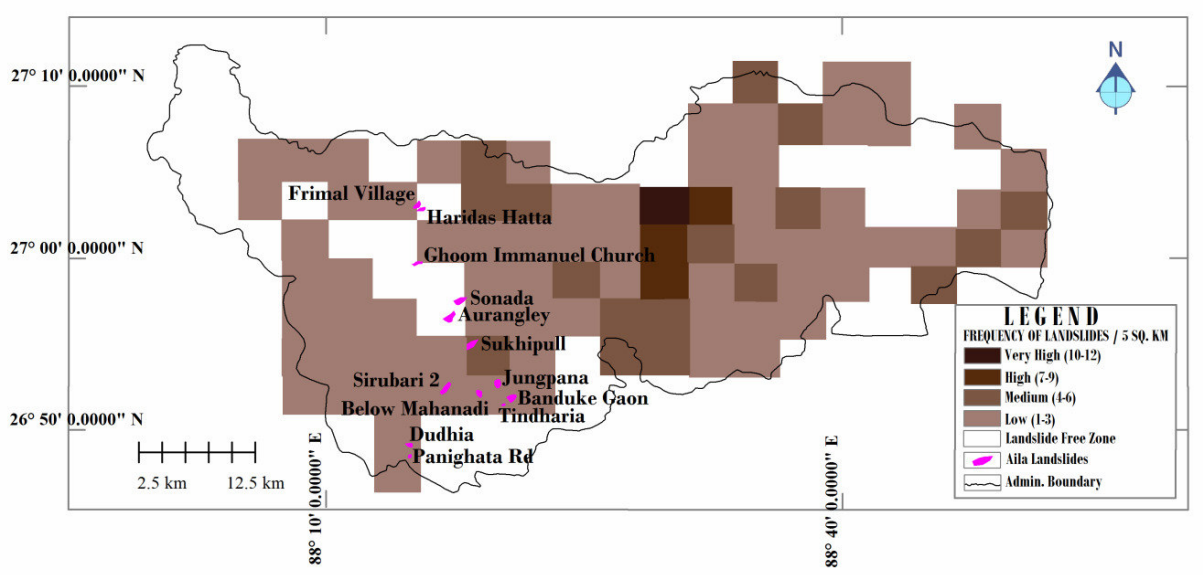


Figure 7.4 Landslide frequency map of the Darjeeling hills (**Source**: Bhattacharya, 2012)

Table 7.5 Major landslide incidences in the KL-India

Name of landslide	**Type of slide**	**Magnitude and intensity**	**Area in danger**	**Triggers**	**Strike time**	**Damage**
Manul	Debris Topple Gneisses, schists	Debris avalanche	North- Sikkim Highway	Steep lope, weak geology, Heavy rain	11/9/19 83	65 dead GREF Camp wiped out
Sao Khola Rongli	Debris flow (Shallow) Overburd en of gneiss and schist	Huge fast avalanche	Rongli Bazaar	Heavy rain Thick debris On steep slope	21/5/97 12.30 PM	07 persons dead, one injured
Gangto k and Vicinity	All types Rock/Soil Material	Widespread fast mud and debris flow	Dev. Area, Rongnek, Syari, Mintokgang Sichey	Heavy rain, overflow of drain water etc.	8-9.30 PM 08/06/9 7	43 persons dead, 300 houses completely 1000 partially
Deorali Gangto k	Mudslide (Shallow) Rock/Soil/ Constructi on	Localised fast mud flow	Kopibari School Area Deorali	Water supply pipe burst and rain	9.30 PM 05/9/95	32 people dead, 08 houses completely
Chawa ng	Complex gneisses, schist debris and boulders	Widespread avalanches	Dentam-Pelling Road	Steep slope, Weak rock	30/9/2005	15 houses

[**Source**: Sikkim State Disaster Management Plan, 2010-2011]

7.4.3 Hailstones

Occurrence of hailstones in the KL-India often is associated with thunderstorms with high intensity frequently during late winter and spring, and injured the large cardamom crop especially at high elevation ranges. Apart from these, other agricultural crops are suffering from this continuous incidence and farmers faced many economic losses. The damage itself is often produced not only by the impact of falling hailstones, but also by the high winds and torrential rains, that is part of the hailstorm. The hailstones events are frequent in the landscape and damaging various field crops, forest vegetations, livestock, domestic commodity, etc.

Hailstone incidence in Khangchendzonga landscape-India (Photo: K. Gaira)

7.4.4 Forest fires

A forest fire has significant impacts on terrestrial, aquatic, and atmospheric systems across the globe, which leads to adverse effects on biodiversity, ecosystem functions and landscape stability. Forest fire is a major cause of degradation of forests. In tropical deciduous forests, fire is a recurrent phenomenon due to higher levels of water stress during summer. While Roy (2004), has estimated the proportion of forest areas prone to forest fires annually ranges from 33% in some states to over 90% in others. In the KL-India, summer is the main fire season, the long dry winter from December to March is the fire season and it is most frequent during winters, when long dry spells. A significance study on forest fires based on land use and forest type classification of Sikkim in the year 2009 has been attempted (Sharma *et al.,* 2012). The forest fire damage has been identified from January to May, using the time series satellite imageries in the different types of forests (Table 7.6). They have observed highest percentage of burnt area in sub-tropical and sal forests and mentioned no fire incidences in alpine forest, conifer forest and forest thickets.

Table 7.6 Forest fire incidences in different forest types in KL, India (Sikkim)

S.N.	Type of forests	Total area (Km²)	Burnt area (Km²)
1.	Agriculture land (Agricultural scrub and cropland)	578.09	10.47
2.	Alder forest	445.83	3.94
3.	Sub-tropical forest	64	3.59
4.	Sal forest	19.02	1.10
5.	Rocky barren	64.0	2.92
6.	Oak forest	887.71	0.30
7.	Forest blank area	141.77	1.68
8.	Forest scrubs	15.95	0.19

(**Source**: Sharma *et al.,* 2012)

7.4.5 Shrinking wetlands

The wetlands are probably more endangered as compared to the any other environmental issues in the KL-India. They are places of intense biological activity including the breeding of many species of fish. However, globally wetlands are estimated that half of the entire world's wetlands have disappeared since 1900 due to dredge, filling, draining and ditching along with a rich range of life forms. Temperature can affect evapo-transpiration rates, which has implications for the hydrological regime of wetlands, by transporting water from the ecosystem to the atmosphere. Precipitation regulates the direct inflow and amount of water to wetland ecosystems, which in turn regulates the hydrologic regimes. The effect of a change in precipitation on a given wetland will depend on the type of wetland, topographic and geographic characteristics of the region (drainage area, relief etc.). However, wetlands are sensitive to extreme climate events such as heavy spring flooding and summer drought, which could influence ecological functions such as vegetation cover, habitat value, and carbon cycling.

7.4.6 Traditional knowledge and adaptation

Human communities living in KL-India have always generated, refined and passed on knowledge from generation to generation. Such 'traditional knowledge' is often an important part of their cultural identities playing a vital role in the daily lives of a vast majority of people, especially on food security and health. Pastoralist communities have been practicing numerous indigenous practices to cope up with climatic variability since time immemorial in KL, India. The above series of consequences are sufficient to understand the inferences of climate change for the region, however several other issues i.e. climate change impact on fisheries, tea cultivation, gardening and agricultural productivity in the Terai range of landscape are topical.

Chapter 8: Policy and Enabling Environment

The well-defined and standardized policies can be employed in checking the over use of natural resources and help monitoring human activities, which are detrimental to society and bringing harmful effects on the biophysical environment. The policies and/or acts fundamentally are the results of thorough assessment of situation, looking at the pros and cons of the decisions and committed through a legal body or organization, formulated to sustain the societal values and conserve natural resources for the posterity. The international body or the national government may formulate the policies and the regional state governments can create policies and acts accordingly to their local specific conditions, in addition to those created by the central government. For past many decades, the conservation and sustainable use of natural resources follows the stipulated formal acts, polices and programmes of the central government. A number of laws and statutes formulated by the concern state government further support such acts. The following account provides glimpses of various important policies and acts relevant to KL-India

8.1 National Framework-Policies and Plans

Towards fulfilling the gaps within the framework of policies and plans in India, national conservation and development programme has an inclusive approach. In India, the general concept of environmental protection is enshrined within the Indian Constitution under the Articles 48A and 51A (g). In case of protection of environment and natural resources, the Ministry of Environment and Forests, Government of India (GOI) is the nodal agency, overseeing the relevant environment and forest policies and programmes, including lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals and prevention and abatement of pollution (MoEF, Annual Report, 2011-12). A number of state laws and statutes concerning forests and other natural resources support several national acts. About 5 % of the total geographical area of India has been brought under protected area network (PAN) which consist of 85 National Parks, 448 Wildlife Sanctuaries and 12 Biosphere Reserves. A number of national conservation projects, notably Project Tiger, initiated in April 1973 by the Government of India (GOI) with support from WWF (IBWL, 1972; Panwar, 1982) and the crocodile Breeding and Management Project, launched on 1 April, 1975 with technical assistance from UNDP/FAO (Bustard, 1982) further strengthened the PA network. Such initiatives have resulted in significant increase in the population of many endangered and threatened species of flora and fauna of the country. In recent years, an Eco-development programme for in-situ conservation of biological diversity involving local communities has been initiated. The concept of eco-development integrates the ecological and economic parameters for sustained conservation of ecosystems by involving the local communities with the maintenance of earmarked regions surrounding protected areas, and by taking care of the economic needs of local communities. For scientific management of wetlands, mangroves and coral reef ecosystems, programmes have also been launched in India. Under the Ramsar Convention, 8 wetlands and 1 Mangroves of India have been declared as "Ramsar Sites" and under the World Heritage Convention, 6 natural sites have been declared as "World Heritage Sites" till 2012.

The Ministry has accessed funding from Global Environment Fund (GEF) for preparing detailed National Biodiversity Strategy and Action Plan (NBSAP) using

participatory planning approach and which is currently being implemented. An All India Coordinated Project on Taxonomy (AICOPTAX) has been launched for prioritized purpose-oriented capacity building in taxonomy for identifying the critically important areas and gaps in taxonomic work. Besides, Government of India formed several policies for enabling environment are as follows:

i) National Wildlife Action Plan (NWAP), 1983

This Plan was launched in November 1983 with the following salient features:

- Establish a network of scientifically protected areas such as national parks, sanctuaries and biosphere reserves to cover adequate geographical areas
- Developing appropriate system of management concerning protected areas and restoration of the degraded areas
- Building up professional cadre of personal fully trained for the management of sanctuaries
- Providing corridors linking all the sanctuaries of a particular area of zone
- Rehabilitating indigenous, endangered and threatened species of fauna and flora
- Supporting the management of captive breeding programmes for plants and animals
- Developing research and monitoring facilities
- Promoting support for the wildlife education and research
- Revising statutory provisions providing protection to wildlife and regulating all forms of trade in wildlife
- Enlisting support from and collaborating with voluntary bodies and agencies in the total wildlife conservation effort

ii) National Forest Policy (NFP), 1988

Protection, conservation, and development of forests are the main pillars of the forest policy. This Policy also calls for the people's active involvement in these efforts, as well as in managing the forests. It also stipulated meeting the basic needs of the people, especially fuel wood, fodder, and small timber for the rural and tribal population. The action points should include the following:

- Maintenance of environmental stability through preservation and, where necessary, restoration of the ecological balance
- Conserving the natural heritage of the country by preserving the remaining natural forests with the vast majority of flora and fauna
- Increasing substantially the forest/tree cover in the country through massive afforestation and social forestry programmes, especially on all denuded, degraded and unproductive lands involving the local people in this endeavour by giving them tangible economic motives and employment opportunities
- Meeting the rights and concessions for requirements of fuel wood, fodder, minor forest produce and small timber of the rural and tribal population with due cognizance of the carrying capacity of forests
- Increasing the productivity of forests to meet the essential national needs
- Encouraging efficient utilization of forest produce
- Restriction on diversion of forest lands for non-forest uses and compensatory afforestation
- Afforestation on common lands by the local communities through usufruct-sharing schemes
- Motivation of farmers/land owners to resort to tree farming in similar manner of crop based farming
- Substitution of wood by other materials, alternative sources of energy and fuel efficient stoves
- Permission to forest-based enterprises after a thorough scrutiny regarding the availability of raw materials

- Supply of forest produce to the industrial consumers only at its true market value and not at concessional prices
- Involvement of local people and dedicated grass roots NGOs, in the afforestation programme and for protection of existing forests
- Creation of land banks for compensatory afforestation

iii) National Environment Policy (NEP), 2006

NEP is a prominent policy that drives the conservation plan of the nation, which was approved by union cabinet on 18 May 2006. It is recognized that maintaining a healthy environment is not the state's responsibility alone, but also that of every citizen. The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all. The most secure basis for conservation it ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource. The chief objectives of this policy are as below:

- Conservation of critical environmental resources
- Intra-generational equity: livelihood security for the poor
- Inter-generational equity
- Integration of environmental concerns in economic and social development
- Efficiency in environmental resource use
- Environmental governance
- Enhancement of resources for environmental conservation

Iv) National Biodiversity Action Plan (NBAP) 2008

Through extensive consultation with various stakeholders and approved by the Union Cabinet on 6 November, 2008, the NBAP has been prepared. The attempt has been to make the NBAP consistent with the ecological, social, cultural and economic mosaic of the country, and provide a focus and impetus to the current efforts towards biodiversity conservation.

v) National Agroforestry Policy (NAFP), 2014

In the Indian economy by way of tangible and intangible benefits, Agroforestry plays a vital and contributes an important role. Also, it helps in rehabilitation of degraded lands and improves farm productivity. The mandate for agroforestry research, agriculture is a state subject, forestry is in the concurrent list, and there are no extension services dedicated for its promotion. Realizing the contribution and potential of agroforestry as a resource developmental tool the Ministry of Agriculture, GOI recently has announced the landmark National Agroforestry Policy, 2014.

vi) National Water Policy (NWP), 1987

The Ministry of Water Resources of the GOI formulated a National Water Policy to govern the planning and development of water resources and their optimum utilization. The first National Water Policy was adopted in September, 1987. It was reviewed and updated in 2002 and later in 2012. The main emphasis of National Water Policy in 2012 is to treat water as economic good which the ministry claims to promote its conservation and efficient use. This provision intended for the privatization of water-delivery services is being criticized from various quarters. The major provisions under the policy are:

- Envisages to establish a standardized national information system with a network of data banks and data bases

- Resource planning and recycling for providing maximum availability
- To give importance to the impact of projects on human settlements and environment
- Guidelines for the safety of storage dams and other water-related structures
- Regulate exploitation of groundwater
- Setting water allocation priorities in the following order: Drinking water, Irrigation, Hydropower, Navigation, Industrial and other uses
- The water rates for surface water and ground water should be rationalized with due regard to the interests of small and marginal farmers

vii) The National Tourism Policy (NTP), 2002

A tourism policy was formulated and presented to the Parliament In November 1982, with objective to develop tourism that it becomes a unifying force nationally and internationally fostering a better understanding, helps preserving Indian Heritage and culture and projecting the same to the world and brings socio-economic benefits in terms of employment, income generation, revenue generation, foreign exchange etc. In 2002, the action plan was finally translated into a tourism policy and it officially became a joint central-state government concern. The policy document attempted to establish tourism's great contribution in national development and its role as an engine of growth. It suggested that tourism not only generates government revenue, foreign currency, but also provides an optimal use of India's scarce resources, sustainable development, high quality employment (especially to youngsters, women and disabled people), and finally peace, understanding, national unity and stability. The policy aimed at increasing the number of domestic and international tourists. In order to do this, the government proposed to diversify the Indian tourism products and substantially improve the quality of tourism infrastructure, marketing, visa arrangements and air travel.

viii) National Agricultural Policy (NAP), 2000

On 28 July 2000, the National Agriculture Policy was announced. The National Policy on Agriculture seeks to actualise the vast untapped growth potential of Indian agriculture, strengthen rural infrastructure to support faster agricultural development, promote value addition, accelerate the growth of agro business, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families. It discourages migration to urban areas and faces the challenges arising out of economic liberalization and globalisation.

ix) National Policy for farmers (NPF), 2007

On recommendations of National Commission on Farmers the National Policy for Farmers, 2007 has provided for a holistic approach to development of the farm sector. The broad areas of its coverage include: i) economic well being of the farmers in addition to production and productivity, ii) asset reforms, iii) water use efficiency, iv) new technologies, v) national agricultural bio-security system, vi) seeds and soil health, vii) support services for women, viii) credit and insurance, etc.

x) Nation Livestock Policy (NLP), 2013

In April 2013 through broad consultations with states and other stakeholders, GoI approved this policy. Policy aims at increasing livestock productivity and production in a sustainable manner, while protecting the environment, preserving animal biodiversity, ensuring bio-security and farmers' livelihood. With this goal, the main objectives of this policy are as follows:

- Support the existing low input production systems for improving productivity and income to improve socio-economic status of a vast majority of our livestock producers, most of which are women and small farmers
- To support research and development initiatives on issues pertaining to livestock sector for improving production and productivity, bio-security and profitability
- To encourage establishment and growth of self-supporting financially viable, medium and large commercial livestock production units capable of adopting latest technology including facility for processing and value addition
- To improve the productivity of livestock and poultry by promoting and disseminating the technologies developed by the research system
- To promote conservation of animal bio-diversity; conservation and genetic improvement of important indigenous breeds of livestock and poultry in the country
- To increase availability of feed and fodder resources to meet the requirement of livestock to attain optimal productivity
- To strengthen overall animal health cover through prevention, control and eradication of various disease conditions and encourage/enable the dairy cooperatives to extend veterinary services to farmers
- To focus on production of quality livestock products as per the international standards for food safety
- To encourage value addition of livestock products like milk and milk products, eggs, wool and meat and meat products etc.
- To expand capacity of milk handled by organized dairy sector including cooperatives
- To ensure transmission and application of improved technology and management practices to the doorstep of the farmers and the entrepreneurs
- To create an enabling environment to attract investment for improving infrastructure support, livestock production, processing, value addition and marketing in the sector

xi) National Conservation Strategy and Policy Statement for Environment and Sustainable Development, 1992

In the policies of various sectors this policy provides the basis for the integration of environmental considerations. It also outlines government's goals and projects for achieving sustainable lifestyles and the proper management and conservation of resources. The National Conservation Strategy and the Policy Statement on Environment and Development is in response to the need for laying down the guidelines that will help to weave environmental considerations into the fabric of national life and development process.

xii) Wetlands (Conservation and Management) Rules, 2010

To ensure better conservation and management and to prevent degradation of existing wetlands in India, wetlands Rules have been drafted. Under the Rules, wetlands have been classified for better management and easier identification. Central Wetland Regulatory Authority has been set up to ensure proper implementation of the Rules and perform all functions for management of wetlands in India. Apart from necessary government representatives, the Authority shall have a number of expert members to ensure that wetland conservation is carried out in the best possible manner. In order to ensure there is no further degradation of wetlands, the Rules specify activities, which are harmful to wetlands such as industrialisation, construction, dumping of untreated waste, reclamation etc. and prohibit these activities in the wetlands. Other activities such as harvesting, dredging etc may be carried out in the wetlands but only with prior permission from the concerned authorities (www.indiawaterportal.org/articles/wetlands - conservation-and-management-rules-2010-notified-moef; retrieved: 16-03-2014).

xiii) National Action Plan on Climate Change (NAPCC), 2008

Realizing the global concern and view of the requirement of a strategy to adapt to climate change, enhance ecological sustainability and explore solutions towards more efficient technologies, NAPCC was formulated and launched in June 2008. It has eight missions which focus on i) enhancing energy efficiency, ii) increasing the penetration of solar photo-voltaics and solar thermal in the total energy mix, iii) developing climate friendly sustainable habitats, iv) a water mission for integrated water resources management v) a mission on sustainable agriculture for making it more resilient to climate change, vi) a green mission for enhancing ecosystem services of forests and for enhancing its Carbon sequestration capacity, vii) *a mission on Himalayan ecosystem for sustaining and safeguarding the Himalayan glacier and mountain ecosystems*, and viii) aimed towards developing strategic knowledge base to address the concerns of climate change.

xiv) Document on National Mission for Sustaining the Himalayan Ecosystem, 2010

To deliver better understanding of the combination between the Himalayan ecosystem and the climate factors, which provides inputs for Himalayan Sustainable development while addressing also the protection of a fragile ecosystem, the National Action Plan on Climate Change (NAPCC) has articulated the launch of a National Mission for Sustaining the Himalayan Ecosystem. It has established to deal with: i) observational and monitoring network for the Himalayan environment, and ii) assess freshwater resources and health of the ecosystem. The some important issues have included as follows:

- Himalayan glaciers and the associated hydrological consequences
- Biodiversity conservation and protection
- Wild life conservation and protection
- Traditional knowledge societies and their livelihood
- Planning for sustaining of the Himalayan ecosystem

A territorial approach is necessary for translating national policies into action, especially at local level, and decentralizing NAPCC objectives into local context. It is in this context, it was felt necessary that the states should develop their prioritised action plan vis-a-vis their respective climate change concerns under the overarching objectives and missions of the National Action Plan on Climate Change.

8.2 Regulation frameworks

The need for conservation and sustainable use of natural resources and awareness about the constitutional, legislative and policy framework was expressed since early centuries. Even before India's independence in 1947, several environmental legislations existed but the real momentum for bringing about a well-developed framework came only after the UN Conference on the Human Environment in Stockholm, 1972. Realizing the importance of the environmental policies framework, the National Council for Environmental Policy and Planning within the Department of Science and Technology was set up in 1972. This Council later evolved into a full-fledged MoEF in 1985, which today is the apex administrative body in the country for regulating and ensuring environmental protection. After the Stockholm Conference, in 1976, constitutional sanction was given to environmental concerns through the 42nd Amendment, which incorporated into the Directive Principles of State Policy and Fundamental Rights and Duties. Since 1970s, an

extensive network of environmental legislation has grown in the country. The MoEF and the Central Pollution Control Board (CPCB) and State Pollution Control Boards) (SPCBs) together form the regulatory and administrative core of the sector. A policy framework has also been developed to complement the legislative provisions. The Environmental Action Programme (EAP) was formulated in 1993 with the objective of improving environmental services and integrating environmental considerations in to development programmes. The government also taken the other measures to protect and preserve the environment. Several sector-specific policies have evolved, which are discussed at length in the concerned chapters. The brief frameworks of the Acts and their regulations have been discussed bellow.

i) Indian Forest Act, 1927

To preserve and safeguard the forests generally in India, The Indian Forest Act (1927) was enacted. The Act makes various provisions for such conservation of forests and certain powers in regard to management of the affairs of the forest like constitution of reserve forest from the forest land or waste lands are vested in the State Government. In this act various provisions about control over forest and forest produce are given. Similarly, this Act discusses the forest offences and penalties against the offenders.

ii) Wild Life (Protection) Act, 1972

With the objective of effectively protecting, the wildlife of this country and to control poaching, smuggling and illegal trade in wildlife and its derivatives, this Act was enacted. The Ministry has proposed further amendments in the law by introducing more rigid measures to strengthen the Act. The objective is to provide protection to the listed endangered flora and fauna and ecologically important protected areas. This Act was enacted by the Parliament of India amending the existing Wildlife Protection Act, 1972, which came into force in January 2003, in which the punishment and penalty related to poaching and illegal trade in wildlife and its derivatives have been made more stringent. This Act has also vested more power to the state government and establishment of more authorities.

iii) Forest (Conservation) Act, 1980

To help conserve the country's forests this Act was enacted. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of Central Government. To this end, the Act lays down the pre-requisites for the diversion of forest land for non-forest purposes.

iv) National Biological Diversity Act, (2002) and Rules, (2004)

India has enacted an umbrella legislation called the Biological Diversity Act 2002 (No.18 of 2003) to help in realizing the objectives of CBD. In exercise of the powers conferred by Sub-Section (1) (4) of Section 8 of the Biological Diversity Act, 2002 (18 of 2003), the Central Government has established a body called the National Biodiversity Authority on 01-10-2003 (www.nbaindia.org; retrieved: 11-04-2014). The Act covers conservation, use of biological resources and associated knowledge occurring in India for commercial or research purposes or for the purposes of bio-survey and bio-utilisation. It provides a framework for access to biological resources and sharing the benefits arising out of such access and use. The Act covers foreigners, non-resident Indians, body corporate, association or organization that is either not incorporated in India or incorporated in India with non-Indian

participation in its share capital or management. These individuals or entities require the approval of the National Biodiversity Authority when they use biological resources and associated knowledge occurring in India for commercial or research purposes or for the purposes of bio-survey or bio-utilisation (http://nbc-india.org/biodiversity-laws-in-india/; retrieved: 11-04-2011).

v) National Food Security Act, 2013

As an Act of the Parliament of India the National Food Security Act, 2013 (also Right to Food Act) aims to provide subsidized food grains to approximately two thirds of India's 1.2 billion people. It was signed into law on September 12, 2013, retroactive to July 5, 2013. Under the provisions of the bill, beneficiaries are to be able to purchase 5 kilograms per eligible person per month of cereals as rice at ₹3 per kg; wheat at ₹2 per kg and coarse grains (millet) at ₹1 per kg.

vi) Protection of Plant Varieties and Farmer's Rights Act, 2001

This act provides protection of plant varieties, rights of farmers and plant breeders, and encourages the development of new varieties of plants by establishing an effective system. Whereas, it is considered necessary to recognize and protect the rights of the farmers in respect of their contribution made at any time in conserving, improving and making available plant genetic resources for the development of new plant varieties. Also, It accelerate the agricultural development in the country and necessary to protect plant breeders' rights to stimulate investment for research and development, both in the public and private sector, for the development of new plant varieties. Such protection will facilitate the growth of the seed industry in the country, ensuring the availability of high quality seeds and planting material to the farmers. Finally India, having ratified the Agreement on Trade Related Aspects of Intellectual Property Rights should *inter alia* make provision for giving effect to subparagraph (b) of paragraph 3 of article 27 in Part II of the said Agreement relating to protection of plant varieties.

vii) The Provisions of the Panchayats (Extension to the Scheduled Areas) Act, 1996

Bu emphasising a more decentralised system of governance to panchayats and gram sabhas in Scheduled Areas this Act confers the ownership and decision-making rights over non-timber forest products (NTFPs) to local institutions.

viii) National Rural Employment Guarantee Act, 2005

Also known as the "Mahatma Gandhi National Rural Employment Guarantee Act", and abbreviated to MGNREGA National Rural Employment Guarantee Act 2005 is an Indian labour law and social security measure that aims to guarantee the 'right to work' and ensure livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a financial year to every household whose adult members volunteer to do unskilled manual work. The government as the largest and most ambitious social security hails the statute and public works programme in the world.

ix) Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

The Act recognises and vests the forest rights and occupation in forest land in forest dwelling Scheduled Tribes and other traditional forest dwellers who have been

residing in such forests for generations but whose rights could not be recorded. This would undo the historical injustice done to the forest dwelling Scheduled Tribes.

x) The Model Bill for Inland Fisheries and Aquaculture Sector

The Government of India through this Model Bill on Inland Fisheries and Aquaculture intends to ensure sustainable fish production to meet the needs of food and nutritional security, generation of gainful employment in rural sector, improving the socio-economic condition of the target groups and increasing the export earnings and recognizes the economic, social, nutritional, environmental and aesthetic importance of inland fisheries and aquaculture. The present Model Bill provides broad guidelines for sustainable development and management of inland fisheries and aquaculture in the country. All concerned stakeholders are encouraged to give effect to this bill for ushering an era of long-term sustainability of inland fisheries and aquaculture. In addition to above, amongst different bilateral agreements with neighbouring countries, on 29.7.2010, following the forth India-Nepal consultation on transboundary issues particularly referring to endangered species conservation such as tiger, elephant, rhino accompanied with focus on the joint monitoring and cooperation (with capacity building) in priority areas a resolution was signed between countries. Such initiatives are imperative for the improved conservation and development in KL, India.

8.3 Sector wise Rules and Policies

Considering the entire KL-India, several policies and acts notified by the GOI are governed similarly at different states however, the way of implementation is varied between the states (Sikkim and West Bengal). Also, there is a provision to framework some location/state specific policies and plan for dealing certain priority issues related to state subjects.

8.3.1 Sikkim

In order to protect the rich biodiversity of Sikkim, there is one national park (Khangchendzonga NP and seven wildlife sanctuaries. In addition, to protect the only national park i.e., Khangchendzonga National Park from degradation and exploitation, four buffer zones i.e. I, II, III, IV of 835.92 Km^2 area and a recent inclusion of transition zone (211.20 Km^2) have been added in accordance with the concept of UNESCO's Man and Biosphere Reserve (MAB) programme (Badola and Subba, 2012). Furthermore, Sikkim Govt has designated several conservation zones in different parts of Sikkim. Besides, Sikkim Government has been able to implement various national Acts and rules like Indian Forest Act 1927 (extended to Sikkim in 1989), Wildlife (Protection) Act 1972, Forest (Conservation) Act 1980 and Biological Diversity Act 2002, Forest (Conservation) Rules, 2003, Forest (Conservation) Amendment Rules 2004. In spite of the National enabling policies, Sikkim state has formed some policies under its laws in respect of natural resource management and biodiversity conservation such as The Sikkim Fisheries Act 1980, The Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act 1988, The Sikkim Forests (Compounding of Offences) Rules 1998, Sikkim State Biological Diversity Rules, 2006. However, some policies and management plans have been implemented promptly at state and grown with a moment of popularity within community and stakeholders at regional and national level. Some initiatives have gained momentum at large extend and contributed as the milestone of the Sikkim progression.

i) Joint Forest Management, 1998

The Government issued notification introducing the system of Joint Forest Management in which the forests are to be protected and managed jointly by the people and Forest Department. From 1998 till date, 159 Joint Forest Management Committees (JFMCs) and 49 Eco-Development Committees (EDCs) have been constituted and registered all over the State. Implementation of plantation and other forestry related programmes is done by the JFMCs and EDCs.

ii) State Green Mission, 2006

In 2006, the government has launched the State Green Mission, which includes plantation of ornamental and flowering trees and shrubs along the roads, institutional vacant lands, School complexes, College and University campuses and vacant lands of public and private sector undertakings. Gaining popularity of Mission among the people, the active participation of people is going to be increased. Realizing its importance, the Mission is now established as a ritual from 15 June onwards every year through government notification even after its competition 5th year in 2010-11.

iii) Ten Minutes to Earth, 2009

With a view to contribute something to the Mother Earth where we live the concept of "Ten Minutes to Earth" programme was conceived. All the citizens of Sikkim planted trees in 10 minutes from 10.30 am to 10.40 am on 15 July 2009. Total of 6,10,000 seedlings were planted on the occasion. From 2010 onwards, this programme is being organized on 25 June by issuing a notification so that on this date i.e. 25 June, the Ten Minutes to Earth programme is made mandatory for all citizens including government, semi-government and non-government organizations as well as defense personnel.

Iv) Glacial Commission, 2007

In 2007, Sikkim became the first State in the Country to constitute the Glacial Commission. The nine-member Commission have been set up by the Sikkim Government to study the state of the glaciers and its impact on water system in this tiny Himalayan State. The state Government announced that receding glaciers and recurring phenomenon of glacial lake outbursts and floods that have been recorded in the entire eastern Himalayan region.

v) Himal Rakshak or Mountain Guard, 2007

To assist the Forest Officer in wildlife conservation the State Government has also made a provision to appoint Himal Rakshak or Mountain Guard (Sikkim Government Gazette No. 35). They have been conferred specific power like power of entry, search, seizure and detention under section 50 for prevention and detection of offences under the Wildlife (Protection) Act 1972.

vi) State action plan on Climate change-

To address climate change the government of Sikkim had taken a very systematic and proactive approach towards the formulation of the state action plan. The key areas of concern for Sikkim that were identified are:

- Water
- Agriculture, horticulture and livestock
- Forests, wildlife, and eco-tourism
- Promotion of energy efficiency
- Urban and rural habitats and communities

v) Sikkim Ecotourism Policy, 2012

With an aim to not only to ensure sustainable livelihood of the local people but also to protect and manage natural integrity of beauty and its resources, as well the Government of Sikkim has launched State Ecotourism Policy in 2012 proactively. The main objectives of Sikkim Ecotourism Policy are as follows:

- Bring all stakeholders on a common platform of understanding of ecotourism
- Promote ecotourism in a sustainable manner based on the Global Sustainable Tourism Criteria (GSTC)
- Generate incentives to local communities for nature conservation through alternative income sources and livelihood, and empower local communities to manage ecotourism with the emphasis on economically disadvantaged people
- Conserve the existing biodiversity, ecosystems and religious monuments of the state of Sikkim as well as Sikkim people's culture and tradition
- Offer memorable and high quality learning experience to visitors, thus encouraging their responsible behaviour during their visits and their collaboration for nature conservation efforts
- Facilitate local children as well as visitors' to enjoy and appreciate excellent nature-based activities
- Encourage people in Sikkim to increase their pride and appreciation of local natural and cultural values
- Ensure that local communities have a role in determining the appropriate presentation of their cultural values
- Regulate the high influx of visitors in heavily visited areas, thus reducing negative impacts of tourism

a) Sikkim Ecotourism Council

As an autonomous body, the Sikkim Ecotourism Council is outlined in the organizational diagram with a vision to the policy, establishes Sikkim as an ultimate and unique ecotourism destination offering memorable and high quality learning experiences to visitors, and to contribute to poverty alleviation as well as to promote nature conservation. It is working under guideline of the Forest, Environment and Wildlife Management Department (FEWMD). The council also has a local village level operational system which is implemented with various Community-based Organizations (CBO) and working in tandem with Panchayat, NGO, Tourism Development Committee (TDC), Self-help Groups (SHG) and other local people's representative groups. The key principles are included under the council, which shape the ecotourism towards development, planning, management, and promotion in the state of Sikkim. Rural/ village tourism and home stay approach under the policy has been proposed. Realizing the importance of the home stay, Sikkim Registration of Home Stay Establishment Rules, has been setup in 2013.

vi) Sikkim Biodiversity and state wildlife Boards

The State Biodiversity Boards (SBBs) focus on advising the State Governments, subject to any guidelines issued by the Central Government, on matters relating to

the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources. The SBBs also regulate, by granting of approvals or otherwise requests for commercial utilization or bio-survey and bio-utilization of any biological resource by Indians. The state wildlife boards is equally important body with institutional and independent members, oversee and monitor and recommends the activities under any wildlife protected area, etc.

vii) Biodiversity Management Committees

For promoting conservation, sustainable use and documentation of biological diversity including preservation of habitats, conservation of land races, folk varieties and cultivars, domesticated stocks and breeds of animals and microorganisms and chronicling of knowledge relating to biological diversity at state level, Biodiversity Management Committees are responsible. Since its establishment, National Biodiversity Authority has supported creation of SBB in the state and facilitated an establishment of around 32,796 BMCs. One of the key mandates of BMCs is to prepare Biodiversity Register, which documents the elements of biodiversity in the areas and issues related to: sustainable utilization, suitability for sharing and traditional knowledge.

viii) Sikkim Biodiversity Action Plan, 2012- a big initiative to enabling policy

The Govt of Sikkim understands that biodiversity is a major resource of the state and facing several threats. Through a consensus, it has identified the key sectors and regions that are likely to be most important and require additional efforts to conserve natural resources. A unique policy document, Sikkim Biodiversity Action Plan 2012 was drafted by a working group having members from GBPIHED, state forest department, BSI, and international experts and release by the Govt of Sikkim. It identifies various institutions having potential to address different problems and work for achieving desired results under three time lines i.e. S-short; M-medium and L-long (Appendix 8.1).

Ix) Economic valuation of forest products (Sikkim), 2010

The Forest Environment and Wildlife Management Department (FEWMD), Govt of Sikkim, has fixed the rates of royalty on different categories of timber and other forest produce collected from persons consuming them for different purposes under the notification No. 08/GOS/FEWMD, on 28 October, 2010. Following the National Forest Policy (India), Govt of Sikkim enunciated 'State Policy of Environment, Forests and Land Use' and passed resolution in the State Legislative Assembly on 18th March 2000 (vide No. 764/F/ENV & WL). This specifically meant to address the problem of over grazing and its consequences.

8.3.2 North Bengal

Under the KL-India, North Bengal part embraced the Darjeeling, Jalpaiguri and Alipurduar districts wherein the climatic conditions varied due to its diverse features (i.e. Himalayan, foothill and plain areas). The North Bengal is the part of the Indian state of West Bengal, and governed by the same rules and regulations implemented by the central as well as the state Government. The state has been able to enforce several rules of its own associated with the biodiversity conservation and natural resource management. These include, *The West Bengal Private Forest Act 1948, The West Bengal Protected Forest Rules 1956, The West*

Bengal Forest-Produce Transit Rules 1959, The West Bengal Inland Fisheries Act 1984, The West Bengal Inland Fisheries (Amendment) Act 1993 and 2008, West Bengal Ground Water Resource (Management, Control and Regulation) Act 2005, The West Bengal Trees (Protection and Conservation in Non Forest Areas) Rules 2007, The West Bengal Forest (Establishment and Regulation of Saw Mills and other Wood-based Industries) Rules 1982, West Bengal Biological Diversity Rules 2005, etc. Further, in 2012, West Bengal Wetlands and Water Bodies Conservation Policy was drafted and submitted to the government of West Bengal.

Brief description of the major policies and rules launched by State Government, which are applicable and implemented in north Bengal part of KL, India, include the following:

i) West Bengal Biodiversity board

The State Biodiversity Board functions towards ensuring proper implementation of the Biological Diversity Act, 2002 and the West Bengal Biological Diversity Rules, 2005 in the state. The important functions undertaken by the Board include the following:

- To make people aware of the biodiversity and its importance in human well being.
- Constitution of Biodiversity Management Committees (BMC) in the Panchayat samitiy and Municipality level,
- Documenting biodiversity, their uses and traditional knowledge and practices associated with those in the form of People's Biodiversity Register (PBR) involving local people through the concern BMCs,
- Initiating and guiding Post PBR activities: conservation initiatives, entrepreneurship development on sustainable biological resources, biological resource management and other such activities,
- Identification of Heritage Sites and Sacred Groves of the state and prepare the management plan of those area in consultation with the concern BMCs,
- Conducting Studies on biodiversity related issues of the state,
- Regulating commercial activities related to bio-resources of the state as per the Biological Diversity Act, 2002,
- Regulating other activities which affect the biodiversity of the state as per the said act and rules, and
- Documentation of Biodiversity of the state: in the form of comprehensive digitized data of available resources of the State along with a digital library and also an annotated bibliography of available literature on biodiversity of the State.

ii) Biodiversity Management Committee (BMC)-West Bengal

In 2002 India enacted the Biological Diversity Act and subsequently in 2004, the Biological Diversity Rules came into effect for fulfilling the three main objectives of the convention, *viz*., conservation of biodiversity, and sustainable use of the same and ensuring equitable sharing of benefits arising out of the use of the biological resources. The Biological Diversity Act envisages a three-tier system for implementing the same with the National Biodiversity Authority at the apex with its headquarters located in Chennai, each state with its individual State Biodiversity Board and each local body with a Biodiversity Management Committee. As per The Biological Diversity Act, 2002 [Section 41], every local body shall constitute a Biodiversity Management Committee (BMC) within its area. Local body in this case refers to the levels of Panchayat Samiti (Block) and Municipality in the state of West Bengal presently on an initial basis.

iii) West Bengal State Action Plan on Climate Change, 2010

On December 2010, West Bengal Government developed its State Action Plan on Climate Change, as closely as possible matching to the 8 national missions and 24 other critical initiatives. It was also pointed out that some specific areas of vulnerabilities of West Bengal like Darjeeling Himalayas were also be properly addressed. Important sectors, i.e. Water, Agriculture, Horticulture, Fisheries, Animal Husbandry, Health, Forestry, Energy Efficiency, Non-conventional Energy Sources, Darjeeling Himalayas, Habitat and Institute for climate change studies were identified for State Action Plan.

iv) West Bengal wetlands and water bodies' conservation policy, 2012

Environment Department, Government of West Bengal released a policy on wetlands by an expert committee set up which focuses the gaps of water bodies. In the West Bengal Wetlands and Water Bodies Conservation Policy, the four-member panel recommends that no wetlands and water bodies can be filled up, degraded, drained, converted or subjected to any kind of activity that is incompatible with the ecological integrity of the wetlands.

v) Implementation of National Bamboo Mission (NBM), 2007 in West Bengal

NBM programme in West Bengal started during 2007-08, undertaking the objective to increase the coverage of area under bamboo with suitable species to enhance yields, as well as to generate employment opportunities. In the forest areas of West Bengal the bamboo programme has been undertaken through the Forest Development Agencies (FDAs) and Forest Protection Committees (FPCs) to establish nurseries for raising bamboo seedlings and to encourage high-yielding bamboo plantations.

vi) West Bengal food processing industry Policy, 2011

Considering the fact that the State is immensely endowed with natural resources conducive for producing a vast range of agri-horticulture products, it is essential to lay down the road map to direct State's resources, independently as well as through Private-Public Partnership (PPP) for setting up of infrastructures, processing units and industries to produce value added processed food products, reduce wastages, generate additional income for the farmers/growers, create employment opportunities for the unemployed persons and earn revenue for the overall socio-economical development of West Bengal and its people and hence this policy document.

viii) People's Biodiversity Register (PBR)

The documentation of the knowledge related to the biological resource by the people of any locality is known as the People's Biodiversity Register. The Registers shall contain comprehensive information on availability and knowledge of local bio-resources, their medicinal or any other use or any other traditional knowledge associated with them. The various forms of knowledge of the people that would be included in the PBR as knowledge of: i) landscape, ii) lifescape, iii) peoplescape, and iv) timescape. Besides, above, most of the national policies and acts are applicable and implemented in the north Bengal part of KL, India.

ix) STI Policy, 2013 for women

Participation of women in STI activities is important and new and flexible schemes would be put in place to address the mobility challenges of employed women

scientists and technologists is acknowledged in STI policy. A broad scope for re-entry of women into R&D and new facilitation mechanisms with special career paths in diverse areas will also be made feasible. Gender parity in STI Policy, 2013 is envisaged to be achieved by addressing the following:

- Enhancing skills for applications of science among the young from all social sectors and linking contributions of STI with inclusive growth agenda
- Increasing accessibility, availability and affordability of STI, especially for women, differentially able and disadvantage sections of society
- Wide range of mechanisms is envisaged to be deployed to realize these policy aspirations, specifically for empowering women through appropriate STI inputs

8.4 Enabling policy frameworks for gender inclusive conservation and development

The National Policy and Action Strategy on Biological Diversity of the Government of India, 1998 recognizes the importance of involving the stakeholders including women in conservation policies and programmes (MoEF 1998). The government also stresses the need of working with women's organizations for developing and implementing national strategies on conservation and sustainable use of biological diversity (ibid, p Vii). As a Party to the Convention on Biological Diversity (CBD), the Indian government has signed the Nagoya Protocol on 11th May 2011, and ratified it on 9th October 2012. The Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefit arising from their utilization to the CBD also recognize the vital role women play in access and benefit sharing and stresses the need for the meaningful participation of women at all of policy making and implementation of biodiversity conservation. The article 22 of the protocol focuses on development and implementation of special measures to increase the capacity of indigenous and local communities, especially women within the communities in relation to access to genetic resources and/or traditional knowledge. Hence the article stresses the need for identifying capacity and priority needs of women (SCBD 2011, p 16-17). In addition, according to the Joint Forest Management (JFM) guidelines (revised in February 2000), the JFM General Body should have 50 per cent of women and the management committee a minimum of 33 percent (Gera, 2002). This policy framework is an opportunity for conservation and development practitioners and researchers to constantly assess the level and extent of change happened within JFM institutions. In terms of gender equality/capacities strengthening to plan, implement and monitor conservation and development that are sensitive to poverty and gender issues.

The strategy of self-employment of poor into Self Help Groups (SHGs) became the cornerstone of the new strategy. An overview of the implementation of SGSY over the last ten years throws up a mixed picture. There is a widespread acceptance in the country of the need for poor into SHGs as a pre-requisite for poverty reduction. However, the focus on single livelihoods activity has not met the multiple livelihoods requirements of the poor. Furthermore, several states have not been able to fully utilize the funds received under SGSY, indicating a lack of appropriate delivery systems and lack of building necessary absorption capacity among the rural poor. Absence of aggregate institutions in the form of SHG federations precluded the poor from accessing higher order support services for productivity enhancement, marketing linkage, risk management, etc.

8.5 Discrepancies and gaps in implementation of policies and rules

Commonly, each state time to time, make slight amendment in the nature of actions and processes in implementation in various policies or sometime amend state policy, according to the current priority and needs. However, the majority of the policies have been formed as according the national interest. Some states government are addressing the same regional issues at their own level, without desired modifications, if permissible. At the grassroots level also, 100% implementations of the national policies are under stress due to some broad fragmented geographical, cultural, social and political areas. In national and/or state level, the absence of pasture management and grazing policy have rendered the pasture lands, including village commons and uncultivable wastes, open to developmental, societal and grazing pressures. At KL-India level, policy related to tea industries setup functional rules at ground level for promoting sustainable livelihood security and health concern of the tea garden workers is missing.

Many of the conservation directions of policies in India focusing the protected areas are confined to protection of national parks and sanctuaries, with limited scope for the people orientation, except in case of biosphere reserves. The participation of community people though recognized in recent decades, but in actualization, their involvement by empowering rights is restricted or partial, particularly towards their traditional rights and ownership on natural resources, which need re-assessment with judicial angle, of course maintaining sustainable streak at the base. In management-plans of protected areas and corridors, the scope for people-oriented conservation appeared to be restricted as the policy to promote community participation is perhaps not well articulated. Under human-wildlife conflicts too, some mitigation management plans have not been properly framed out, which is required on urgent basis, framing the suitability and affectivity of policies and plans in regional context in KL, India. Looking at the socio-cultural, economic and biodiversity setting, at landscape level and/or KL, India level uniform implementation mechanisms of policies or a modified landscape specific policy provision would strengthen the approaches of conservation and development. Recasting of policy structures by recognizing stronger community participation, improved partnerships of stakeholders supported with ecosystem conservation management approaches, thus ensuring accessibility of people to natural resources in sustainable manner and practicing good practices within a trans-boundary cooperation framework is the need of the day.

Chapter 9: Major Issues and Research Gaps

Conservation and management issues are broadly represented at global, national and region level touching certain parameters and/or addressing thematic areas and may differ in some way along the regional-specific lives. Khangchendzonga-India as a whole encompasses enormous variety of biodiversity ranging from Terai to alpine zones, such biodiversity rich landscape has big challenges to meet and substantial efforts needed to maintain its sustainability. Various issues related to the subject are topical in the Khangchendzonga landscape, India in classified ways which are laid out within the national and between international boundaries. The broad issues related to the proposed landscape have been provided in Appendix 9, which are gathered from extensive and insightful consultations with different groups of expertise, ground level workers, NGOs and individual experts and field managers and administrators, etc. The extensive literature review also helped identifying issues and gap areas. Among these, some important issues are detailed out below:

9.1.1 Concerns on illegal wildlife related trade

The demand for wildlife and animal parts is universal and much depended in several society and cultural taboos and believes; widely acknowledged fact that the wildlife will suffer due to continued pressure of illegal trade, until ensured mechanism to curb such practices are fully realized. As trading in any form is economy-driven it goes to prove that more trade volume fetches more economic returns and this situation gives birth to trade in wildlife which has been notified as illegal trade. Following the CITES guidelines India provides data to the CITES secretariat regularly on the trade of endangered species through its CITES Management Authority. It has been brought to note that a trend of growing conflict scenario in North Bengal could facilitate the trade in illegal wildlife in the near future. It is suspected that there is a secret trade of skin and leopard bones through the highly porous border. As the area is considered as gateway of North East India and very near to international border with Nepal, China, Bangladesh and Bhutan, control of poaching and illegal trade in wild life articles is very serious problem unless local population residing in fringe areas of PAs is involved in various efforts of government agencies and various level of governance. The Wildlife (Protection) Amendment Act, 2002 was enacted by the Parliament of India for improving the existing Wildlife Protection Act, 1972, which came into force in January, 2003, in which the punishment and penalty related to poaching and illegal trade in wildlife and its derivatives have been made more stringent. This Act has also vested more power to the state government and establishment of more authorities.

A case concerning illegal procurement and trade in leopard body parts has been depicted in bellow (Table 9.1) which shows only the recorded official figures. It may be envisaged that even if the source of all items are not directly from state forests, an organized and well established illegal trafficking is in operation. So far the trade in tiger body parts has been recorded in much detail owing to its being in the limelight for so many years; nevertheless, leopards are not far behind in being pursued and killed for illegal trade. Leopards take about a decade to turn into adults and the statistics certainly show bleak future for the animal. Such data suspect that there is

possible trade of skin and leopard bones through high porous border between in India and neighbouring countries having transboundary passages.

Table 9.1. Seizure of leopard body parts from West Bengal

Year	Item	Amount
1997-1998	Skin	4 Nos.
1998-1999	Skin	3 Nos.
1999-2000	Skin	2 Nos.
	Leopard flesh	100 gm
2000-2001	Leopard skin	4 Nos.
	Skin with mounted head	1 No.
2002-2003	Leopard flesh	500 gm
	Leopard skin	21 Nos.
2003-2004	Leopard bone	2 kg
2005-2006	Leopard skin	3 Nos.
	Leopard skin	8 Nos.

(Source: Anonymous 2007-08)

For taking legal actions at local level, it has been amplified elsewhere that formally awarding empowerment to the communities, JFMCs, FPCs, etc., would lessen illegal collection and trade of wildlife species (Chettri *et al*., 2011).

9.1.2 Pasture management issues

Pasture lands in KL-India, occupy a considerably large geographical area which harbor unique floral and faunal assemblages and represent important ecological and cultural integrity with marginal and apparently low productive ecosystems. The pasture land management issue has increased in the current scenario due to constant pressure of increasing population of human and developmental activities i.e. road constructions and settlements, grazing by sheep and yak, and tourist flow in some constraints. The grazing lands are constantly subjected to changes affecting their succession processes. Grazing results in continuous defoliation of palatable species rendering the habitat open to invasive weed species. Nevertheless, the government of Sikkim has banned the practice of open grazing in the only reserve forests areas from 1999. Grazing inside forest areas is contempt of the judgment of the Hon'ble High court of Sikkim delivered on 14/05/1999 *upholding ban on grazing as ordered by Government of Sikkim.* In continuation, selective enforcement of this ban in the KNP resulted in the removal of about 300 agro-pastoralists owning about 6000 cattle from the reserve forests and adjacent to KNP by 2002. By 2006 onwards, again massive evictions of grazing animals by dismantling of the cattle sheds/goaths were done by the KBR management in high altitudes (Subba, JB personal communication). In this management process and enforcement have created three way conflicts i.e. between the evicted agro-pastoralists, the yak herders, and the forest department (Tambe and Rawat, 2009). The grazing in pastures in reserve forests in Darjeeling and Jalpaiguri districts and adjacent areas are too a challenge.

At lower elevations, converting open pastures to community forests conflicts with traditional pasture management practices.

9.1.3 Trans-boundary movement of people and pastoral issues

In KL, India, the transhumance with seasonal movements of livestock is a traditional practice. Such practices are now constrained by policy changes such as notifying pasture lands as protected areas, banning traditional transborder movements of herders, and conversion of pastures into forests. These changes are bringing challenges to the people dependent on livestock-based livelihoods, especially those living in high-altitude areas. The traditional transhumance grazing method is practiced throughout much of the high-altitude grazing lands. Trans-boundary rangeland issues is not much apparent, except some areas, in the region as the northern border which is totally restricted (China-TAR) and the eastern part touching the Bhutan hills is not suitable as a grazing field and limited in pastoral use. The western flank contiguous to Nepal, however, had several issues on grazing and illegal trade but with a chain of talks with country representatives, these have been greatly minimized. Nonetheless, the moment along the trans-boundary locations including that in the west part beyond Utteray with Nepal border is a matter of conflict for unauthorized movements of cattle grazing. Such problems are serious issues and need better management resolution from either party. The grazing problems along transboundary locations with Darjeeling district are many. The review of information on corridors also reveals that alpine and sub-alpine pasturelands and common property resources for grazing by transhumance and settled communities are extensively overgrazed. Transhumance as well as stall feeders extensively use the warm temperate rangelands, not giving enough time for rangelands to regenerate. Subtropical rangelands in KL India are grazed extensively in winter by transhumance herders as well as sedentary farming communities.

Amongst many concerns, in higher altitudes, the localized intensive fuel wood collection, especially targeting the rhododendron shrubberies and Junipers, along temporary sheds, and killing of wild animals and pheasants, etc. are prominent. Another problem with open movement of dogs of herders, which during night depredate the birds, their nests, and sometime the small mammals; the grazing activities thus not only degrade the pastures but their allied activities turns detrimental to flourishing biodiversity, especially intensive observations are known in the Singalila range of KL, India. Apart from these, some other illegal activities are growing concern in trans-boundary areas. Recently, the Indio- China border along the mountainous corridor of the Nathu La in the East Sikkim has emerged as a new cross-border smuggling route with the seizure of 160 kg of white sandalwood at Siliguri by West Bengal custom officials and consignment evaluated around Rs.20-22 lakhs (Sikkim express, 7 July 2014). Moreover, Sikkim police had seized earlier back a large consignment of sandalwood in Bojoghari area of Gangtok. Such evidences are sufficient to point towards several other trans-boundary smuggling and other illegal activities. In this concern, there is a need to resolve such illegal activities.

9.1.4 Dolomite mining

The dolomite mining activity along the Indo- Bhutan border has been bringing in recurrent problems at the Dooars plains from the past many years. The dolomite aerosol and escape of chemicals into the water stream has been causing problems to both human and animals living downstream. The dolomite mined are used by the Bhutanese industries but most of the dolomite excavated in Bhutan is bought by Indian companies to produce cement at this side of the border which makes way for bilateral talks between the parties involve. India has been pursuing the matter for the past 20 years, pointing out the problems dolomite mining have created on this side of the border and out of this the Bhutan government has lately relented by closing two of the five mine-cum-factories operating on the borders area. Bhutan has further decided to crack down on illegal mining of dolomite along the Indo-Bhutan border in an attempt to curb pollution of groundwater in the foothills of Eastern Himalayas that has affected productivity of the tea gardens of Dooars in West Bengal (Source: https://www. google.co.in /search?q=dolomite+mining+along+India+Bhutan+border; accessed on 12.4.2014).

Dolomite siltation at Jayanti River, Buxa Tiger Reserve (Bhutan Hills in the background) in KL-India

Dolomite mining activities have been emerged as a big issue to create several natural hazards in the area, which are highlighted as below:

- Affecting the Bhutan foothills riverbeds of the Titi, Reti, Sukriti, Pagli and Torsha, which flow down to north Bengal from the hill kingdom and dolomite dust causes water pollution in the down steam
- Affecting tea estates (around 50-60) in the Dooars areas which are close to the border of mines and dolomite dust covers the plantations and also affects soil fertility
- Affecting the human health and wild animals, especially the elephant suffering from severe skin rashes, while bathing in the river
- Threatening the flora and fauna of Jaldapara Wildlife Sanctuary and Buxa Tiger Reserve by dolomite mining

The above issues affect the several areas of concern and need further attention as on priority.

9.1.5 Tea Industry

Somewhere around 1875, with a beginning, the Jalpaiguri, Alipurduar and Darjeeling districts have a rich heritage of tea industry in the KL-India. There are more than 240 numbers of tea garden embellished the rolling plains of Dooars alone covering an area of over 82,000 acres with ca. 600,000 people engaged in this huge enterprise to sustain livelihood. In the last few decades, however, great erosion in production and human dimension have been observed turning closer of many tea gardens and the workers forced to hunger, disease and death. The direct impact of this situation has visible effect on the bio-resources of the local area where people are forced to rely more on forests resources and the destruction of natural resource takes place at a faster rate. The major issues have been emerged from the industry are as follows:

- Human-wildlife conflict increased due to the increased presence of people in forested area, where people are mauled and killed and the animal's feeding, foraging and littering pattern is also disturbed.
- The complete closers of tea estates of Kanthalguri, Rahimabad, Ramjhora, Mujnai, Dheklapara, Srinathpur, Tundu, Kohinoor, Dhauajhora, Samsing, Chamurchi, Bamandanga, etc. have abandoned the people. The supply of potable water, electricity, primary medical facilities –all has been stopped in many tea gardens, although as per law the tea garden owners must continue to provide these amenities.
- Several health challenges to surrounding people emerged due to extensive use of chemicals in tea gardens. Often, people go to the nearby river to fetch water, but it is contaminated by pesticides. In a period of one year, 320 persons have died of gastro-enteritis and other stomach ailments and malaria. A total of 500 children have died In Kanthalguri tea garden. Owing to vitamin deficiency, also, around 200 children are on the verge of blindness. According to a report, out of 5000 children suffering from vitamin deficiency in the closed tea gardens, around 2000 will turn completely blind in a few months if the deficiency is not overcome (Anandabazaar Patrika, 20 November 2002). In the tea gardens more than 40,000 workers are suffering from starvation; the lack of proper maintenance of death registers in most of the tea gardens, exact number of deaths is not in picture.
- Affecting the biotic as well as physical resources of the region
- Poverty being the key mover for any kind of natural resource conservation it will play a crucial role in inflicting grave impact over it in the coming years, especially in Dooars area
- As regular inputs in the gardens majority of the tea gardens in north Bengal part of KL, India use many types of pesticides, fungicides, herbicides, rodenticides, insecticides, nematocides, etc, which affect the biodiversity especially of the aquatic fauna, especially along the national parks. The issue emerged the pesticides procured from these tea gardens is used by people to poison the leopards if situation arises of human wildlife conflict.

Tea gardens of Dooars are the major economy of this region, facing multiple threats (Bhutan Hills in the background) in Khangchendzonga landscape, India (Photo: Animesh Bose)

9.1.6 Human-wildlife conflicts

Most of the incidence of human-wildlife conflicts is observed in the plains Jalpaiguri, Alipurduar and Darjeeling districts of the KL-India and sporadic cases are recorded from the hills of Darjeeling and Sikkim (details are provided in Chapter 6). The main habitat of leopard falls within the Terai area and in particular, the forests of Kurseong division, Mahananda WS and western part of Baikunthapur forest division. There are large tea plantation areas for commercial use, human settlements, new sites of real estate development, small villages etc. Many areas of Mahananda WS and small part of Bamanpokhri forest are the only remaining chunk of natural forest. The foothill and plains of Darjeeling hills mainly in Bagdogra, Panighata, Tukriajhar and Bamanpokhri ranges are prone to human-leopard problems. Severe fragmentation and degradation of forest in Tukriajhar and along the River Mechi made the adjoining habitat unfit for wildlife. Livestock lifting by leopard is common in majority of the tea gardens in Panighata, Naxalbari and Bagdogra ranges. In the KL-India, the entire terai area has a higher proportion of livestock loss due to leopard attacks. More than 71 % conflict cases have been occurred in the area and resulted with lifting of cattle, goats, pig, poultry and dogs (1998-2007).

In view of above, such incidences have been emerged rapidly due to *i) rapid human settlements, ii) increasing and fragmented tea gardens, iii) immense pressure of livestock grazing, iv) exploitation of forest resources especially in the PAs and reserve forests and shrinking forest habitat*. In spite of these, in recent time majority of the tea gardens are running at loss and a major part of the labourers depend on forests, which brings more opportunities for human-wildlife conflicts. The cases of leopards giving birth within the tea bushes have brought in concern for the animal's shrinking habitat. The conflicts between Elephants and humans in north Bengal part

are much more severe than any other conflicts with animals. Growing cases of human-elephant conflict highlights the following reasons:

- Large destruction on migratory route of elephant through Sevoke, Gulma Valley, Choklong, Champasari, Mahanadi, Punding, Sukna, Rongdong, Koklong).
- Between Senchal WS to Neora Valley WS through Mahanada WS, the corridors are fragmented and linking is unsuitable.
- One of the major causes of conflicts is the unavailability of foraging resources in the migratory routes. However, elephants have been found to be foraging in the Sittong block which supports a good crop of wild banana and lately in Latpanchar block. In Kurseong Division, out of the total area of 30,259 ha, elephant zone is approximately 10,000 ha.

Elephant death in railway trek in north Bengal part of Khangchendzonga landscape, India (Photo: VK Sood)

- The suitable habitat niches like recreational destinations along migratory routes have altered for the elephants, including insufficient food resources, which turned detrimental to elephants during pregnancy.
- Death of elephants by colliding with moving trains is very common scenario. Number of hits indicated significant elephants' death tolls as the track inside Mahananda WS (11 deaths) should receive highest priority attention, followed by the section below Chapramari Sanctuary (8 hits), Mongpong RF and neighbourhood tea estates (4+3), BTR (6) and Jaldapara Sanctuary (4) areas.
- During 2004 and 2013, 2 leopards and 6 Bisons killing were officially recorded in the area. However, the conflicts due to human death or injuries due to leopard are yet another area of concern

In the past, illegal tapping of power have led to death of wild elephants in North Bengal and most of the incidents occurred in the Tea Garden areas.

9.1.7 Threat to rhinoceros population

Out of the many faunal resource in the KL-India, one-horned Rhinoceros happens to be the most vulnerable to get extinct, particularly due its dwindling habitats and for

its poaching to get good money of rhino horn in international markets. In spite of having its endangered status under IUCN Red Data Book and placement in the Schedule I of Wildlife (Protection) Act, 1972 of India, the rhino has been facing continuous anthropogenic threats. In early twenties of the last century Sumatran Rhinoceros was eliminated, and the second species, the Javan Rhinoceros got extinct during the late nineteenth century from this area.
At present, the *Rhinoceros unicornis* (Asian Rhino) is only surviving species in flood plains in dooars in north Bengal part of KL, India. Only two protected areas (Gorumara and Jaldapara NPs) in entire west Bengal boost to have the presence of this species, the later is known for the presence of one horned, great Indian Rhinoceros. Since 1968 onwards, the reliable reporting on rhino poaching appeared in knowledge; however, the years between 1968-69 and 1975 witnessed the biggest rhino poaching, which pathetically recorded 80 and 14 numbers of rhino, respectively, a great decline in population. Fortunately, in the rhino population retrieved to reasonable size, though not up to satisfaction, in recent years. Sometimes, the rhino stray out to national park across river Jaldhka flowing down along the eastern boundary, may be victim to killing. Still, any type of relaxation in management may be harmful and can offer accessibility to poachers.

9.2 Research Gaps

The various issues that impact the conservation and development of biodiversity in the KL-India are due to various gaps that exist at different framework levels as: i) research, ii) resource, iii) management and administrative and v) enable policy. Realizing the significance of some research gaps, insufficient research studies have been undertaken on various subjects in the region as a whole landscape. Hence, it is urgent need to fulfill gaps in the research areas on priority level. Apart from the gaps listed in the Appendix 9.1, some fundamental research gaps are included urgently for developing and implementing sustainable approaches and strategies for conservation and development of the landscape as follows:

- Majority of PAs are under-explored for their status on biological diversity
- The KL India received relatively poor attention from scholars around the world. Majority of protected areas are still to be explored for their biodiversity and the systematic;
- Mammals especially the flagship species like red Panda in temperate and sub-alpine forests and also, different assessment studies of bats population have not been undertaken
- Gaps in systematic research on the ecology of Asiatic elephant and tiger in the tropical forests, except a few.
- Except the butterflies and spiders, the invertebrates are majorly neglected for KL-India
- Detailed scientific information about how forest utilization may alter environmental conditions and the environmental functions of forests is often not available
- An ecological and ecosystem service as a broad area of research is unexplored
- Livelihood options and related policy aspects have not sufficiently researched
- Climate change modeling has been not worked out appropriately

Collaborative conservation efforts are needed to be directed towards addressing the research gaps in the priority areas.

Chapter 10: Conservation and Development – *Identifying priorities*

Policies often overlap and many a time appeared conflicting in nature, insufficiently addressing many social and economical problems that are linked closely with most of the conservation issue at local level. The success or failure of global conventions depends primarily on their implementation at the national level. For developing countries, depend on the commitment at the regional level for cooperation, sharing of information, access to genetic resources, and access to technology transfer (Belbase, 1999), the conservation and development priorities appeared diversified in place to place. These require immediate attention ensuring a sound framework in place for better implementation of the projects and plans which may deal both country and regional specific issues. In KL, India context, this chapter identifies various priorities on conservation and development aspects taking help from the issues and gaps identified in FA report.

10.1 Major priorities of the Khangchendzonga landscape, India

The following priorities deserve consideration for the conservation and development in Khangchendzonga landscape, India (Table 10.1):

Table 10.1 Identification of conservation and development priorities for Khangchendzonga landscape, India

Thematic areas	Priorities
Land use pattern and climate	• Land use and land cover change assessment using GIS/RS; segregated landuse after bifurcation of Jalpaiguri district.
Climatic change and environmental hazards	• Establishment of automatic weather stations (AWS) along ec-climatic zones for obtaining continuous climatic variables and extracting models • Detailed Environmental monitoring plans • Socio-political assessment on rapid urbanization; Model urbanization plan development • Climate impact assessment on flagship species distribution and agro biome, and receding glaciers • Developing long term phenology monitoring plans • Assessment of pollution on ground water quality and aquatic life
Socio-economics and livelihoods	• Assessment of tourism flow and carrying capacity in representative locations/transects • Strengthening alternative livelihood approaches (village tourism, value addition of agrobiodiversity produces, involvement of youth in eco-marketing, and promotion of local crafts) • Developing model plans for gender equity and decision making • Assessment on eco-social vulnerability of tea gardens • Extensive status of traditional knowledge

	• Assessment of cultural diversity and social fabrics • Gender focused socio-cultural and economic assessment
Biodiversity	• Detailed biodiversity assessment along representative biomes and prioritizing elements for immediate conservation • Biodiversity assessment and finalizing corridors' connectivity amongst PAs in Sikkim and with those of north Bengal and partner countries • Updating gaps on basic biodiversity inventories for all the protected areas in KL, India • Biodiversity assessment • Population assessment and conservation plan for rare and threatened taxa
Agrobiodiversity	• Documentation on crop diversity and action plan for conserving minor crop diversity • Assessment based action plan addressing diseases and long term sustainability in large cardamom and other cash corps • Scientific assessment on organic farming
Ecosystem function and services	• Prioritization and impact assessment of sensitive wetlands especially from the point of view of catchment degradation • Ecosystem functioning assessment in the PAs and corridors • Valuation of ecosystem services and prioritization
Resource management	• Standardizing and rationalizing approaches in addressing trans-boundary issues to arrive at fruitful coordination and cooperation between the parties • Management plans targeting to MFPs including medicinal and aromatic plants • Strengthening forest management and community participation approaches • Developing improved protocols for monitoring transboundary areas • Documentation assessment of actual transboundary illegal trade and poaching/MFP extraction • Documentation /assessment on pasture lands and grazing especially along transboundary and dooars areas • Extensive documentation on traditional resource management institutions for their utility at present time and efficacy dealing local governance • Capacity building in dealing natural resources
Long term conservation and monitoring	• Biodiversity monitoring through establishing permanent stations along different climatic biomes along prioritized transects, using various biological indicators (community composition, habitats, tree line, distribution range of flagship species, phenology, pollinator services, cropping pattern, susceptibility of crops to

	disease, etc) • Strengthen monitoring protocols on human-wildlife conflicts' • Tourism monitoring on carrying capacity and ecotourism driven manifestations on natural resources and biodiversity and socio-economy of community people • Monitoring impacts of globalization impacts on socio-economic and cultural vulnerability • Climate change monitoring using both high profile (glaciers, wetlands, rainfall and temperature, etc.) as well as conventional approaches of phenology. • Capacity building of concern institutions
Policy and enabling environment	• Biodiversity Action plan for KL, India with extensive focus on north Bengal part, by taking Sikkim Biodiversity Action Plan 2012, as a base and guideline • Review assessment of landscape planning and management • Assessment of ineffectiveness of policies and schemes, if any, and newer propositions • Rationale advocacy for transboundary eco-tourism amongst partner countries • Encourage gender based policy advocacy • Policy amendments helping landscape conservation and transboundary cooperation amongst partner countries • Strengthening policies to revive and uphold local governance • Establishment of knowledge network centre and effective dissemination

In addition, exchange of information and sharing knowledge amongst stakeholders, scientists, scientists and area managers and with policy makers would be imperative priority for conservation and development of KL, India. To ensure future actions turn fruitful, development of institutional capacity would be crucial, apart from policy amendments. For better interpretation of action and results Institutional mandate can take in a variety of media platforms. A majority of initiatives should be participatory in nature, with long-term institutional and legal support, harnessed either for subsistence livelihoods through the consumptive use of resources or for enterprise development and that communities benefit from it. Small pockets of areas or "islands" of success on effective biodiversity management have been noted, however, efforts to replicate and upscale them are yet being taken. However, addressing conservation concerns and effective coordination at national, regional and local levels ensuring long-term commitments for a commonly agreed regional policy framework would be the biggest challenge in KL. The vast potential in terms of both resources and expertise available in the landscape could be harnessed for long-term sustainability of biodiversity conservation and societal development in the region.

Chapter 11: Need Assessment Framework

With the envisage expected outcomes, the aim of the programme is not only to achieve the objectives of biodiversity conservation but concurrently the human development index reaches a level of satisfactory remark in KL-India. Therefore, there is a need to framework the action plans for KLCD initiatives at wider canvas, covering possibly all feasible approaches, which may deal with the emerging issues in the landscape. Furthermore, the action will be taken such a way that the socio-economic level of the societies will be enriched for their knowledge, management and sustainability of approaches and resources. The information gathered in the earlier chapters in this feasibility report have been used to formulate possible priority interventions and action under different thematic areas for the KL-India as a whole or for the specific priority target actions, which would be focused for actual implementation of the conservation and development strategies. This framework brief will help developing the combined regional conservation and development framework for the entire KL in general and specific to KL, India. Various guidelines suggested on the conservation and development of an area by different global agencies has been taken as a help while defining the themes. For the Khangchendzonga landscape (India), the tentative proposed location specific activities are presented in the Appendix 11.1.

The above interventions are the basic platform for taking up activities in near future; however, as per situation and location in KL, India and along the transboundary locations, these interventions could be altered and revised. Certainly, the entire conservation and development programme for KL cannot be feasible unless this is harmonized with initiatives of other partner countries and the role of local/regional governments under national support is in place. The efforts should be seen in the wider global context, which will take care of the national and local interests with strong convictions. The entire initiative thus offers most appropriate options for the conservation of local/regional biodiversity and sustainable development of society and landscape.

11.1 Projected framework of the KLCDI, India

KLCDI programme has been launched by the ICIMOD, Nepal with support of national governments of three participating countries, viz. Bhutan, India and Nepal, respectively in three parts of identified landscape. In India, MoEF, GOI, as a National Nodal Agency for the programme, is monitoring KLCDI, and the GBPIHED, India is entrusted the task as National Coordinator institute of the project. The GBPIEHD (India) has responsibility to lead the project activities in the identified landscape i.e. Khangchendzonga landscape, India with the collaboration of government agencies [Directorate of Forest, West Bengal, Government of West Bengal and Forests, Environment and Wildlife Management Department (FEWMD), Government of Sikkim]. The programme is being implemented through Sikkim based unit of the GBPIHED, India. On the basis of the major gaps and priorities and strength of the baseline information gathered and analyzed for the KL, India, the need assessment process will be implemented with the involvement of other government agencies,

experts and qualifying NGOs and other stakeholders. The assessment process will be taken up within time frame i.e. short and long term. Further, based on the available wide range of the data/information gathered at present and in near future, suitable and appropriate strategies and plans for the conservation and development of KL (India) will be proposed, which will suggest appropriate transboundary cooperation framework to deal trans-boundary issues or problems and connect the protected areas through developing the corridors as well. The generated models and general interpretations will be shared among the partners' counties for sustainable conservation and development of biodiversity within the landscape and between the countries (Figure 11.1).

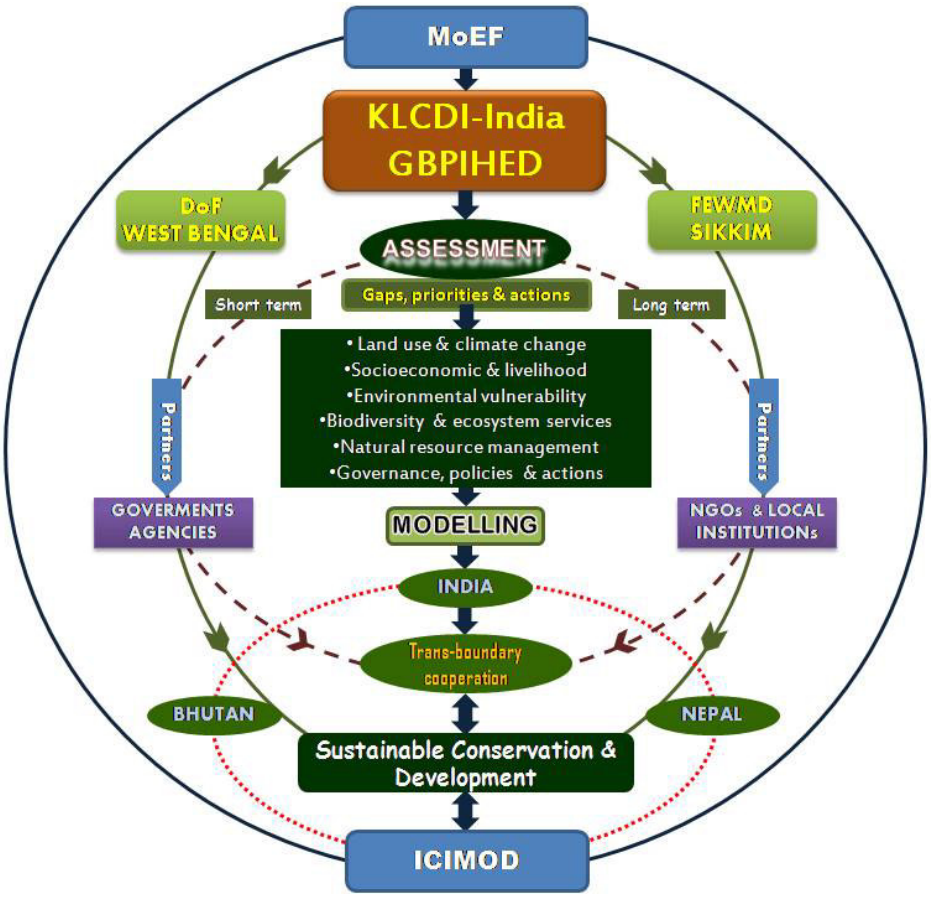


Figure 11.1 Projected intervention and action framework in the Khangchendzonga landscape (India)

References

Acharya, B. K. 2008. *Bird communities and their distribution pattern along the elevation gradient of Teesta Valley, Sikkim*. Ph.D. Thesis. Salim Ali Centre for Ornithology and Natural History and Bharathiar University, Coimbatore, India

Acharya, B. K. and Vijayan, L. 2007. Little-known Asian Bird. Range extension of Rusty-bellied shortwing *Brachypteryx hyperythra* in Sikkim, India. Birding ASIA 7: 50-51.

Acharya, B. K. and Vijayan, L. 2010. Status and distribution of endemic and threatened birds of the Eastern Himalaya in Sikkim, India. Jour. of Threatened Taxa 2(2): 685-689

Acharya, B. K. and Vijayan, L. 2011. Butterflies of Sikkim with reference to elevational gradient in species, abundance, composition, similarity and range size distribution. In: Arawatia, M. L. and Tambe, S. (eds.) *Biodiversity of Sikkim: Exploring and conserving a global hotspot.* IPR Department, Government of Sikkim, Gangtok, India.

Acharya, B. K. and Vijayan, L. 2012. Climate Change and Sustainability of Agrodiversity in Traditional Farming of the Sikkim Himalaya. In: Arrawatia, M. L. and Tambe, S. (eds). *Climate Change in Sikkim* - Patterns, Impacts and Initiatives. IPR Dept. Govt. of Sikkim. pp 193-217

Acharya, B. K., Sanders, N. J., Vijayan, L. and Chettri, B. 2011. Elevational gradients in bird diversity in the Eastern Himalaya: An evaluation of distribution patterns and their underlying mechanisms. In PLoS ONE 6(12): e29097.doi:10.1371/Jour.pone.0029097.

Acharya, B. K., Vijayan, L. and Chettri, B. 2010. The bird community of Shingba Rhododendron Wildlife Sanctuary, Sikkim, Eastern Himalaya, India'. Tropical Ecology 51(2): 149-159

Acharya, K., Rai, M. and Pradhan, P. 2010. Agaricales of Sikkim Himalaya: A Review, Researcher 2(5):

Agrawal, V. C., Das, P. K., Chakraborty, S., Ghose, R. K., Mandal, A. K., Chakraborty, T. K., Poddar, A. K., Lal, J. P., Bhattacharya, T. P. and Ghosh, M. K. 1992. Mammalia. In: *State Fauna Series 3: Fauna of West Bengal, Part I*: 27 – 169. Publ. Zoological Survey of India, Calcutta

Alfred, J. R. B., Sanyal, A. K., Roy, A., Tiwari, S., Mitra, S. and Bhatta, B. 2004. Biodiversity in West Bengal: A Demographic approach. Proceedings of the 7th Annual International Conference. MAP- India, 2004, New Delhi, 69pp

Ali, S. 1962. The Birds of Sikkim. Oxford University Press. New Delhi. 414 pp

Allen, D., Anderton, J., and Kazmierczak, K. 1997. *Report on an ornithological visit to Buxa Tiger Reserve, West Bengal, India*, 17 February to 6 March 1992. Forktail 31-48

Annual Administrative Report, 2010-11. *Annual Administrative Report for the year 2010-11*. Forest, Environment and Wildlife Management Department, Govt. of Sikkim

Anonymous, 2002. *An introduction to the fauna of Fambang Lho Wildlife Sanctuary, East Sikkim*. Unpublished report of the Department of Forests, Environment and Wildlife, Government of Sikkim.

Anonymous, 2007-08. Review of the status of Leopard and Gaur with respect to human animal conflict in northern west Bengal (2007-08). Implemented by WWF-India, west Bengal state office; supported by WWF-India Sikkim Programme office. P. 45.

Arrawatia, M. L. and Tambe, S. (eds.) 2011. *Biodiversity of Sikkim - Exploring and Conserving a Global Hotspot.* Information and Public Relation Department, Government of Sikkim, Gangtok, Sikkim.

ATREE, 2007. *Final Report on Corridor Project*, Submitted to International Center for Integrated Mountain Development (ICIMOD), NepalAvasthe, R. and Jha, A. 1999. *Mammals of Sikkim*. Gangtok, Sikkim: WWF India

Badola, H .K. 1994. Bud phenological studies as an aid to forestry research: An overview. In: Dogra, P.D. and Dhiman, R.C. (eds). Forestry Research and Education (Diamond Jubilee Publication, Indian Natl. Sci. Acad., New Delhi. pp. 142–153

Badola, H. K. 1998. Biodiversity conservation study of Kanawar Wildlife Sanctuary in Himachal. Pp. 407-430. In *Research for Mountain Development: Some Initiatives and Accomplishments.* Himavikas Publ. No. 12, Nainital, India: Gyanodaya Prakashan.

Badola, H. K. 2009. Agrobiodiversity, livelihood and conservation: focusing north-east Himalaya. Pp 34-58. In: Borgohain, R. and Pathak, P.K. (eds.) *Promoting Conservation and Sustainable Use of Agrobiodiversity in North-East India*. Jorhat-Assam, India,: Assam Agri. Univ, and Wageningen Intl., Wageningen Univ. and Res. Centre, Wageningen, The Netherlands. P.167.

Badola, H. K. 2010a. Phenology and climate responses in Himalayan rhododendrons. Pp. 48-59. In: Mainra, A., Badola, H.K. and Mohanty, B. (eds), *Proc., International Conference, Rhododendrons:* Conservation and Sustainable Use*,* FEWMD, Government of Sikkim, Gangtok-Sikkim. Printed at CONCEPT, Siliguri-India. P 100.

Badola, H. K. 2010b. A vegetable fern, *Diplazium esculentum* - potential to food security and socio-economic development in Himalaya. Non-wood News (Rome) 20: 10-11.

Badola, H. K. 2011. Nettle (*Urtica dioica*) - a potential wild resource for socio-economic upliftment in the Indian Himalayas. Non-Wood News Rome 23: 29-30.

Badola, H. K. 2013. Sustenance of biological resources: key factor leading to conservation threats. Proceed. Workshop on Conservation of Bioresources-Concepts, Practices and Instruments. 1-3 March 2013. Jeewanti Centre for Med Plants (Dabur India Ltd), Vijay Nagar, Uttarakhand. Pp.10-17.

Badola, H. K. and Aitken, S. 2003. The Himalayas of India: A treasury of medicinal plants under siege. Biodiversity 4: 3-13.

Badola, H. K. and Aitken, S. 2010. Potential biological resources for poverty alleviation in Indian Himalaya. Biodiversity 11(3-4): 8-18.

Badola, H. K. and Pal, M. 2002. Endangered medicinal plant species in Himachal Pradesh. Current Science 83: 797-798.

Badola, H. K. and Paliwal, G. S. 1987. Vegetative bud development in *Rhododendron arboreum* during annual growth cycle. I. Morphology and histology. Phytomorphology 37: 69-80.

Badola, H. K. and Pradhan, B. K. 2010a. Discovery of new populations of a rare species *Rhododendron niveum* in Khangchendzonga National Park, Sikkim. The Rhododendron

Badola, H. K. and Pradhan, B. K. 2010b. Population exploration of *Rhododendron maddenii* in Sikkim, bordering Khangchendzonga Biosphere Reserve - questioning rarity and endangerment. NeBIO 1: 1-9.

Badola, H. K. and Pradhan, B. K. 2011. Economic viability of cultivation of *Swertia chirayita*, a high value endangered medicinal herb in Himalaya. Zeitschrift für Arznei- and Gewürzpflanzen (J. Medicinal and Spice Plants, Germany) 16(3):118-124. [+ cover photograph]

Badola, H. K. and Pradhan, B. K. 2013. Plants used in healthcare practices by Limboo tribe in South –West of Khangchendzonga Biosphere Reserve, Sikkim, India. Indian Jour. Traditional Knowledge 12(3): 355-369

Badola, H. K. and Subba, J. B. 2012. Khangchendzonga Biosphere Reserve (Sikkim). Pp. 133-142. In: Palni, L.M.S., Rawal, R.S., Rai, R.K. and Reddy, S.V. (eds), *Compendium on Indian Biosphere Reserves: Progression During Two Decades of Conservation*, GBPIHED, Kosi-Almora and Ministry of Environment and Forests (Govt. of India).

Badola, H. K., Pradhan, B. K., Subba, S., Rai, L. K. and Rai Y. K. 2009. Sikkim Himalayan screw-pine, *Pandanus nepalensis*: a much neglected and underexplored NTFP. Non-wood News Rome18: 44-45.

Badola, H. K., Singh, K. K., Lepcha, L., Kumar, S. and Pradhan, B. 2006. Plants Conservation Park in Gangtok-Sikkim Zoo. Hima-Paryavaran 18(2): 15-16.

Badoni, A. K., Badola, H. K. and Sharma, S. P. 1989. Inter- disciplinary approach towards environmental management: A case study with wild bamboos in Garhwal Himalayas, In: Prakash, R. (Ed) *Advances in Forestry Research in India,* Vol. III, Intl. Book Distrib., Dehradun, pp. 261-280.

Bahuguna, I. M., Kulkarni, A. V., Arrawatia, M. L. and Shrestha, D. G. 2001. *Glacier Atlas of Teesta Basin (Sikkim Himalaya)*. (SAC/RESA/MWRG-GLI/SN/16/2001)

Bakshi, B. K., Reddy, M. A. R., Puri, Y. N. and Singh, S. 1972. *Survey of the disease of important native and exotic forest trees in India.* PL-480. Report FRI, Dehradun.

Bantawa, P. and Rai, R. 2000. Studies on Ethnomedicinal Plants used by Traditional Practitioners, Jhankri, Bijuwa and Phedangma in Darjeeling Himalaya. Natural Product Radiance 8(5): 537-541

Bashir, T., Bhattacharya, T., Poudyal, K., and Sathyakumar, S. 2011. Notable observations on the melanistic Asiatic Golden cat (*Pardofelis temminckii*) of Sikkim, India. In NeBio 2 (1): 1-4

Basnet, K. and Badola, H. K. 2012. Birds of Fambonglho Wildlife Sanctuary, Sikkim, India: A baseline survey for conservation and area management. NeBio 3(2): 1-12

Basnett, S. and Kulkarni, A. V. 2012. *Monitoring the Seasonal Snow Cover in Sikkim Himalaya using Remote Sensing Techniques.* In: Arrawatia, M.L. and Tambe, S.

(eds.) Information and Public Relations Deaprtment, Government of Sikkim, Gangtok

Basu, A., Dutta, D., and Banerjee, S. 2012. Indigenous ornamental fishes of West Bengal. Recent research in Science and Technology 4(11): 12-21.

BCTL Report, 2010. *Biodiversity Conservation in Transboundary Landscapes Project in Sikkim- Assessment of Biodiversity Values and Ecosystem Services in the Protected Areas of Sikkim Himalayas.* A Project supported by International Centre for Integrated Mountain Development (ICIMOD), Under Letter of Agreement between ICIMOD, Nepal and GBPIHED, Kosi-Almora, India. Final Technical Report. Dec. 2010.

Belbase, N. 1999. *National Implementation of the Convention on Biological Diversity: Policy and Legislative Requirements. Kathmandu, Nepal*: World Conservation Union (IUCN)

Bennett, G. and Mulongoy, K. J. 2006. *Review of experience with ecological networks and buffer zones*. Technical Series No. 23, p 69. Montreal, Canada: Secretariat of the Convention on Biological Diversity.

Bhatt, D. and Joshi, K. K. 2011. Bird assemblages in natural and urbanized habitats along elevational gradient in Nainital district (western Himalaya) of Uttarakhand state, India. Current Zoology 57: 318-329.

Bhattacharya, R. 2008. *Crop diversification: a search for al ternative income of the farmers in the state of west Bengal in India*. International Conference on Applied Economics – ICOAE .pp 83-94

Bhattacharya, S. K. 2012. Landslide disaster perception of the AILA cyclone in the Darjeeling town, West Bengal, India *International Journal of Geomatics and Geosciences* (1): 13-29.

Bhattacharya, T., Bashir, T., Poudyal, K., Sathyakumar, S. and Saha G. K. 2012. Distribution, Occupancy and Activity Patterns of Goral (Nemorhaedus goral) and Serow (Capricornis thar) in Khangchendzonga Biosphere Reserve, Sikkim, India. Mammal Study 37(3):173-181

Bhattacharya, V. 2008. *Crop Diversification*: *A search for an alternative income of the farmers in the state of west Bengal in India.* International Conference on Applied Economics – ICOAE 2008

Birdlife International, 2001. *Threatened birds of Asia*: *The Birdlife International Red Data Book.* Parts A and B. Cambridge, U.K.: Birdlife International.

Borah, T. R. and Rahman, H. 2011. Mushrooms in Biodiversity and Food Security of Sikkim. In: Arawatia, ML, and Tambe, S. (eds) *Biodiversity of Sikkim Exploring and Conserving a Global Hotspot.* Information and public relations department, Govt. of Sikkim, Gangtok

Borthakur, U., Saini, R. P., Gupta, S. S., Jakher, R., Das, C., Das, A. K., and Bharali, R. 2013. Noninvasive genetic assessment of population status of tigers (Panthera tigris tigris) in Buxa Tiger Reserve, West Bengal, India. International Jour. Biodiversity and Conservation, 5(1), 27-32.

Bradley, N. L., Leopold, A. C., Ross, J. and Huffaker, W. 1999. Phenological change reflect climate change in Wisconsin. Pro. Natl. Acad. Sci. USA 96:9701-9704

Brookfield, H., Parsons, H. and Brookfield, M. (eds). 2003. *Agrodiversity: Learning from Farmers Across the World*. United Nations University Press, Tokyo. P. 343.

Bustard, H. R. 1982. Crocodile breeding project. In Saharia, V.B. (Ed.), *Wildlife in India*. Natraj Publishers, Dehra Dun. Pp. 147-163.

Butola, J. S. and Badola, H. K. 2006. Growth, phenology and productivity of *Dactylorhiza hatagirea* (D. Don) Soo, a critically endangered medicinal orchid in Himalaya: domestication compared with wild. Jour. Orchid Soc. India 20: 37-43.

CDAP, 2007-12. *Comprehensive District Agriculture Plan*, For Jalpaiguri District 2007-2012 by NABARD

Chakraborty, S. and Agrawal, V. C. 1993. Mammals of West Bengal: An ecological aspect. ENVIS Newsletter 1(1): 2–3

Chamberlain, D. F. 1982. A Revision of Rhododendron. II. Subgenus Hymenanthes. Notes from the Royal Botanic Gar- den Edinburgh 39(2): 209-486

Champion, F. W. and Seth, S. K. 1968. *A Revised Survey of the Forest Types of India*. *Nasik, India: Manager*. Government of India Press, Delhi, India

Chanchani, P., Rawat, G. S., and Goya, S. P. 2010. Unveiling a wildlife haven: status and distribution of four Trans-Himalayan ungulates in Sikkim, India. In Oryx, 44(3): 366–375

Chandra, S., Fraser-Jenkins, C. R., Kumari, A. and Srivastav, A. 2008. A summary of the status of threatened pter- idophytes of India. Taiwania 53(2): 170-209

Chatterjee, D. 1939. Studies on the endemic flora of India and Burma. J. Asiat. Soc. Bengal. Pt.II. Nat. Hist. 5: 19-67

Chettri, N. and Sharma, E. 2007. Assessment of Natural Resource Use Patterns: A case study along a trekking corridor, West Sikkim, India. Current Science 92(12): 1744-1747

Chettri, N. 2000. *Impact of Habitat Disturbances on Bird and Butterfly Communities along Yuksam-Dzongri Trekking Trail in Khangchendzonga Biosphere Reserve*. PhD Thesis, North Bengal University, Darjeeling, India

Chettri, N. and Sharma, E. 2006. Assessment of Natural Resource Use Patterns: A case study along a trekking corridor of Sikkim Himalaya, India. Resources, Energy and Development 3(1): 21-34

Chettri, N., Deb, D. C., Sharma, E. and Jackson, R. 2005. The relationship between bird communities and habitat: A study along a trekking corridor of the Sikkim Himalaya. Mt. Res. Dev. 25(3): 235-244.

Chettri, N., Deb, D. C., Sharma, E. and Sundriyal, R. C. 2007. Effect of Firewood Extraction on tree structure, regeneration, and woody biomass productivity in a trekking corridor of Sikkim Himalaya. Mountain Research and Development 22(2): 150-189

Chettri, N., Shakya, B. and Sharma, E. 2008. *Biodiversity conservation in the Kangchenjunga landscape*. ICIMOD, Kathmandu.

Chettri, N., Shakya, B. and Sharma, E. 2011. Facilitating regional cooperation through development of conservation corridors in the Khangchendzonga Landscape. In Arrawatia, ML; Tambe, S (eds) Biodiversity of Sikkim – Exploring and

conserving a global hotspot, pp 529–542. Gangtok, Sikkim: Information and Public Relations Department, Government of Sikkim

Chettri, N., Sharma, E. and Thapa, R. 2009. Long term monitoring using transects and landscape approaches within Hindu Kush Himalayas. Proceedings on 'International Mountain Biodiversity Conference. 16-18 November 2008, ICIMOD, Kathmandu, Nepal. Pp 201-208.

Chhetri, D. R. and Basnet, D. *et al.* 2005. Current Status of ethno medicinal plants in Darjeeling Himalaya. Current Science 89(2): 264-268

Chhetri, D. R., Parajuli, P. and Subba, G. C. 2005. Antidiabetic plants used by Sikkim and Darjeeling Himalayan tribes, India. Jour. Ethnopharmaceology 99: 199-202.

Choudhury, M. 1998. An outline of the Physical Geography of Sikkim. *Sikkim Perspective for Planning and Development*. Sikkim Science Society, pp 17-24

Coppock, D. L., Ellis, J. E. and Swift, D. M. 1986. Livestock feeding ecology and resource utilization in a nomadic pastoral ecosystem. Jour. Applied Ecology 23: 573-583.

Costanza, R. 2008. Ecosystem services –Multiple classification systems are needed. Biological Conservation141 (2): 350-352

Coutecuisse, R. 2001. Current trends and perspective for the global conservation of fungi. In: Moore, D., Nauta, M. M., Evans, S.E., Rotheroe M., (eds) *Fungal Conservation: Issues and Solutions*. British Mycological Society, Cambridge University Press, UK. 2001:7-18.

Critical Ecosystem Partnership Fund (CEPF), 2005. *Ecosystem Profile: Indo-Burma Hotspot, Eastern Himalayan region*. World Wildlife Fund US Asia Programme, Washington, DC

Dandotiya, D., Govindapyari, H., Suman, S. and Uniyal, P. 2011. Checklist of the bryophytes of India. Archive for Bryology 88: 1-126.

Das, A. P., Rajib, B. and Goutam, S. 2013. Survey of medicinal plants in the Gorumara National Park, Jalpaiguri, West Bengal, India. Pleione 7(1): 127 - 137.

Das, K. 2010. Diversity and conservation of wild mushrooms in Sikkim with special reference to Barsey Rhododendron Sanctuary. NeBio1 (2):1-13

Department of Forest, Government of Sikkim, 1997. *Khanchendzonga Biosphere Reserve*. *Gangtok*: Government of Sikkim.

Department of Forest, Government of West Bengal, 2014. *List of flora and fauna of protected areas of north Bengal*. Government of West Bengal

Desai, M. 2011. Identification and Mapping of Hazard Prone areas regarding landslide in the Darjeeling Hill area. Retrieved May 2nd, 2011, from http://www.darjeeling.gov.in/geography.html#land-use.

Dhakal, T. D. 2012. Women's conservation of soyabean genetic resources through Kinema making practices in Sikkim, India. India. In Khadka, M. and Verma, R. (eds) *Gender and Biodiversity Management in the Greater Himalayas: Towards Equitable Mountain Development*. Pp, 33-36, Kathmandu: ICIMOD

Dhakal, T. D. 2012. Women's practices of in-situ agrobiodiversity conservation in Sikkim, India. In Khadka, M. and Verma, R. (eds), *Gender and Biodiversity*

Management in the Greater Himalayas: Towards Equitable Mountain Development. Pp, 31-32, Kathmandu: ICIMOD.

Dhyani, P. P. 2003. Badrivan: an innovative model in the Indian central Himalaya for restoration of degraded lands and biodiversity conservation. http://www.fao.org/docrep/ARTICLE/WFC/XII/0082-B1.HTM (accessed on 12.-06.2014)

Dhyani, P. P. and Dhar, U. 1994. *Box Myrtle (Myrica esculenta, Kaiphal) - A promising underexploited tree crop of the Himalaya*. Himavikas Occ. Publ. No. 3, GBPIHED-Almora. p.33

Dhyani, P. P. and Kala, C. P. 2005. Current research on medicinal plants: Five lesser known but valuable aspects. Current Science 88: 335

FAO, 2004. *Status and Trends in Mangrove Area Extent Worldwide*. FAO, Rome

Fitter, A. H. and Fitter, R. S. R. 2002. Rapid changes in flowering time in British plants. Science 296:1689-1691

Gaira, K. S., Dahal, D. R. and Singh, K. K. 2010. Climate Change and Large Cardamom farming in the Sikkim Himalaya. In: *International workshop on Mountain Biodiversity and Impacts of Climate Change with special reference to Himalayan Biodiversity Hotspot.* December 6-8, 2010, GBPIHED, Kosi-Katarmal, Almora, India.

Gaira, K. S., Dhar, U. and Belwal, O. K. 2011 Potential of herbarium records to sequence phonological pattern – a case study of *Aconitum heterophyllum* Wall. in the Himalaya. Biodiversity and Conservation 20:2201–2210

Gaira, K. S., Rawal, R. S., Rawat, B. and Bhatt, I. D. 2014. Impact of climate change on the flowering of *Rhododendron arboretum* in central Himalaya, India. Current science 106(12): 1735-1738

Ganguli-Lachungpa, U. 1990. Osprey Pandion haliaetus in Sikkim. Jour. Bombay Natural History Society 87: 291

Ganguli-Lachungpa, U. 1992. Occurrence of Black-necked Grebe *Podiceps nigricollis* Brehm, Little Grebe *P. ruficollis* (Pallas) and Goosander *Mergus merganser* Linn. in west Sikkim. Jour. Bombay Natural History Society 88: 280

Ganguli-Lachungpa, U. 2002. Eurasian Eagle-Owl *Bubo bubo tibetanus* Bianchi at 2,100 m in north Sikkim. Journal of the Bombay Natural History Society 99: 305-306.

Gansser, A. 1983. Geology of the Bhutan Himalaya, Birkhauser Verlag, Basel, 1983, p 181.

Gates, G. M., Ratkowsky, D. A. and Grove, S. J. 2005. A Comparision of macro fungi in young Silvicultural regeneration and mature forest at the Warra LTER siet in the southern forests of Tasmania. Tasfor 16: 127.

Geist, H. J. and Lambin, E. F. 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. Bioscience 52:143-149.

Gera, P. 2002. *Sub-group on sex disaggregated data of the IAWG on gender and development: Women's role and contribution to forest-based livelihoods*. New Delhi: UNDP India, UNESCO India.

Ghost, S. N. and Sheela, S. 2008. On a collection of Formicidae Hymenoptera: Vespoidea from Buxa Tiger Reserve, West Bengal, India, with new records of one rare genus and a rare species. Asian Myrmecology 2: 99-102.

Ghosh, S. P. 1992. Mandarin production in the sub-Himalayan tracts of India, Nepal and Bhutan, and the prevalence of citrus greening disease. Proceedings of the 12th IOCV Conference, Oman, India, pp. 447-448

GoN/MFSC, 2006. Sacred Himalayan Landscape (SHL) Strategic Plan: 2006-2016. Ministry of Forest and Soil Conservation, Government of Nepal, Kathmandu.Pp 1-48

Govindha, R. K. B., Remya, S. N. and Kumar, K. V. 2013. Remote sensing-based hazard assessment of glacial lakes in Sikkim Himalaya, Current science104 (3): 10

Govt. of West Bengal. 2009. Disaster management plan, Office of the D. M., Darjeeling, pp 1-6.

Gurung, B., Rai, L.K. and Singh, K. K. 2011. *The strange case of early flowering rhododendrons: a profiler note from Sikkim Himalaya*. Unpublished Poster. GBPIHED-Sikkim Unit

Gurung, C. 1999. Case study in Darjeeling District and Sikkim, India. In: Gurung, J.D. (Ed) *Searching for women's voices in the Hindu-Kush Himalayas.* pp. 237-256. Kathmandu: ICIMOD.

Hooker, J. D. 1849. *The Rhododendrons of the Sikkim Himalaya being an account, botanical and geographical of the rhododendron recently discussed in the mountains of eastern Himalaya*. Reeve and Co., London Hooker JD (1875-97) Flora of British India. Vols. I-VII Reeve and Co., London http://www.plantauthority.gov.in/hotspots.htm, assessed on 27 Jan 2014)

Hooker, J. D. 1853. The Himalayan Journal. Notes of a Naturalist. Vol. I and II. (Reprint). Natraj Publishers, Dehra Dun, India

Hooker, J. D. 1888-1890. The Flora of British India. Vol. 5 and 6. L. Reeve and Co. London.

IBWL, 1972. *Project Tiger*. *A planning proposal for preservation of tiger (Panthera tigris tigris Linn.) in India*. Indian Board for Wildlife, Government of India, New Delhi. 114 pp.

ICIMOD, 2014. HKH Conservation Portal. URL http://hkhconservationportal. icimod.org/Landscape. aspx?ID=2 assessed 17 March 2014

Idrisi, M. S., Badola, H. K. and Singh, R. 2010. Indigenous knowledge and use of medicinal plants by local communities in Rangit Valley, South Sikkim, India. NeBIO 1(2): 34-45.

IPCC, 2007. *Climate change impacts, adaptation and vulnerability*. Summery for policy maker. Intergovernmental Panel on Climate Change.

Jha, A. 2002. Ecological Prudence for the Lepchas of Sikkim. Tigerpaper 29(1): 27-2

Jhunjunwala, S., Rahmani, A. R., Ishtiaq, F. and Islam, Z. 2001. The Important Bird Areas Programme in India. Bombay Natural History Society 6(2).

Joshi, R. and Dhyani, P. P. 2009. Environment Sustainability and tourism – implication of trend synergies of tourism in Sikkim Himalaya. Current Science 97(1): 33-41

Jovan, S. 2008. *Lichen bioindication of biodiversity, air quality and climate*: *baseline results from monitoring in Washington, Oregon and California*. General Technical Report. PNW-GTR-737. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Karki, M. 2001.*Institutional and socio-economic factors and enabling policies for non-timber forest products based development in Northeast India*. In: Preidentification workshop for NTFP led Development in NE India, IFAD, Rome

Khaling, S., Kaul, R. and Saha, G. K. 1998. Survey of the Satyr Tragopan Tragopan satyra in the Singhalila National Park, Darjeeling, India using spring call counts. Bird Conservation International8: 361-372

Kholia, B. S. 2010. *Ferns and Fern Allies of Sikkim*: A Pictorial Handbook, Part 1. Sikkim State Biodiversity Board and Botanical Survey of India

Kholia, B. S. 2011. Pteridophytic wealth of Sikkim Himalaya pp43-65. In: Arawatia M.L. and Tambe S. (eds) *Biodiveristy of Sikkim Exploring and Conserving a Global HotspotInformation and public relations department, Govt. of Sikkim, Gangtok*

Kholia, B. S. and Joshi, R. 2010. International Year for Biodiversity – Reviewing Practices for Conservation in Eastern Himalaya and North-east India. NeBIO 1(2): 55-61

Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C. and Tscharntke, T. 2007. Importance of pollinators in changing landscapes for world crops. Proc R Soc Lond [Biol] 274: 303-313.

Korner, C. 2009. Climate Change in Mountains – Who Wins and Who Loses? Sustainable Mountain Development 55: 7-9. ICIMOD, Nepal

Kremen, C. 1992. Assessing the indicator properties of the species assemblages for natural areas monitoring. Ecological Applications 2: 203-217.

Krishna, A. P. 2005. Snow and glacier cover assessment in the high mountains of Sikkim Himalaya, Hydrol Process. 19: 2375–2383

Kumar, P. 2012. Assessment of impact of climate change on Rhododendrons in Sikkim Himalayas using Maxent modelling: limitations and challenges. Biodivers Conser. DOI 10.1007/s10531-012-0279-1

Kumar, R., Tiwari, J. K., Dwivedi. and Lal, B. 2011. A survey and enumeration of Lichen flora of Darjeeling district (W.B.). National Journal of Life Sciences 8(1): 17-20

Kushwaha, S. P. S., Padmanaban, P., Dipankar, P. and Roy, P. S. 2005. Geospatial Modeling of Plant Richness in Barsey Rhododendron Sanctuary in Sikkim Himalayas. Geocarto International 20 (2), Hong Kong

Lama, M. P. 2001. Sikkim Human Development Report. The Government of Sikkim, Social Science Press, Delhi.

Lucksom, S. Z. 2007. *The Orchids of Sikkim and North East Himalaya*, *Sikkim, India.*

Lucksom, S. Z. 2011. The Orchid Diversity in Sikkim and Effect of Change of Environment on the Distribution of Native Orchids in Sikkim Himalaya, India. In: Arrawatia, M.L. and Tambe, S. (Eds). Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot. pp 125-48. IPR Dept., Govt. of Sikkim

Luitel, K. K, Shrestha, D. G., Sharma N.P. and Sharma, R.K. 2012. Impact of climate change on east-rathong glacier in rangit basin, west Sikkim. In: Arrawatia, M. L. and Tambe, S. (eds) *Climate Change in Sikkim: Patterns, Impacts, Initiatives*. Information and Public Relations Department, Government of Sikkim, Gangtok, India (ISBN: 978-81-920437-0-8) 57-68

MacKinnon, J. and Mac, K. 1986. *Review of the Protected Areas of the Indo-Malayan Realm*. IUCN-The World Conservation Union, Gland, Switzerland

Maity, D. and Maiti, G. G. 2007. *The Wild Flowers of Kanchenjunga Biosphere Reserve, Sikkim*. Noya Udyog, Kolkata, India

Majumdar, N. C., Krishna, B. and Biswas, M. C.1984. Vegetation of the Neora and adjacent regions in Kalimpong Forest Division, West Bengal. Jour. of Economic and Taxonomic Botany 5(5):1013-1025

Mallick, J. K. 2010. Past and present status of the Indian Tiger in northern West Bengal, India: an overview. Jour. of Threatened Taxa 2(3).

Mallick, J. K. 2010. Status of Red Panda Ailurus fulgens in Neora Valley National Park, Darjeeling District, West Bengal, India. Small Carnivore Conservation 43: 30-36.

Mallick, J. K. 2013. Himalayan Yellow–throated Marten (Martes flavigula) in West Bengal, India. TAPROBANICA: The Jour. of Asian Biodiversity 5(1): 89-93

Manoj, K., Bhattacharya, R. and Padhy, P.K. 2013. Forest and Wildlife Scenarios of Northern West Bengal, India: A Review. International Research Jour. of Biological Sciences 2(7): 70-79

Mao, A. A., Singh, K. P. and Hajra, P. K. 2001. *Rhododendrons*. In: Singh, N. P. and Singh, D. K. (eds) *Floristic Diversity and Conservation Strategies in India*, vol. IV. Bot. Surv. India, Culcutta.

Mao, A.A. 2006. Notes on Dendrobium denudans D. Don- an endangered medicinal orchid of north east India. Jour. Orchid Soc. India 20: 53-55.

McNeely, J. A. 2003. Biodiversity in arid regions: values and perceptions. Jour. Arid Environments 54: 61-70.

Menzel, A., Sparks, T. H. and Estrella, N. 2006. European phonological response to climate change matches the warming pattern. Global Change Biology 12: 1969–1976.

Michell, B. 2003. International models of protected landscapes. The George Wright Forum 20: 33-40.

Millenium Ecosystem Assessment, 2005. *Ecosystems and Human Well-being: Synthesis*. Millennium Ecosystem Assessment. Island Press, Washington, DC

Millennium Ecosystem Assessment 2005. *Ecosystems and Human Well-being: A Framework for Assessment*. Millennium Ecosystem Assessment. Island Press, Washington, DC

Mishra, P. K. and Rai, S. C. 2013. Use of indigenous soil and water conservation practices among farmers in Sikkim Himalaya. Indian Jour. Traditional Knowledge 12(3):454-464

Mitra, S. 2004. In dire straits: The crisis of theBengal Elephants. Panda (WWF- India Newsletter) October: 19–20.

Mittermeier, R. A., Gils, P. R., Hoffman, M., Pilgrim, J., Brooks, T., Mittermeier, C. G., Lamoreaux, J. and Fonseca, G. A. B. (eds) *Hotspots Revisited. Earth's Biologically Richest and Most EndangeredTerrestrial Ecoregions*. CEMEX/Agrupación Sierra Madre, Mexico City, 2004.

MOEF, 1998. *Implementation of article 6 of the Convention of Biological Diversity in India*. National Report. Delhi, The Ministry of Environment and Forests. The Government of India

Molina, R., Pilz, D., Smith, J., Dunham, S., Dreisbach, T., O'Dell, T. and Castellano, M.2001. Conservation and management practices of forest fungi in the Pacific Northwestern United States: an integrated ecosystem approach. In: Moore, D.; Nauta, N.N.; Evans, S.E.; Rotheroe, M. (eds), *Fungal Conservation Issues and Solutions*. Cambridge, UK: Cambridge University Press: 19-63

MSME, 2010. Brief Industrial Profile of Darjeeling district, West Bengal. MSME-Development Institute Kolkata (Ministry of Environment and Forest (MoEF), Govt. of India. National Wetland Atlas. India and West Bengal.

Mukhopadhyay, S. C. 1998. Geomorphology of the Sikkim Himalaya. Sikkim Perspective for Planning and Development. Sikkim Science Society, pp 1-16

Mukul, M. 2000. The geometry and kinematics of the Main Boundary Thrust and related neotectonics in the Darjeeling Himalayan fold- and-thrust belt, West Bengal. J. Struct. Geol 22(9): 1261– 1283.

Mukul, M. 2010. First-order kinematics of wedge-scale active Himalayan deformation: insights from Darjeeling–Sikkim–Tibet (DaSiT) wedge. J. Asian Earth Sci. 39: 645–657

Mukul, M., Jade, S., Ansari, K. and Martin, A. 2014 Seismotectonic implications of strike–slip earthquakes in the Darjeeling–Sikkim Himalaya. Current Science 2(106): 198–210.

Murphy, M. L., Oli, K. P. and Gorzula, S. 2005. *Conservation in Conflict: the impact of Moist- Government conflict on conservation and biodiversity in Nepal*. International Institute for Sustainable Development, Canada.

Nandi, N. C., Mukhopadhyay, P., Ghosh, S. K. and Das, S. K. 2004. Notes on aquatic entomofauna of Narathaly lake of buxa tiger reserve, west Bengal. Records of the Zoological Survey of India102 (1-2): 53.

NATCOM, 2004. India's initial National communication to the United Nations Framework Convention on Climate change. National Communication Project, Ministry of Environment and Forests, Government of India.

National Wetland Atlas, Sikkim, 2010. SAC/RESA/AFEG/NWIA/ATLAS/13/2010 Space Applications Centre (ISRO), Ahmedabad, India, 88p.

Nautiyal, D. C., Sharma, S. K. and Pandit, M. K. 2009. Notes on the taxonomic history, rediscovery and conservation status of two endangered species of Ceropegia (Asclepiadaceae) from Sikkim Himalaya. Jour. Botanical Research Institute Texas 3(2): 815-822

NCD, 2004 *Bhutan Biological Conservation Complex: A Landscape Conservation Plan-way forward*. Nature Conservation Division, Department of Forestry Services, Ministry of Agriculture, Bhutan, Thimpu

NESPON, 2009. Developing a Transboundary Conservation Landscape in the Kangchenjunga Complex: Village Level Participatory Development Planning Conservation and Development Strategy in the Proposed Mahananda WLS-Neora Valley NP Corridors. Report submitted to International Center for Integrated Mountain Development (ICIMOD), Nepal

Panwar, H. S. 1982. Project Tiger. In: Saharia VB (Ed.), *Wildlife in India*. Natraj Publications, Dehra Dun. Pp 130-137.

Parmesan, C. and Yohe, G. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37-42.

Paul, A., Khan, M. L., Arunachalam, A. and Arunachalam, K. 2005. Biodiversity and conservation of rhododendrons in Arunachal Pradesh in the Indo-Burma biodiversity hotspot. Current Science 89: 623-634

Planning Commission, 1981. Report of High Level Team for Land Use Plan of Sikkim. Planning Commission, Govt. of India, New Delhi, India

Pounds, J. A., Fogden, M. P. L. and Campbell, J. H. 1999. Biological response to climate change on a tropical mountain. Nature 398:611-615

Pradhan, B. K. and Badola, H. K. 2012. Effects of microhabitat, light and temperature on seed germination of a critically endangered Himalayan medicinal herb, Swertia chirayita: Conservation implications.Plant Biosystems (Italy)-An International Journal Dealing with all Aspects of Plant Biology 146: 345-351.

Pradhan, B. K. and Badola, H. K. 2012. *Swertia chirayita*, a high value critically endangered medicinal herb of Himalaya – an overview on its potential, conservation status and policies. Pp. 333-355. In: Panda, S. and Ghosh, C. (*eds*), *Diversity and Conservation of Plants and Traditional Knowledge*. Bishen, S. and Mahendra, P. S. Dehra Dun (India).

Pradhan, B. K. and Badola, H. K. 2008. Ethnomedicinal plant use by Lepcha tribe of Dzongu valley, bordering Khangchendzonga Biosphere Reserve, in North Sikkim, India. Journal of Ethno biology and Ethno medicine 4:22 doi: 10.1186/1746-4269-4-22.

Pradhan, G. M. 1974. Diplomeris hirsuta. American Orchid Society Bulletin 43(6): 520-524

Pradhan, K. C., Sharma, E., Pradhan, G., and Chettri, A. B. 2004. *Sikkim Study Series: Geography and Environment*. Department of Information and Public Relations Government of Sikkim, India.

Pradhan, S. and Bhujel, R. 2000. Biodiversity Conservation in the Darjeeling Himalayas. In: *Kangchenjunga Mountain Complex*. Biodiversity Assessment and Conservation Planning, 31-78 pp. Kathmandu: WWF Nepal Programme

Pradhan, U. C. 1974. Diplomeris hirsuta (Lindl.) Lindl: a survey. American Orchid Society Bulletin 43(6): 525-52

Pradhan, U. C. 1976. *Indian Orchids Guide to Identification and Culture*, (Vol. I) Premulaceae Books, Kalimpong, India.

Pradhan, U. C. and Lachungpa, S. T. 1990. *Sikkim Himalayan Rhododendrons*. Sikkim

Prakash, D., Upadhyay, G., Gupta, C., Pushpangadan, P. and Singh, K. K. 2012. Antioxidant and free radical scavenging activities of some promising wild edible fruits. International Food Research Journal 19 (3):1109-1116.

Prena, D. L. R. 2007. *Transboundary Corridor Planning Report. Report of village level planning on Developing a Transboundary Conservation Landscape in the Complex*. Submitted to ICIMOD, Nepal

Rahman, H., Karuppaiyan, R., Senapati, P. C., Ngachan, S. V. and Kumar, A. 2012. An analysis o past three deade weather phenomenon in the mid-hills of Sikkim and strategies for mitigation possible impact of climate change on agriculture. In: Arrawatia M.L. and S. Tambe (Eds.) *Climate Change in Sikkim - Patterns, Impacts and Initiatives.* IPR Dept., Govt. of Sikkim. pp 19-48

Rai, L. K. and Sharma, E. 1994. *Medicinal Plants of Sikkim Himalaya*: Status, Potential and Usage. Bishen Singh Mahindra Pal Singh, Dehra Dun

Rai, M., Ghosh, S. and Acharya, K. 2007. On nutritional parameters of Oudesmansiella mucida. Jour. of Mycopathological Research 42: 113-116.

Rai, P. C. and Das, A. P. 2004. Ethnobotanical significance of the flora of Neora Valley National Park in the district of Darjeeling, West Bengal (India). Bulletin of the Botanical Survey of India 46(1-4): 337-355

Rai, Y. K. and Badola, H. K. 2009. *Spondias axillaris* Roxb. (Lapsi), a wild edible in Sikkim Himalaya: potential for entrepreneurship. Ecotone 1: 6-8

Rai, Y. K., Chettri, N. and Shrama, E. 2002. Fuel wood value index of woody tree species from Mamlay watershed in south Sikkim, India. For. Trees Livelihoods 12: 209-219

Rai, Y. K., Singh, K. K., and Rai, L. K. 2012. *Diversity of edible wild plants in Sikkim Himalaya*. In: Tamang P., Shrivastava AK., Lepcha SR. (eds) Sikkim Biodiversity: Significance and Sustainability. pp. 1-19, Govt. of Sikkim.

Raina, V. K. 2009. *Himalayan Glaciers: A State-of-Art Review of Glacial Studies, Glacial Retreat and Climate Change*. MoEF Discussion Paper, pp 60. MoEF (Govt. of India) and GBPIHED

Ramakantha, V., Gupta, A. K. and Kumar, A. 2003. Bio- diversity of Northeast India: an overview. Pp.1- 24. In: Gupta, A. K., Kumar, A. and Ramakantha, V. (eds.) *Envis Bulletin: Wildlife and Protected areas, Conservation of Rainforests in India.*

Ramakrishnan, P. S. 1996. *Conserving the sacred: from species to landscape*. Nature and Natural Resources, UNESCO, Paris.

Rastogi, A., Shengi P., and Amatya, D. 1997. *Regional consultation on conservation of Kangchenjunga mountain ecosystem*. Kathmandu, Nepal: ICIMOD

Rawal, R. S., Bankoti, N. S., Samant, S. S. and Pangtey, Y. P. S. 1991. Phenology of tree layer species from the timberline around Kumaun in central Himalaya, India. Vegetation **93:**109-118.

Rawal, R.S., Rastogi, A. and Palni, L.M.S. 2012. *Journey through a Sacred Landscape*…. GB Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora, Uttarakhand, India. P. 76.

Risley, H. H. 1894. *The Gazetteer of Sikhim*. Bengal Secretariat Press, Calcutta, India

Roy, A. K., Pradhan, B. B., Ray, A. and Jaswal, V. 2013. Study on the alternative energy technologies implementation for promoting the sustainability of technologies in Sikkim. Int. Jour. Emerging Technology and Advanced Engineering 3(3): 560-565

Roy, U. S., Pal, A., Banerjee, P., and Mukhopadhyay, S. K. 2011. Comparison of avifaunal diversity in and around Neora Valley National Park, West Bengal, India. Jour. of Threatened Taxa, 3(10)

Saha, S. and Raychaudhuri, D. 2006. Heteropodine spiders (*Sparassidae: araneae*) from Jaldapara Wildlife Sanctuary, Jalpaiguri, West Bengal. Jour. Bombay Natural History Society, 103(1), 82.

Samant, S. S., Dhar, U. and Palni, L. M. S.1998. Medicinal Plants of Indian Himalaya: Diversity, Distribution Potential Values. HIMAVIKAS Publication No. 13, Gyanodaya Prakashan, Nainital. P.163.

Sanyal, A. K., Ramakrishna. and Alfred, J. R. B. 2007. Faunal resources in West Bengal. West Bengal 49(10–11): 38–48.

Sarin, M. 1995. Regenerating India's forests: Reconciling gender equity with joint forest management. IDS bulletin, 26 (1): 83-91.

Sarker, D. and Das, N. 2002. Women's participation in forestry: Some theoretical issues. Economic and Political Weekly 37 (43): 4407-4412.

Sathyakumar, S., Bashir, T., Bhattacharya, T. and Poudyal, K. 2011. Assessing mammal distribution and abundance in intricate eastern Himalayan habitats of Khangchendzonga, Sikkim, India. In Mammalia 75: 257–268.

Sathyakumar, S., Gupta, S. K., Karki, R. R. and Dimri, N. K. 2012. *Monitoring Land Use by Wildlife, Livestock and Humans in Khangchendzonga Biosphere Reserve*. Progress Report (June 2011 to March 2012), Wildlife Institute of India, Dehradun. 30pp.

Sathyakumar, S., Kumar, P. and Mainra, A. 2012. Bear Conservation Action Plan, Sikkim. In: Sathyakumar, S., Kaul, R., Ashraf, N. V. K., Mookherjee, A., and Menon, V. (eds). *National Bear Conservation and Welfare Action Plan*. Ministry of Environment and Forests, Wildlife Institute of India, and Wildlife Trust of India Pp: 273-279

SCBD, 2011. *Nagoya protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization*. Secretariat of the Convention on Biological Diversity, United Nations Environment Programme. Montreal, Quebec, Canada Retrieved on 22 March 2014 from www.cbd.int/abs/

Sekar, K. C. and Badola, H. K. 2013. Biodiversity of Indian Trans Himalaya. pp. 15-19. In: Rawal, R.S., Bhatt, I. D., Sekar, K. C. and Nandi, S. K. (eds). *The Himalayan Biodiversity: Richness, Representativeness, Uniqueness and Life-Support Values*. Almora, Uttarakhand: GBPIHED.

Sengupta, P., Banerjee, K. K. and Ghorai, N. 2014. Seasonal diversity of butterflies and their larval food plants in the surroundings of upper Neora Valley National Park, a sub-tropical broad leaved hill forest in the eastern Himalayan landscape, West Bengal, India. Jour. Threatened Taxa 6(1): 5327-5342

Sharma, E., Chettri, N., Gurung, J. and Shakya, B. 2007. *Landscape approach in biodiversity conservation: A regional cooperation framework for implementation of the Convention on Biological Diversity in the Kangchenjunga landscape*. ICIMOD, Kathmandu.

Sharma, E., Sharma, R., Singh, K. K. and Sharma, G. 2000. A boon for mountain population's large cardamom farming in the Sikkim Himalaya. Mountain Research Development 20:108–111.

Sharma, G. and Acharya, B. K. 2013. *Agriculture Systems and Management Diversity*. Govt of Sikkim

Sharma, G. and Dhakal, T. 2011. Opportunities and Challenges of the Globally Important Traditional Agriculture Heritage Systems of the Sikkim Himalaya pp 411-440. In: Arawatia M. L. *and* Tambe S. (eds*). Biodiversity of Sikkim: Exploring and Conserving a Global Hotspot.* Published by Information and Public Relations Department, Government of Sikkim. (ISBN-978-81-920437-0-9).

Sharma, G. and Rai, L. K. 2012. Climate Change and Sustainability of Agrodiversity in Traditional Farming of the Sikkim Himalaya. In: Arrawatia, M. L. and Tambe, S. (eds) *Climate Change in Sikkim: Patterns, Impacts, Initiatives*. Information and Public Relations Department, Government of Sikkim, Gangtok, India (ISBN: 978-81-920437-0-8) 193-218.

Sharma, G., Sharma, R. and Sharma, E. 2009. Traditional knowledge systems in large cardamom farming: Biophysical and management diversity in Indian mountainous regions. Indian Jour. Traditional Knowledge 81(1): 17–22.

Sharma, R. K., Sharma, N., Shrestha, D. G., Luitel, K. K., Arrawatia, M. L. and Pradhan, S. 2012. Study on forest fires in Sikkim Himalayas, India using remote sensing and GIS Techniques. In: Arrawatia, M. L. and Tambe, S. (eds) *Climate Change in Sikkim: Patterns, Impacts, Initiatives*. Information and Public Relations Department, Government of Sikkim, Gangtok, India (ISBN: 978-81-920437-0-8). 233-244

Shrestha, A., Wake, C., Mayewski, P. and Dibb, J. 1999. Maximum temperature trends in the Himalaya and its vicinity: an analysis based on temperature records from Nepal for the period 1971-94. J Clim 12: 2775-2787

Sikkim Biodiversity Action Plan, 2012. Published by Sikkim Biodiversity Conservation and Forest Management Project, FEWMD, Govt. of Sikkim, Concept, India (working group: Badola, H.K., Kholia, B. S., Lachungpa, U., Buffum, B., Iguchi, J. and Patnaik, S.K.) P. 44.

Singh, K. K. 2008. Large cardamom agro forestry: A sustainable practice in the Sikkim Himalaya. Indian Jour Arecanut Spices and Medicinal Plants 10(2):67–77.

Singh, K. K., Krishna, A. and Chhetri, S. 2005. Large cardamom agro forestry based sustenance in fringe areas of Khangchendzonga Biosphere reserve, Sikkim Himalaya. In: Bhatt, B.P. and Bujarbaruah, K. M. (eds) *Agroforestry in North East India:* opportunities and challenges, pp 71-78. ICAR Research Complex for NEH Region, Umiam, Meghalaya.

Singh, K. K., Kumar, S., Rai, L. K. and Krishna, A. P. 2003. Rhododendron conservation in Sikkim Himalaya. Current Science 85: 602-606.

Singh, L. A. K. 2012. Mammals of Kalimpong Hills, Darjeeling District, West Bengal, India. Jour. Threatened Taxa 4(12): 3103-3136.

Singh, P. and Chauhan, A.S. 1997. Plant Diversity in Sikkim Himalaya. In: Hajra, P.K. and Mudgal, V. (eds.) *Plant diversity Hotspots of India:* An Overview. pp 137-158. Botanical Survey of India, Kolkata

Singh, S. P. 2007. *Himalayan Forests Ecosystem Services*: Incorporating in National Accounting. CHEA, Nainital

Sinha, G. P. and Jagdeesh, R. T. A. M. 2011. Lichen diversity in Sikkim. 13-29. In: Arrawatia, M. L. and Tambe, S. (eds) *Biodiversity of Sikkim. Exploring and conserving a global hotspot*. Govt. of Sikkim, Information

Sivakumar, S. and Prakash, V. 2004. Water birds of Buxa Tiger Reserve, West Bengal. Zoos' Print J 19 (4): 1451-1452.

Sivakumar, S., Varghese, J. and Prakash, V. 2006. Abundance of birds in different habitats in Buxa Tiger Reserve, West Bengal, India. FORKTAIL 22: 128

Smith, W. W. and Cave, G. H. 1911. *The Vegetation of the Zemu and Llonakh Valleys of Sikkim*. Records of the Botanical Survey of India, Volume IV, No 5. Superintendent Government Printing, India

Soil Survey Staff, 1994. Keys to Soil taxonomy, (Sixth Edition), United States Department of Agriculture, Soil Conservation Service, USA.

Srivastava, L. S. 1983. *Plant Diseases of the important agricultural and horticultural crops of Sikkim*. Report of ICAR Research complex for N.E.H. Region Sikkim centre, Tadong, Gangtok, Sikkim 30p.

Srivastava, L. S. 1998. Crop diseases and their management in Sikkim. In: Rai, S.C. Sundriyal, R.K., Sharma, E. (eds) *Sikkim: Perspectives for Planning and Development*. Published by Sikkim Science Society and Bishen Siingh Mahendra Pal Singh, Dehra Dun India.

Stattersfield, A. J., Crosby, M. J., Long, A. J. and Wege, D. C. 1998. *Endemic Bird Areas of the world: priorities for conservation*. Cambridge, U.K.: Birdlife International.

Subba, J. R. 2009. Indigenous knowledge on bio-resources management for livelihood of the people of Sikkim. Indian Jour. Tradl. Know. 8: 56-64.

Subba, S. and Badola, H. K. 2011. Ethnobotanical knowledge, populations, and *ex-situ* conservation trials in *Juglans regia* Linnaeus (Juglandaceae) in Sikkim. Pleione 5(2): 304-313.

Sundriyal, M. and Rai, L. K. 1996. Wild edible plants of Sikkim Himalaya. Jour. Hill Research 9:267-278

Sundriyal, M. and Sundriyal, R. C. 2001. Wild edible plants of the Sikkim Himalaya: Nutritive values of selected species. Economic Botany 55(3): 377-390.

Sundriyal, M. and Sundriyal, R. C. 2003. Underutilized edible plants of the Sikkim Himalaya: need for domestication. Current Science 85(6):731-736

Sundriyal, M. and Sundriyal, R. C. 2004. Wild edible plants of the Sikkim Himalaya: marketing, value addition and implications for management. Economic Botany 58:300-315.

Sundriyal, M., and Sundriyal R. C. 2005. Seedling growth and survival of selected wild edible fruit species of the Sikkim Himalaya, India. Acta Oecologica 28:11-21.

Sundriyal, M., Sundriyal, R. C., and Sharma, E. 2004. Dietary use of wild plant resources in the Sikkim Himalaya, India. Economic Botany 58: 626-638

Takhtajan, A. 1969.*Flowering plants: Origin and Dispersal*. Edinburgh

Tamang, D. K., Dhakal D., Gurung S., Sharma N. P., and Shrestha D. G. 2013. Bamboo Diversity Distribution Pattern and its uses in Sikkim (India) Himalaya.Int Jour. Scientific Res Publications 3(2): 1-6.

Tambe, S. and Rawat, G. S. 2009. Ecology, Economics, and Equity of the Pastoral Systems in the Khangchendzonga National Park, Sikkim Himalaya, India. Ambio 38: 95-100

Tambe, S., Kharel, G., Arrawatia, M. L., Kulkarni, H., Mahamuni, K., and Ganeriwala, A. 2012. Reviving dying springs: Climate change adaptation experiments from the Sikkim Himalaya. Mountain Research and Development 32(1): 62–72.

Tashi, T. 1998. Mineral Resources and utilization in Sikkim. Sikkim Perspective for Planning and Development. Sikkim Science Society. pp 25-32

Telwala, Y. 2012. Climate Change and Alpine Flora in Sikkim Himalaya. Pp 103-124. In: Arrawatia, M.L. and Tambe, S. (eds). Climate change in Sikkim - *Patterns, Impacts and Initiatives*. IPR Dept. Govt. of Sikkim.

Thomas, C. D., Cameron Green, R. E., Bakkenes, M., Beaumont, L. J., Collingham, Y. C., Erasmus, B. F. N., Siqueira, M. F. D., and Grainger, A., *et al*. 2004. Extinction risk from climate change. Nature 427: 145-147

Tiwari, S. K. 2005. Elephant corridors in Norther West Bengal. In: Menon, V., Tiwari, S. K., Easa P. S. and Sukumar, R. (eds) *Right of Passage*: *Elephant Corridors of India*. Conservation Reference Series 3. Wildlife Trust of India, New Delhi. Pp 120 – 153.

Tse-ring, K., Sharma, E., Chettri, N. and Shrestha, A. B. 2010. *Climate change vulnerability of mountain ecosystems in the Eastern Himalayas Climate change impact and vulnerability in the eastern Himalayas- Synthesis report. Kathmandu*: ICIMOD.

Uniyal, S. K., Singh, K. N., Jamwal, P. and Lal, B. 2006. Traditional use of medicinal plants among the tribal communities of Chhota Bhangal, Western Himalaya. Jour. Ethnobiol. Ethnomed. 2:14 doi: 10.1186/1746- 4269-2-14.

Urfi, A. J. 2011. Climate change and its impacts on Indian birds: monsoon phenology and monitoring heronry birds. Current Science 101: 1140-1142.

Verma, R. 2012. Sikkim - A Guide and Handbook. pp 1-216.

Vetaas, O. R. 2000. Comparing species temperature response curves: population density versus second- hand data. Jour Vegetation Science 11: 659-666.

Walther, G. R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T. J. C., Fromentin, J. M., Guldberg, O. H. and Bairlein, F. 2002. *Ecological responses to recent climate change*. *Nature* 416(28): 389-395.

Wikramanayake, E., Dinerstein, E., Loucks, C.J., Olson D.M., Morrison J., Lamoreus J. L., McKnight M., and Hedao P. 2002. *Terrestrial Ecoregions of the Indo Pacific:* A Conservation Assessment. Washington: Island Press

Wood, A., Stedman-Edwards, P. and Mang, J. (eds) 2000. *The Root Causes of Biodiversity Loss.* World Wildlife Fund and Earthscan Publications Ltd., London, UK.

WWF and ICIMOD, 2001. *Ecoregion based conservation in the eastern Himalaya*: Identifying important areas of biodiversity conservation. ICIMOD, Kathmandu.

Yonzon, P. 2005. Impacts of insurgency and conflict on Nepal's protected areas. Pp 354-357 In: Harmone, D. and Worboys, G. L. (eds). *Managing Mountain Protected Areas*: Challenges and Responses for the 21st. Century Andromeda Editrice, Italy.

Yonzone, R. *et al.* 2012. Ethnomedicinal plants of Darjeeling. Intl. Jour. Advances in Pharmaceutical Res. 3 (1): 713 – 729

Yonzone, R., Lama, D., Bhujel, R. B., Gogoi, K. and Rai S. 2012. Taxonomic assessment on the reported orchid species of Darjeeling district from flora of Bhutan, the Orchids of Bhutan - A review. Int. Jour. of Pharm. and Life Sci. 3: 1590-1606

Yonzone, R., Lama, D., Bhujel, R.B. and Rai, S. 2011. Epiphytic orchid species diversity of Darjeeling Himalaya of West Bengal, India. Asian J. Pharmacy Life Science 1 (4): 449-465

Yuming, Y., Kanglin, W., Shengji, P. and Jiming, H. 2004. *Bamboo Diversity and Traditional uses in Yunnan, China*. Mountain Res. Dev. 24:157-165.

Appendix- 1.1: List of Participants for National Consultation (Inception meeting) of technical working groups on, 'Khangchendzonga Landscape Conservation and Development Initiative in India' on 28-29 January 2014, Gangtok, Sikkim

Name and Address	Name and Address
Shri A. Zaidi Principal Chief Conservator of Forests Forest Department,Govt. of West Bengal, Kolkata - 700 098, West BengalIndia	Shri Pradeep Kumar Chief Wildlife Warden FEWMD, Government of Sikkim, Forest Secretariat, Deorali, Gangtok 737101, Sikkim, India
Shri S. B. S. Bhadauria Special PCCF & Project Director: JAICA FEWMD, Govt. of Sikkim, Forest Secretariat, Deorali, Gangtok 737101, Sikkim	Dr. Vipan K. Sood Chief Conservator of Forests Wildlife North, Forest Department, Govt of West Bengal, Siliguri, West Bengal
Dr. P. K. Mathur Sr. Professor & Scientist 'G' Landscape Level Planning and Management Department, Wildlife Institute of India, P.B.18, Chandrabani, Dehradun - 248 001, Uttarakhand	Shri J. B. Subba Director Khangchendzonga Biosphere Reserve, FEWMD, Govt. of Sikkim, Forest Secretariat, Deorali, Gangtok 737101, Sikkim
Dr. G. S. Rawat Deputy Programme Manager ECES (ICIMOD), G.P.O. Box 3226, Kathmandu, Nepal	Dr. Nakul Chettri Programme Coordinator (ICIMOD), P.O. Box 3226, Kathmandu, Nepal
Dr. Usha Lachugnpa PSO, Forests, Environment & Wildlife Management Department, Gov. of Sikkim	Mr Nawraj Pradhan Ecosystem Analyst (ICIMOD), P.O. Box 3226, Kathmandu, Nepal
Mr Sangay Gyatso Bhutia DFO cum Field Director Khangchendzonga National Park and BR FEWMD, Goverment of Sikkim	Shri Samuel Thomas Communication Manager ATREE Regional Office Darjeeling office, Darjeeling
Dr. Sunita Pradhan Eastern Himalaya Programme ATREE, Khangsar House, Above Brahmkumari Development Area, Gangtok 737101, Sikkim	Ms Priyadarshani Shrestha Officer in-charge World Wide Fund for Nature - India, Sikkim office Deorali, Gangtok, Sikkim 737 101
Dr. Ghanashyam Sharma Program Manager The Mountain Institute- India, Abhilasha, Development Area, Gangtok Sikkim-737101	Shri Roshan Rai Programme Officer Darjeeling Ladenla Road PRERNA, Hayden Hall Complex, 42 Ladenla Road, Darjeeling 734101, India
Shri Rajendra P Gurung CEO, ECOSS, J-155 Tayakhim, Daragaon, Tadong, Gangtok-737102, East Sikkim	Dr. B. S. Kholia Officer in-charge, Botanical Survey of India Gangtok, Sikkim 737 101
Shri Mika Lepcha Advisor, Mutanchi Lom Aal Shezom (Community based NGO), Namprikdang, PO Sankalang, Upper Dzongu North Sikkim, India	Shri Ugen Palzor Lepcha Executive Director, Mutanchi Lom Aal Shezom (Community based NGO), Namprikdang, PO Sankalang, Upper Dzongu, North Sikkim, India
Shri Vivek Chettri Programme manager Khangchendzonga Conservation Committee P.O. Yuksam, West Sikkim, 737113, India	Dr. R. S. Rawal Scientist F GBPIHED, Kosi, Katarmal, Almora 263643, Uttarakhand, India
Dr. H. K. Badola Scientist in-charge & Nodal Scientist: KLCDI (India) GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India	Dr. K. K. Singh Scientist- F GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India
Dr. S. C. Joshi Scientist -F GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India	Dr. Mithlesh Singh Scientist-C GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India

Shri Y. K. Rai Tech IV (3) GBPIHED,Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India	Shri L. K. Rai Tech IV (3) GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India
Dr. Kailash S. Gaira Project Site Manager (Global Pollination Project) GBPIHED, Sikkim Unit (Campus: Pangthang) Gangtok, Sikkim 737101, India	

Appendix 5A.1 Forest and vegetation types found in the KL-India region

Groups	**Characteristic Species**	**Altitude (m asl)**	**Typical Location**
1. Riverine Forests*			
Seral type of Khair-Sissoo association (5B/1S2)	*Acacia catechu, Dalbergia sissoo, Toona ciliata*, *Gmelina arborea*, *Bischofia javanica*, *Trewia nudiflora, Anthocephalous cadamba*	Foothills (<115 m)	North Sevoke, Ruyem
2. Savannah Forests*			
Moist Sal Savannah (3C/2S1)	*Emblica officinalis*, *Saccharum* sp., *Arundo donax, Phragmites karka, Imperata cylindrica, Themeda arundinacea*	Foothills (<115 m)	Samardanga
Low alluvium Savannah woodland (3C/1S1)	*Bombax ceiba, Albizia* sp., *Saccharum procerum, S. spontaneum, Themeda arundinacea, Imperata* sp.,	Foothills (<115 m amsl)	North Sevoke, Punding block
Eastern alluvial grassland (4D/2S2)	*Saccharum spontaneum, S. procerum, Erianthus arundinacea, Phragmitis karka*, *Arundo donax*, *Setaria* sp.	Foothills (<115 m amsl)	Torsa, Chilapata, Lankapara, Nilpara and Jaldapara Ranges
3. Sal Forests: Northern tropical moist deciduous forests*			
Eastern Bhabar (3C/C1b)			
a. East Himalayan lower Bhabar sub-type (3C/C1b-i) i. Bamba Sal ii. Sevoke Sal	i. *Schima wallichii, Hymenodictyon excelsum, Chukrassia tabularis, Garuga pinnata, Tetrameles nudiflora* ii. *Terminalia crenulata, Machilus gamblei, M. villosa, Cedrella toona, Chukrassia tabularis*	Foothills (<115 m amsl)	i. Gola, Gulma, Ghoramara, Champasari Upper, etc. ii. North, West and East Sevoke forest blocks
b. East Himalayan upper Bhabar sub-type (3C/C1b-ii)	*Dillenia pentagyna*, *Sterculia villosa*, *Careya arborea*, *Stereospermum tetragonum*, *Machilus villosa*, *Phoebe attenuata*, *Meliosma simplicifolia*	Foothills (<115 m amsl)	North Sevoke
Eastern Terai Sal (3C/C1c)	*Leea* sp., *Eupatorium odoratum, Acacia himalayana, Clerodendron viscosum, Butea parviflora, Bauhinia vahlii, Parthenocissus himalayana*	Foothills (<115 m amsl)	Silibhita forest block
Lower Hill Sal Forests (3C/C3b)			
Eastern Hill Sal	*Dillenia pentagyna*, *Careya arborea, Terminalia crenulata, Chikrassia tabularis*	Foothills (<115 m amsl)	Samardanga, Silibhita, Choklong, Jogi jhora, Gulma
Eastern Himalayan Sal	*Tertrameles nudiflora, Streculia villosa, Gmelina arborea, Duabanga sonneratioides, Acrocarpous fraxinifolius, Largerstroemia parviflora*	Foothills (<115 m amsl)	North and West Sevoke, Upper Champasari, Fanding
Khair-Sissoo Forests (5B/1S2)	*Toona ciliata*, *Gmelina arborea*, *Bischofia javanica*, *Trewia nudiflora, Anthocephalous cadamba*	Foothills (<115 m amsl)	Jaldhaka, part of Gorumara NP

Simul-Siris Forests (3C/1S1)	*Trewia nudiflora, Hymenodictyon excelsum, Adina cordifolia, Bischofia javanica, Lagerstroemia parviflora*, *Tetrameles nudiflora*	Foothills (<115 m amsl)	North Sevoke, Punding
Middle hill Forests (8B/C1)	*Schima wallichii, Castanopsis* sp.*, Talauma hodgsonii, Betula alnoides, Erythrina arborescens, Quercus* sp.*, Acrocarpus fraxinifolius, Phoebe attenuata*, *Engelhardtia spicata*	800-1500 m amsl	Kuhi, Latpanjer forest blocks
Semi-evergreen Forests: Eastern sub-montane semi-evergreen forests (2B/C1b)	*Litsaea monopetala, Macaranga denticulata, Leea asiatica, Ehretia acuminata, Mallotus philippinensis*	Foothills (<115 m amsl)	Dhupjhora, Indong, Medla, Barahati
Evergreen Forests: Northern Tropical Evergreen forests (1B/C1a)	*Shorea robusta, Dysoxylum* sp., *Stereospermum suaveolans*	Foothills (<115 m amsl)	Chilpata Range
4. Tropical Moist Deciduous Forest			
Tropical Moist Deciduous Forest	*Dillenia pentagyna, Dysoxylum floribundum, Gymnema arborea, Lagerostroemia parviflora, Shorea robusta, Toona ciliata*	250-900 m	Rangpo Chhu, Sirwani, Jorethang, Rangit
5. Sub-Tropical Forest			
i) Sub-Tropical Broad Leaved Forest	*Albizia procera, Alnus nepalensis, Bauhinia purpurea, Castanopsis indica, Macaranga denticulata, Michelia champaca,Schima wallichii*	1000-2000 m	Tong,Gyalzing, Sangklang Selem Chakung Chhu
ii) Sub-Tropical Pine forests	*Pinus roxburghii, Engelhardtia colebrookiana*	1000-1800 m	Gangtok, Gyalzing, Rongli
6. Montane Wet Temperate Forest			
i) Temperate Broad-leaved Forest	*Acer campbellii, Engelhardtia spicata, Machilus edulis, Michelia cathcartii, Quercus lamellosa, Taxus baccata*	1700-2700 m	Chungthang- Lachung, Yumthang
ii) Mixed Coniferous Temperate Forest	*Abies densa, Acer campbellii, Betula utilis, Rhododendron arboreum, Taxus baccata, Tsuga dumosa, Larix griffithiana*	2700-3000 m	Lachen, Zemu, Yathang, Lachung
7. Sub-Alpine Forest			
Sub-Alpine Forest	*Abies densa, Betula utilis, Cassiope fastigiata, Rhododendron* sp.	Above 3000 m	Above Yathang
a) Moist Sub-Alpine Forest			
i) Birch Rhododendron Scrub Forest	*Betula utilis, Sorbus foliolosa, Rhododendron campanulatum*	Above 3600 m	Thangu, Menmoitsho
ii) Deciduous Sub-Alpine Scrub	*Betula utilis, Berberis* sp.*, Lonicera* sp.*, Rosa* sp*,*	3600-3900 m	Changu Thangu
iii) Dwarf Rhododendron Scrub	*Rhododendron lepidotum*	Above 3600 m	Thangu
iv) Sub-Alpine pastures	*Allium* sp.*, Anemone* sp.*, Delphinium* sp.	Above 4000 m	Chopta Yumasamdong
b) Dry Sub-Alpine Scrub			
i) Dwarf Juniperus scrub	*Juniperus recurva, J. wallichiana*	Above 3600 m	Chopta Chhangu
ii) Dry Sub-Alpine scrub	*Ephedra gerardiana, Meconopsis* sp.*, Ribes* sp.	Above 4000 m	Chopta

* followed the Champion and Seth, 1968

Appendix5A.2: Diversity, distribution and conservation status of rhododendrons in protected areas of Khangchendzonga landscape in India

S. No	Species	Altitudinal range, Global (m)	Distribution in KL (India)	Status	Habitats and global distribution
1	*R. aeruginosum* Hook. f. Aeruginose Rhododendron N- Nilo-pate Chimal	4500-5000	Sikkim	Threatened	Shrub - open rocky places at Lachung and Yumthang in Northeast Sikkim.
2	*R. anthopogon* D. Don Bearded Rhododendron N- Dhupi Gurans	3000-5000	Sikkim	Threatened	Aromatic shrub, widely distribute; Kashmir, Nepal, Sikkim, Dzongri, Arunachal Pradesh and S.E. Tibet.
3.a	*R. arboreum* Smith Scarlet Arborescent Rhododendron N- Lali Gurans	1700-3400	Sikkim, Darjeeling	Vulnerable	Tree, Kashmir through Nepal, Sikkim, Darjeeling, Bhutan, Arunachal Pradesh, Burma and S.E. Tibet
3.b	*R. arboreum* Smith subsp. *Arboreum* Pradhan & Lachungpa, Sikkim Himal. Rhod.	2300-2600	Sikkim, Darjeeling	Common	Nepal, Sikkim, Bhutan, north and north-east India, China
3.c	*R. arboreum* Smith subsp. *Cinnamomeum* (Wallichi ex G. Don) Tagg, Sp. Rhod.	-	Sikkim, Darjeeling	Very common	Tree, Eastern Nepal, West Bengal (Darjeeling), Sikkim north-east India, China
3.d	*R. arboreum* subsp. *Delavayi* (Franch.) D.F. Chamberlain, in J.L. Luteyn, Contrib. Classif. Rhod.	2500-3200	Sikkim, Darjeeling	Vulnerable	Tree, Bhutan, north-east India, Myanmar, Thailand, Vietnam China.
4	*R. baileyi* Balf.f. Bailey's Rhododendron N- Bailey ko Chimal	3000-4800	Sikkim	Threatened	Terrestrial evergreen Shrub, distributed in Tibet, Bhutan and Sikkim.
5	*R. barbatum* Wall. ex G. Don. Bristly Rhododendron N- Lal-Chimal	3000-3700	Sikkim, Darjeeling	Out of danger	Tree, grows with *R. hogsonii* and other rhododendrons, from Kumaon through Nepal, Sikkim, Darjeeling, Bhutan and south Xizang
6	*R. camelliiflorum* Hook.f. Camellia-flowered Rhododendron N-Chia-phule Gurans	2500-3500	Sikkim	Out of danger	Straggly shrub, open rocky situations, from Pakistan through Western and Central Himalayas.
7	*R. campanulatum* D. Don Bell-flowered Rhododendron N- Nilo Chimal	3300-3500	Sikkim, Darjeeling	Out of danger	Shrub, Nepal, Sikkim, Darjeeling, Bhutan Arunachal Pradesh, Kashmir, south Xizang
8	*R. campylocarpum* Hook.f. Curve-fruited Rhododendron N - Bango-phale Gurans	3200-4000	Sikkim	Out of danger	Shrub, from Eastern Nepal through Sikkim, Darjeeling, Bhutan, Arunachal Pradesh and Burma
9	*R. ciliatum* Hook.f. Ciliated Rhododendron N - Junge Chimal	3000-3800	Sikkim	Threatened	Dwarf, Lithophytic shrub Marshy situations,; Lachung and Lachen in North-east Sikkim, Eastern Nepal through Sikkim and Bhutan
10	*R. cinnabarinum* Hook.f. Cinnabar Rhododendron N-Sano Chimal	1900-4000	Sikkim, Darjeeling	Out of danger	Branched shrub, mixed rhododendron forests in association with *R. thomsonii, R. campanulatum,* etc.; from Nepal, Sikkim, Bhutan, and Darjeeling

11	*R. dalhousiae* Hook.f. Lady Dalhousie's Rhododendron N - Laharey Chimal	2900-3600	Sikkim, Darjeeling	Out of danger	Epiphytic shrub, parasitical on trunks of *Michelia* and *Quercus*; Nepal, Sikkim, Darjeeling, Bhutan and Arunachal Pradesh
12	*R. decipiens* Lacaita Deceiving Rhododendron N- Jhukaune Korlinga	3100-3400	Sikkim, Darjeeling	Threatened	Medium tree, Singalila Ridge, Lachung Lachen, Darjeeling, Sikkim
13	*R. edgeworthii* Hook.f. Edgeworth's Rhododendron N- Edgeworth ko Chimal	2000-4000	Sikkim, Darjeeling	Out of danger	Epiphytic shrub, Sikkim, Darjeeling, Bhutan, S.E. Tibet, N.E. Burma, and Yunnan in China, Myanmar, north India
14	*R. falconeri* Hook.f. Dr. Falconer's Rhododendron N- Pahelo Ko+rlinga	2900-3500	Sikkim, Darjeeling	Threatened	Tree, Nepal, Sikkim, Darjeeling, Bhutan and Arunachal Pradesh.
15	*R. fulgens* Hook.f. Brilliant Rhododendron N-Chimal	4000-5000	Sikkim, Darjeeling	Rare	Small tree, Nepal through Sikkim and Bhutan, Assam. Charhatey, between Sandkphu-Sabargram
16	*R. glaucophyllum* Rehder Glaucous-leaved Rhododendron N - Takma Chimal	2700-4000	Sikkim	Out of danger	Shrub, prefer open rocky moss-covered ridges and undergrowths of *Abies densa*; Sikkim Himalaya: Lachung, Lachen and Chola; E. Nepal, Bhutan S.E. Tibet and Arunachal Pradesh.
17	*R. grande* Wt. Large Silvery Rhododendron N- Patle Korlinga	2300-2900	Sikkim, Darjeeling	Threatened	Tree, E. Nepal, Sikkim, Darjeeling and Bhutan, south-east China
18	*R. griffithianum* Wt. Lord Auckland's *Rhododendron* N - Seto Chimal	2000-3200	Sikkim	Out of danger	Small tree, oak forest, bamboo thickets; E. Nepal, Sikkim, Bhutan, S.E. Tibet and Arunachal Pradesh, Darjeeling, north India, south China
19	*R. hodgsonii* Hook.f. Hodgson's Rhododendron N- Gulabi Korlinga	3500-4000	Sikkim, Darjeeling	Out of danger	Branched Tree Nepal through Sikkim, Darjeeling and Bhutan, south China
20	*R. lanatum* Hook.f. Wooly Rhododendron N- Bhutle Gurans	4000	Sikkim	Out of danger	Small tree inhabits rocks and gulli in Nathula, Dzongri in Sikkim.
21	*R. lepidotum* Wall.ex. G. Don. Scaly Rhododendron N - Bhale Sunpate	2500-5000	Sikkim, Darjeeling	Out of danger	Resinous shrub, W. and Central Himalaya to S.W. China. Nepal, Darjeeling, Sikkim, Bhutan, north-east India, w. Sichuan, s. Xizang and north-west Yunnan
22	*R. leptocarpum* Nuttall Slender-fruited Rhododendron N - Jhinophale Gurans	3000-3500	Sikkim	Endangered	Epiphytic shrub, Choka village in Sikkim, Shingba and Tobrang in N. Bhutan, and Mande La and Sakden in E. Bhutan, S.E. Tibet, China, N.E. and Arunachal Pradesh.
23	*R. lindleyi* T. Moore Dr. Lindley's Rhododendron N-Sano Lahare Chimal	2000-3000	Sikkim, Darjeeling	Out of danger	Epiphytic shrub, Nepal, Sikkim, Bhutan, Manipur, Burma and S.E. Tibet, Darjeeling, Myanmar, south Xizang
24	*R. maddeni* Hook.f. Major Madden's Rhododendron N - Major Madden ko Chimal	2500-4000	Sikkim	Endangered	Shrub, Epiphytic on trees, very rare in thickets; Lachen, Lachung, Chungthang in Sikkim and Bhutan
25	*R. nivale* Hook.f.	4500-6000	Sikkim	Threatened	Cushion-like shrub, Odoriferous,

	Snow Rhododendron N- Hiun Gurans				western Nepal, through Sikkim and Bhutan
26	*R. niveum* Hook.f. Snow-leaved Rhododendron N - Hiun-pate Gurans	3100	Sikkim	Endangered	Rocky valleys and ridges growing; Yakchey in North Sikkim; endemic to Bhutan and Sikkim.
27	*R. pendulum* Hook.f. Pendulous Rhododendron N-Jhundinae Chimal	3300-4000	Sikkim	Rare	Epiphytic shrub in Abies forest; Lachung and Yumthang in North Sikkim
28	*R. pumilum* Hook.f. Dwarf Rhododendron N-Purke Gurans	3500-4500	Sikkim	Endangered	Faintly fragrant shrub, dwarf, grows in the alpine region, reported from E. Nepal, Sikkim and Bhutan.
29	*R. setosum* D. Don Bristly Rhododendron N- Tsallu Gurans	3000-5500	Sikkim	Threatened	Shrub, Highly aromatic, growing in association with other high altitude species like *R. nivale*, *R. lepidotum,* etc., distributed from Eastern Nepal, Sikkim and Bhutan.
30	*R. sikkimense* Pradhan and Lachungpa Sikkimese Rhododendron N-Sikkimae Gurans	3700	Sikkim	Endangered	Terrestrial shrub; Northeast Sikkim.
31	*R. thomsonii* Hook.f. Dr. Thomson's Rhododendron N - Dr. Thomson's ko Gurans	3300-4500	Sikkim	Vulnerable	Large shrub,; Nepal, Sikkim, Bhutan and Darjeeling.
32	*R. triflorum* Hook.f. Three-flowered Rhododendron N- Pahenle Chimal	2300-4000	Sikkim, Darjeeling	Threatened	Shrub inhabits. Nepal, Darjeeling, Sikkim, Bhutan, Assam, Arunachal Pradesh, Burma, south Xizang, Yunnan in China
33	*R. vaccinioides* Hook.f. Vaccinium-like Rhododendron N- Khiaune-pate Gurans	2400-3000	Sikkim, Darjeeling	Out of danger	Epiphytic shrub; Nepal, Sikkim,Darjeeling, Bhutan, S. Tibet to N. Burma, north-east India, south-east Xizang, Yunnan
34	*R. virgatum* Hook.f. Twiggy Rhododendron N- Hanginae Gurans	2500-3300	Sikkim	Out of danger	Erect twiggy shrub, Chungthang, Lachung and Lachen.
35	*R. wallichii* Hook.f. Dr. Wallich's Rhododendron N-Wallich ko Chimal	3500-5000	Sikkim, Darjeeling	Out of danger	Shrub; Lachung and Yumthang north Sikkim and distributed in Nepal, Bhutan, Assam, Darjeeling, north-east India,China
36	*R. wightii* Hook.f. Dr. Wight's Rhododendron N- Wight ko Gurans	3500-4500	Sikkim	Rare	Small tree, Nepal, Sikkim, Bhutan, and N. Burma.

[N – Vernacular names in Nepali]

Appendix 5A.3: A list of gymnosperms found in Khangchendzonga landscape, India

Sl No	Genus and Species	Family	Altitude (in m asl)	Distribution in KL, India
1.	*Abies densa* Griff.	Pinaceae	>3000	Sikkim, Darjeeling
2.	*Larix griffithiana Carriere*	Pinaceae	2400-3600	Sikkim
3.	*Picea spinulosa* (Griff.) Henry	Pinaceae	2400-3600	Sikkim
4.	*Pinus roxburghii* Sarg	Pinaceae	1000-2500	Sikkim, Darjeeling, Jalpaiguri
5.	*Tsuga dumosa* (D.Don) Eichler	Pinaceae	2400-3600	Sikkim

6.	*Cryptomeria japonica* (L.) D.Don	Taxodiaceae	1500-2500, cultivated	Sikkim, Darjeeling, Jalpaiguri
7.	*Taxodium distichum* (L.) Rich	Taxodiaceae	1200-1600, cultivated	Sikkim, Darjeeling, Jalpaiguri
8.	*Juniperus pseudosabina* Fischer and Meyer.	Cupressaceae	3500-4700	Sikkim
9.	*Juniperus recurva* D.Don	Cupressaceae	2900-4200	Sikkim, Darjeeling
10.	*Juniperus squamata* D.Don	Cupressaceae	3200-4700	Sikkim
11.	*Podocarpus neriifolius* D.Don	Podocarpaceae	40-1400	Jalpaiguri
12.	*Taxus wallichiana* (Zucc.) Pilger	Taxaceae	1800-3500	Sikkim, Darjeeling

Appendix-5A.4: Bamboos of Khangchendzonga landscape, India with their distribution within landscape

Scientific names of Bamboos	**Distribution**
Arundinaria recemosa	Sikkim, Darjeeling
Bambusa multiplex	Sikkim, Darjeeling, Jalpaiguri
Bambusa nutans	Common up to 1600m
Bambusa pallida	Sikkim, Darjeeling, Jalpaiguri
Bambusa tulda	Common up to 1500m
Bambusa vulgaris var. vittata	Sikkim, Darjeeling, Jalpaiguri
Bambusa vulgaris var. waminii	Sikkim, Darjeeling, Jalpaiguri
Dendrocalamus asper	Sikkim, Jalpaiguri
Dendrocalamus giganteus	Sikkim, Darjeeling
Dendrocalamus hamiltonii var. hamiltonii	Common up to 1500m
Dendrocalamus hamiltonii var. edulis	Common up to 1500m
Dendrocalamus hookeri	Sikkim, Darjeeling
Dendrocalamus patellaris	Common between 800-1500m
Dendrocalamus sikkimensis	Sikkim, Darjeeling
Dendrocalamus strictus	Sikkim, Darjeeling, Jalpaiguri
Melocanna baccifera	Sikkim, Darjeeling
Phyllostachys aurea	Sikkim, Darjeeling
Phyllostachys nigra	Sikkim, Darjeeling
Schizostachyum capitatum	Sikkim, Darjeeling
Schizostachyum dulloa	Sikkim, Darjeeling
Schizostachyum fuchsianum	Sikkim, Darjeeling
Schizostachyum polymorphum	Sikkim, Darjeeling
Schizostachyum sharmae	Sikkim, Darjeling
Sinarundinaria hookeriana	Common between 800-2000m
Sinarundinaria intermedia	Sikkim, Darjeeling
Sinarundinaria maling	All district above 1800m-3600m
Sinarundinaria microphylla	Sikkim, Darjeeling
Sinarundinaria pantlingii	Sikkim, Darjeeling
Sinarundinaria falconeri	Sikkim, Darjeeling
Thomnocalamus aristatus	Sikkim, Darjeeling

Based on: Tamang *et al.,* 2013

Appendix 5A.5: Fern diversity in the KL-India (**Source**: Kholia 2011)

Families	**Number of species**	**Number of sub-species**
Dryopteridaceae	155	7
Pteridaceae	72	7
Polypodiaceae	67	1
Thelypteridaceae	34	2
Aspleniaceae	24	2
Dennstaedtiaceae	17	-
Hymenophyllaceae	14	-
Davalliaceae	11	-
Vittariaceae	11	
Ophioglossaceae	9	-
Lomariopsidaceae	8	-
Cyatheaceae	6	-
Gleicheniaceae	4	-
Blechnaceae	3	-
Schizaeaceae	3	-
Grammitidaceae	2	-
Marattiaceae	2	-
Nephrolepidaceae	2	-
Oleandraceae	2	-
Osmundaceae	2	-
Plagiogyriaceae	2	-
Monachosoraceae	1	-
Total	451	19

Appendix 5A6: Ferns allies (Lycophyes) group of KL-India

Families	**Number of species**
Lycopodiaceae	11
Selaginellaceae	18
Equisetaceae	2
Total	31

Appendix- 5A.7: List of Genera and Species of fungi reported from Khangchendzonga Landscape, India

Genus	**Species**	**Habitat, Place and area (References)**
Agaricus L. ex Fr.	*A. exaltatus* Berk. *A. fulviceps* Berk. *A. silvaticus* Schaeff.	Clay earth banks, Darjeeling (a) Ground, Sikkim (a) Soil, Darjeeling (a)
*Amanita (*Pers. ex Fr.) S.F. Gray	*A. gemmata* (Fr.) Bertill. *A. muscaria* var. flavivolvata (Singer) Jenkins	Darjeeling (p) Darjeeling (p)
Amanitopsis Roze.	*A. berkeleyi* (Hook.f.) Sacc. *A. eriophora* (Berk.) Sacc. *A. regalis* (Berk.) Sacc.	Ground, Darjeeling (a) Ground, Darjeeling (a) Ground, Darjeeling (a)

*Armillaria (*Fr.) Quel	*A. adelpha* Berk. *A. dichupella* Berk. *A. duplicata* Berk *A. horrens* Berk. *A. mellea* Berk. *A. multicolor* Berk. *A. omnituens* Berk. *A. vara* Berk.	Dead wood, Darjeeling (a) Dead wood, Darjeeling (a) Dead wood, Darjeeling (a) Bark old tree, Darjeeling (a) Root *C. japonica*, Calimpong (b). Dead wood, Jalapahar (a) Dead wood, Darjeeling (a) Rotten timber, Sinchel (a)
Clitocybe (Fr.) Kummer	*C. incongrua* Berk. *C. laccata* (Scop) Sacc.	On the ground, Jalapahar (a) Pine wood, Sikkim (a)
Collybia (Fr.) Quel	*C. antitypha* Berk. *C. blandulq* Berk. *C. camptopoda* Berk. *C. dryophila* (Bull.) Fr. var. Caespitis Berk. *C. macera* Berk. *C. maculata* (Alb. & Schw.) Fr. *C. napipes* Hook.f. in Berk. *C. papaveracea* Berk. *C. podagrosa* Berk. *C. raphanipes* Berk. *C. rhodella* Berk. *C. stillaticia* Berk. *C. triplicata* Berk. *C. undabunda* Berk. *C. ustipes* Berk. *C. velutipes* (Curt.) Fr.	Pine wood, Sikkim (a) Wood, Darjeeling (a) Wood, Darjeeling (a) Amongst grass and moss, Lachen, (a) Ground in pine wood, Sikkim. (a) Pine wood, Lachen. (a) Ground, Darjeeling (a) Ground, Darjeeling (a) Clay banks, Sinchal. (a) Jalapahar, Darjeeling (a) Wood, Darjeeling (a) Dead, living tree, Jalapahar (a) Sikkim (a) Old timber wood, Darjeeling (a) Ground, Darjeeling (a) Dead wood, Darjeeling & Sikkim (a)
Coprinus (Pers. ex Fr.) S.F. Gray	*C. comatus* Fr. *C. disseminates* (Pers. ex Fr.) S.F.Grey *C .hookeri* Berk. *C. micaceous* (Bull.) Fr. *C. plicatilis* (Curt ex Fr.) Fr. *C. vellereus* Berk	Grassy land, Darjeeling (a) Forest floor, moist wall Darjeeling (o) Grassy place, Jalapahar (a) Rotten log, Darjeeling (o) Grassy meadow, Darjeeling (o) Dead wood & earth, Darjeeling (a)
Cortinarius S.F. Gray	*C. emodensis* Berk. *C. flameus* Berk. *C. saniosus* Fr. *C. vinosulus* Sacc.	Pine wood Lachen (a) Pine wood, Sikim (a) Pine wood, Sikim (a) Pine wood, Sikim (a)
Crepidotus (Fr.) Staude	*C. mollis* (Schaeff.) Staude *C. variabilis* (Pers.) P. Kumm.	P. Kumm. Darjeeling (p)
Entoloma (Fr.) Kummer	*E. cystopodium* Berk. *E. euthelum* Berk. *E. goliath* Hook.f.	On dead leaves, twig, Darjeeling (a) Pine wood, Sikkim (a) Wood, Darjeeling (a)
Flammula (Fr.) Kummer	*F. chrysomyces* Berk. *F. flavida* (Schaeff.) Fr. *F. macrophala* (Berk.) Sacc. *F. phelegmatica* Berk.	Dead wood, Darjeeling (a) Pine wood, Sikkim. (c) Tree trunk, Darjeeling (a) Pine wood, Sikkim (a)
Flammulina P. Karst.	*F. velutipes* (Curt. ex Fr.)	Sing Darjeeling (p)
Hygrophorus Fr. Kummer	*H. fulvus* Berk. *H. miniatus* Fr.	Pine wood, Sikkim (a) Pine wood, Lachen, Sikkim (a)
Hypholoma (Fr.) Quel	*H. atrichum* Berk. *H. castanophyllum* Berk. *H. condensum* Berk. *H. fasciculare* (Huds.) Fr. *H. hemisodes* Berk. *H. sublateritium* (Schaeff.) Fr. *H. velutinum* (Pers) Fr.	Dead timber, Darjeeling (a) Ground, Darjeeling (a) Ground, Darjeeling (a) Dead wood, Darjeeling (a) Earth Bank, Darjeeling (a) Dead wood, Darjeeling (a) Earthy bank, Darjeeling (a)

Laccaria Berk. & Br.	L. laccata (Scop.) Cooke.	Darjeeling (q)
Lactarius D.C. ex S.F. Gray	*L .deliciosus* (L.) Fr. *L. vellereus* Fr.	Lachen, Sikkim (e), Darjeeling (m) Fire wood, Sikkim (a), Darjeeling (m)
Lentinus Fr.	*L. coadunatus* Hook. f. *L. hepaticus* Berk. *L. hookerianus* Berk. *L. inquinans* Berk. *L. subdulcis* Berk. *L. tecomtei* Fr.	Dead wood, Darjeeling (a) Tree trunks, Darjeeling (a) Dead wood, Darjeeling (a) Dead wood, Sikkim (a) Dead wood, Darjeeling (a) Wood, Tonglo, Sikkim (a)
Lepiota (Pers. ex Fr.) S.F. Gray	*L. delicolum* Berk. *L. montosa* Berk.	Dead trees, Darjeeling (a) Ground, Sikkim (a)
Leucoagaricus Singer	*L. excoriatus* (Schaeff. ex Fr.) Singer.	Ground, Darjeeling (f)
Marasmius Fr.	*M. caperatus* Berk. *M. consocius* Berk. *M. erythropus* Fr. *M. hematodes* Berk. *M. irridescens* Berk. *M. rotula* (Scop ex Fr.) Fr.	Live & dead bush, Tonglo (a) Dead twig, Darjeeling (a) Ground, Darjeeling (a) Pine twig, Sikkim (a) Mossy bark, Sikkim (a) Leaves of maple & pine wood, Sikkim (a)
Mycena (Fr.) S.F. Gray,	*M. bicrenata* Berk. *M. broomiana* Berk. *M. colligata* Berk. *M. dentosa* Berk. *M. discors* Berk. *M. epipterygia* (Scop.) Fr. *M. flavo-miniata* Berk. *M. galericulata* (Scop.) Fr. *M. incommiscibilis* Berk. *M. manipularis* Berk. *M. myriadea* Berk. *M. nubigena* Berk. *M. prasia* Berk. *M. puberula* Berk. *M. pura* (Pers.) Fr. *M. rubiaetincta* Berk. *M. rufata* Berk. *M. rufo-picta* Berk. *M. russulina* Berk. *M. xanthophylla* Berk.	Roots of trees, Sikkim (a) Rotten wood, Jalapahar (a) Dead wood, Darjeeling (a) Pine wood, Sikkim (a) Pine wood, Sikkim (a) Pine wood, Sikkim (a) Pine wood, Sikkim (a) Pine wood, Sikkim (a) Pine wood, Sikkim (a) Trunk & stump, Sinchel (a) Dead trunk, Darjeeling (a) Old timber, Darjeeling (a) Ground, Tonglo (a) Pine wood, Sikkim (a). Pine wood, Sikkim (a), Darjeeling Tree bark, Darjeeling (a) Tree trunk, Darjeeling (a) Dead wood, Darjeeling (a) Tree trunk, Darjeeling (a) Tree roots, Darjeeling (a)
Naucoria Fr.	*N. descendens* Berk. *N. scrupea* Berk.	Pine wood, Sikkim (a) Moist earth, Darjeeling (a)
Omphalia (Fr.) Staude.	*O. radiatus* Berk. *O. ranunculina* Berk. *O. umbellifera* (L) Fr.	Pine wood, Sikkim (a) On Turf, Lahu, Sikkim (a) Pine wood, Sikkim (a)
Oudemansiella Speg.	*O. radicata* (Reih ex Fr.) Singer *O. mucida* (Schrd.) Hoehn.	Soil, Kurseong (g) Sikkim (l)
Panus Fr.	*P. conchatus* Fr. *P. monticola* Berk.	Darjeeling (a) Ground, Tonglo (a)
Paxillus Fr.	*P. chrysites* Berk. *P. pinguis* Hook.f. *P. sulphureus* Berk.	Dead wood, Darjeeling (a) Earth & mossy banks, Darjeeling (a) Dead wood & Ground, Darjeeling (a)
Peniophora Cooke	*Peniophora* sp.	Ground, Sikkim (h)
Pholiota (Fr.) Kummer	*P. aurivella* (Batsch.) Fr. *P. examinans* Berk. *P. microspora* Berk.	Tree stump, Darjeeling (a) Dead wood, Darjeeling. (a) Dead wood, Darjeeling (a)
Pleurotus (Fr.)	*P. anserinus* Berk.	Dead wood, Darjeeling. (a)

Kummer	*P. eous* Berk. *P. hapalosclerus* Berk. *P. himalayensis* Thind & Waraitch. *P. ninguidus* Berk. *P. placentodes* Berk. *P. salignus* (Pers.) Fr. *P. verrucarius* Berk.	Dead tree trunk, Sikkim (a) Tree trunk, Darjeeling (a) Burnt wood & Soil, Darjeeling (i) Dead timber, Sikkim (a) Birch wood, Sikkim (a) Sikkim (a) Dead wood, Darjeeling (a)
Pluteus Fr.	*P. chrysoprasius* Berk. *P. plumbinus* Berk.	Burnt wood of Abies, Sikkim (a) Living tree trunk, Darjeeling. (a)
Psathyra (Fr.) Quel	*P. clavescens* Berk. *P. flavo-grisea* Berk. *P. nassa* Berk.	Mossy earth, Darjeeling (a) Dead wood, Darjeeling (a) Dead wood, Darjeeling (a)
Psathyrella (Fr.) Quel	*P. discolor* Berk.	Dead timber & ground, Darjeeling (a)
Psilocybe (Fr.) P. Kumm.	*P. caespiticia* Berk.	Clay banks, Darjeeling (a)
Russula Pers.ex S.F. Gray	*R. cinnabaarina* Hook.f. *R. emetica* Fr. *R. furcata* Fr. *R. grossa* Berk. *R. lepida* Fr. *R. ochroleuca* Pers. ex Fr. *R.rosacea* Fr. *R. sororia* (Fr.) Romell. *R. xerampelina* Fr.	Clay bank, Darjeeling (a) Clay bank, Darjeeling (a) Clay bank, Sinchel, (a) Darjeeling (a) Clay bank, Darjeeling (a) Forest floor, Darjeeling (n) Pine wood, Lachen, Sikkim. (j) Forest floor, Darjeeling (n) Forest floor, Darjeeling (n
Schizophyllum Fr.	*S. commune* Fr.	Dead wood, Darjeeling (a)
Stereogloeocystidium Rick	*S. spadiceum* (Fr.) Rick	Dead wood, Darjeeling (f)
Stropharia (Fr.) Quel.	*S. aureo-fulva* Berk.	Dead wood, Jalapahar (a)
Tricholoma (Fr.) Quel.	*T. cremoriceps* Berk	Tree trunk, Darjeeling (a)
Tricholomopsis Singer	*T. rutilans* (Schaeff ex Fr.) Singh	Humicolous soil, Darjeeling (k)
Volvaria (Fr.) P. Kumm.	*V. thwaitesii* Hook. f.	Dead wood, Darjeeling (a)
Xerotus Hill ex Grev.	X. cantharelloides Berk.	Dead wood, Jalapahar (a)

Based on: (a) Berkeley, M.J. (1856); (b) Bakshi, B.K. et al., (1972); (c) Banerjee, S.N. (1947); (d) Massee, G. (1912); (e) Butler, E.J. and Bisby, G.R. (1931); (f) Ramakrishnan, K. and Sundaram, N.V. (1952); (g) Ghosh, R.N. et al., (1967); (h) Banerjee, S.N. (1948); (i) Thind, K.S. and Waraitch, K.S. (1971); (j) Mundkur, B.B. (1938); (k) Sarwal, B.M. (1984); (l) Rai et al., (2007); (m) Acharya et al ., (2004a); (n) Acharya et al., (2004b); (o) Rai et al., (2005); (p) Acharya and Rai, (2003); (q) Rai and Acharya, (2006) [Source: Acharya et al. 2010]

Appendix 5A.8 : Faunal elements in different protected areas of Khangchendzonga landscape, India

S. No.	Protected Area	Mammals	Birds	Butterflies	Reptiles	Fishes
1.	Khangchendzonga Biosphere Reserve	47	204	190		
2.	Barsey Rhododendron Sanctuary	23	113			
3.	Fambong Lho Wildlife Sanctuary	23	139			
4.	Kyongnosla Alpine Sanctuary	21	27			
5.	Mainam Wildlife Sanctuary	NA	NA			
6.	Singhba Rhododendron Sanctuary	NA	100			
7.	Pangolakha Wildlife Sanctuary	37	40			
8.	Kitam Bird Sanctuary	NA	165			
9.	Jore Pokhari Salamander Sanctuary	NA	NA			
10.	Singhalila National Park	26	156			
11.	Senchal Wildlife Sanctuary	22	142			
12.	Mahananda Wildlife Sanctuary	70	215	17	11	
13	Neora Valley National Park	31	85	161	59	13
14.	Buxa Tiger Reserve	68	246		41	33
15.	Jaldapara National Park	33	246		29	54
16.	Chapramari Wildlife Sanctuary	NA	NA			
17.	Gorumara National Park	48	193		36	50

Acharya *et al.,* 2010; Chettri 2000; Basnet and Badola, 2012; ICIMOD 2014; Department of Forest, West Bengal 2014; Sengupta *et al.,* 2014

Appendix-5A.9: Mammal species of Khangchendzonga landscape, India

S. No	Species	Common Name	Family
1.	*Ailurus fulgens* Cuiver	Red Panda	Ursidae
2.	*Alticola stracheyi* (Thomas)	None	Hystricidae
3.	*Amblonyx cinereus* (Illiger)	Small-clawed Otter	Mustelidae
4.	*Arctictis biturong* (Raffles)	Binturong	Viverridae
5.	*Arctonyx collaris* Cuvier	Hog-Badger	Mustelidae
6.	*Arctonyx eol/aris*	Hog badger	Mustelidae
7.	*Areilulus circumdatus* (Temminck)	Large Black Pipistrelle	Vespertilionidae
8.	*Axis axis* (Erxleben)	Spotted Deer Spotted	Cervidae
9.	*Axis porcinus*	Hog deer	Cervidae
10.	*Bandicota indica nemorivaga* (Hodgson)	Large bandicoot Rat	Hystricidae
11.	*Barbastella leucomelas* (Cretzschmar)	Eastern Barbastella	Vespertilionidae
12.	*Belomys pearsoni* (Gray)	Hairy-footed Flying Squirrel	Sciuridae
13.	*Bos gaurus*	Indian Bison	Bovidae
14.	*Bos grunniens* Linnaeus	Yak	Bovidae
15.	*Callosciurus caniceps crumpi* Wroughton	Golden backed Squirrel	Sciuridae
16.	*Callosciurus pygerythrus lokroides* (Hodgson)	Hoary-bellied Himalayan Squirrel	Sciuridae
17.	*Canis aureus* Linnaeus	Asiatic Jackal	Canidae
18.	*Canis lupus* Linnaeus	Wolf	Canidae

19.	*Caprolagus hispidus*	Hispid hare	Leporidae
20.	*Catopuma temminckii* (Vigors & Horsfield) *Felis temmincki, Pardofelis temmincki*	Golden Cat	Felidae
21.	*Cervus unicolor*	Sambar	Cervidae
22.	*Chimarrogale himalayica* (Gray)	Himalayan Water Shrew	Soricidae
23.	*Crocidura attenuata* Milne-Edwards	Gray Shrew	Soricidae
24.	*Cuon alpinus primaevus* (hodgson)	Indian Wild Dog	Canidae
25.	*Cynopterus sphinx* (Vahl)	Short-nosed Fruit Bat	Pteropodidae
26.	*Dremomys lokriah lokriah* (Hodgson)	Orange-bellied Himalayan Squirrel	Sciuridae
27.	*E/ephas maximus*	Indian EIephant	Elephantidae
28.	*Eonycteri's spelaea* (Dobson)	Dobson's Long-tongued Fruit Bat	Pteropodidae
29.	*Equis kiang* Moorcroft	Kiang	Equidae
30.	*Eupetaurus cinereus* Thomas	Wolly Flying Squirrel	Sciuridae
31.	*Euroscaptor micrura* (Hodgson)	Eastern Mole	Talpidae
32.	*Felis chaus* Schreber	Jungle Cat	Felidae
33.	*Funambulus pennanti*	Five stripped squirreI	Sciuridae
34.	*Harpiocephalus harpia lasyurus* (Hodgson)	Hairy-winged Bat	Vespertilionidae
35.	*Hemitragus jemlahicus* (Smith)	Himalayan Tahr	Bovidae
36.	*Herpestes auropunctatus*	Small Indian Mongoose	Herpestidae
37.	*Herpestes edwardsi*	Common Mongoose	Herpestidae
38.	*Hipposideros armiger* (Hodgson)	Greater Himalayan Leaf-nosed Bat	Rhinolophidae
39.	*Hipposideros pomoa* Anderson	Anderson's Leaf-nosed Bat	Rhinolophidae
40.	*Hylopetes alboniger alboniger* (Hodgson)	Parti-coloured Flying Squirrel	Sciuridae
41.	*Hystrix brachyura* Linnaeus	Himalayan Crestless Porcupine	Hystricidae
42.	*Hystrix indica*	Indian porcupine	Hystricidae
43.	*Kerivoula picta* (Pallas)	Painted Bat	Vespertilionidae
44.	*Leopoldamys edwardsi* (Thomas)	Edward's Rat	Hystricidae
45.	*Lepus nigricollis ruficaudatus* Geoffroy	Rufous -tailed Hare, Smooth Indian hare	Leporidae
46.	*Lepus oiostolus* Hodgson	Wolly Hare	
47.	*Lutra lutra* (Linnaeus)	Common Otter	Mustelidae
48.	*Lutra perspicillata*	Smooth Indian Otter	Mustelidae
49.	*Macaca assamensis pelops* Hodgson	Assamese Macaque	Cercopithecidae
50.	*Macaca mulata*	Monkeys (Rhesus macaque)	Ceropithecidae
51.	*Macroglossus sobrinus* Anderson	Hill Long-tongued Fruit Bat	Pteropodidae
52.	*Manis crassicaudata*	Pangolin	Manidae
53.	*Manis pentadactyla* Linnaeus	Chinese Pangolin	Manidae
54.	*Marmota himalayana* (Hodgson)	Himalayan Marmot	Sciuridae
55.	*Martes flavigula* (Boddaert)	Yellow-throated Marten	Mustelidae
56.	*Me/ursus ursinus*	Sloth bear	Ursidae
57.	*Microtus sikimensis* (Hodgson)	Sikkim Vole	Hystricidae
58.	*Moschus chrysogaster* Hodgson	Musk deer	Moschidae

59.	*Moschus fuscus* Li	Alpine Musk Deer, Black Musk Deer	Moschidae
60.	*Muntiacus muntjac* (Zimmerman)	Barking Deer	Cervidae
61.	*Murina aurata* Milne Edwards	Little Tube-nosed Bat	Vespertilionidae
62.	*Murina cylotis* Dobson	Round-eared Tube-nosed Bat	Vespertilionidae
63.	*Murina tubinaris* (Scully)	Scully's Tube-nosed Bat	Vespertilionidae
64.	*Mus booduga*	Indian field mouse	Muridae
65.	*Mus cervicolor* Hodgson	Fawn-coloured Mouse	Hystricidae
66.	*Mus musculus castaneus* Waterhouse	House Mouse	Hystricidae
67.	*Mus musculus homourus* Hodgson	House Mouse	Hystricidae
68.	*Mus pahari pahari* Thomas	Sikkim Mouse	Hystricidae
69.	*Mustela altaica* Pallas	Mountain Weasel	Mustelidae
70.	*Mustela sibirica* Pallas	Himalayan Weasel	Mustelidae
71.	*Mustela kathia* Hodgson	Yellow-bellied Weasel	Mustelidae
72.	*Mustela strigidorsa* Gray	Back-striped Weasel	Mustelidae
73.	*Mutiaeus muntjak*	Barking deer/Muntjac	Cervidae
74.	*Myotis muricola* (Gray)	None	Vespertilionidae
75.	*Myotis sicarius* Thomas	None Mandelli's Mouse eard Bat	Vespertilionidae
76.	*Myotis siligorensis* (Horsfield)	Himalayan Whiskered Bat	Vespertilionidae
77.	*Myotisformosus* (Hodgson)	Hodgson's Bat	Vespertilionidae
78.	*Nectogale elegans* Milne-Edwards	Szechuan Water Shrew	Soricidae
79.	*Nemorhaedus goral hodgsoni* Pocock	Goral	Bovidae
80.	*Nemorhaedus sumatraensis* (Bechstein)	Serow, Mainland Serow	Bovidae
81.	*Neofelis nebulosa* (Griffith)	Clouded Leopard	Felidae
82.	*Niviventer eha* (Wroughton)	Little Himalayan Rat	Hystricidae
83.	*Niviventer eha eha* (Wroughton)	Little Himalayan Rat	Hystricidae
84.	*Niviventer fulvescens fulvescens* (Gray)	Chestnut Rat	Hystricidae
85.	*Niviventer niviventer* (Hodgson)	Himalayan White-bellied Rat	Hystricidae
86.	*Niviventer niviventer lepcha* (Wroughton)	White-bellied Rat	Hystricidae
87.	*Nyctalus noctula* (Schreber)	Noctula Bat	Vespertilionidae
88.	*Ochotona curzoniae* (Hodgson)	Black-lipped Pika, Platue Pika	Ochotonidae
89.	*Ochotona forresti* Thomas	Forrest's Pika	Ochotonidae
90.	*Ochotona macrotis* (Gunther)	Large-eared Pika	Ochotonidae
91.	*Ochotona nubrica* Thomas	Nubra Pika	Ochotonidae
92.	*Ochotona roylei* (Ogilby)	Royle's Pika	Ochotonidae
93.	*Ochotona thibetana sikimaria* Thomas	Moupin Pika	Ochotonidae
94.	*Otocolobus manul* (Pallas)	Palla's Cat	Felidae
95.	*Ovis ammon hodgsoni* Blyth	Nayan or Argali	Bovidae
96.	*Paguma larvata* (Hamilton-Smith)	Himalayan Palm Civet	Viverridae
97.	*Panthera pardus* (Linnaeus)	Common Leopard, Leopard	Felidae
98.	*Panthera tigris*	Royal Bengal Tiger	Felidae
99.	*Pardofelis marmorata* (Martin)	Marbled Cat	Felidae
100.	*Petaurista elegans* (Muller)	Lesser Giant Flying Squirrel	Sciuridae
101.	*Petaurista magnificus magnificus* (Hodgson)	Hodgson's Giant Flying Squirrel	Sciuridae

102.	*Petaurista nobilis nobilis* (Gray)	Gray's Giant Flying Squirrel	Sciuridae
103.	*Pipistrellus babu* Thomas	Babu's Pipistrelle	Vespertilionidae
104.	*Pipistrellus coromandra* (Gray)	Indian Pipistrelle	Vespertilionidae
105.	*Pipistrellus javanicus* Gray	Javan Pipistrelle	Vespertilionidae
106.	*Pitymys sikimensis* (Hodgson)	Sikkim Vole	Hystricidae
107.	*Plecotus auritus* (Linnaeus)	Brown Big-eared Bat	Vespertilionidae
108.	*Prionailurus bengalensis* (Kerr)	Leopard Cat	Felidae
109.	*Prionodon pardicolor*	Spotted Linnsang	Viverridae
110.	*Procapra picticaudata* Hodgson	Tibetan Gazelle	Bovidae
111.	*Pseudois nayaur nayaur* (Hodgson)	Baharal	Bovidae
112.	*Pteropus giganteus* Brunnich	Indian Flying Fox	Pteropodidae
113.	*Rattus turkestanicus* (Satunin)	Turkestan Rat	Hystricidae
114.	*Rattus nitidus nitidus* (Hodgson)	Himalayan Rat	Hystricidae
115.	*Rattus rattus brunneusculus* (Hodgson)	Hodgson's House Rat, Common houserat	Hystricidae, Muridae
116.	*Rattus rattus tistae* Hinton	Hinton's House Rat	Hystricidae
117.	*Rattus sikkimensis* Hinton	Sikkim Rat	Hystricidae
118.	*Rattus tanezumi* Tem minck	None	Hystricidae
119.	*Ratufa bicolor gigantea* (M'Clelland)	Malayan Giant Squirrel	Sciuridae
120.	*Rhinoceros unicornis*	One homed rhinoceros	Rhinoceritidae
121.	*Rhinolophus ferrymequinum* (Schreber)	Greater Horse-shoe Bat	Rhinolophidae
122.	*Rhinolophus luctus* Teminck	Wolly Horse-shoe Bat	Rhinolophidae
123.	*Rhinolophus pearsoni* Horsfield	Pearson's Horse-shoe Bat	Rhinolophidae
124.	*Rhinolophus rouxi* Temminck	Rufous Horse-shoe Bat	Rhinolophidae
125.	*Rhinolphus sinicus* (Anderson)		Rhinolophidae
126.	*Rousettus leschenaulti* (Desmarest)	Indian Fulvous Fruit Bat	Pteropodidae
127.	*Scotomanes ornatus* (Blyth)	Harlaquin Bat	Vespertilionidae
128.	*Scotophilus heathi*	Common yellow bat	Vespertilionidae
129.	*Semnopithecus entellus schistaceus* (Hodgson)	Hanuman Langur, Central Himalayan langur	Cercopithecidae
130.	*Soriculus caudatus* (Horsfield)	Hodgson's Brown-toothed Shrew	Soricidae
131.	*Soriculus leucops* (Horsfield)	Indian Long-tailed Shrew	Soricidae
132.	*Soriculus macrurus* Blandford	Indian Long-toothed Shrew	Soricidae
133.	*Soriculus nigrescens* (Gray)	Sikkim Large-Clawed Shrew	Soricidae
134.	*Sphaerias blanfordi* (Thomas)	Blanford's Fruit Bat	Pteropodidae
135.	*Suncus murinus soccatus*	House Shrew	Soricidae
136.	*Sus scrofa*	Wild boar	Suidae
137.	*Sus salvanius* (Hodgson)	Pygmy Hog	Suidae
138.	*Tamiops macclellandi* (Horsfield)	Himalayan Stripped Squirrel	Sciuridae
139.	*Taphozous nudiventris kachhensis* Dobson	Naked-bellied Tomb Bat	Emballonuridae
140.	*Tupaia belangeri* (Wagner)	Common Tree Shrew	Tupaiidae
141.	*Tylonycteris pachypus* (Temminck)	Bamboo Bat	Vespertilionidae
142.	*Uncia uncia* (Schreber)	Snow Leopard	Felidae

143.	*Ursus thibetanus* Cuvier	Asiatic Black Bear	Ursidae
144.	*Viuerricula indica*	Small omdoam Civet	Viverridae
145.	*Viverra zibetha* Linnaeus	Large Indian Civet	Viverridae
146.	*Vulpes bengalensis*	Indian Fox	Canide
147.	*Vulpes vulpes montana* (Pearson)	Himalayan Red Fox	Canidae

Appendix-5A.10: Fishes of Khangchendzonga landscape, India

S. No	Species	Common Name	S. No	Species	Common Name
1	*Aborichthyes elongatus*	Wedge tail loach	**2**	*Acanthocobitis botia*	Leopard loach
3	*Acanthophthamus pangia*	Not Known	**4**	*Alia coila*	Baspata, Gangetic ailia
5	*Amblyceps mangois*	Scissor tail catfish	**6**	*Amblyceps mangois*	Scissor tail catfish
7	*Amblyceps mangois*	Scissor tail catfish	**8**	*Amblyceps mangois*	Scissor tail catfish
9	*Amblypharyngodon microlepis*	Mourala (Variety)	**10**	*Amblypharyngodon mola*	Maurala
11	*Amphipnous cuchia*	Koochia	**12**	*Anabus testudineus*	Koi
13	*Anguilla bengalensis*	Rajabam	**14**	*Anguilla bengalensis*	Rajabam
15	*Aspidoparia jaya*		**16**	*Aspidoparia morar*	Carplet
17	*Babbus mosal*	Red finned Mahseer	**18**	*Badis badis*	
19	*Bagarius bagarius*	Gonch, Bagara	**20**	*Bagarius yarrelli*	
21	*Balitora brucei*	Titay, Tita-kabri, Gray's stone loach	**22**	*Bangana dero*	
23	*Barbus dukai*	Valo,Bholuk	**24**	*Barbus putitoora*	Mahseer, Golden Himayalan Mahseer
25	*Barilius barila*	Boraly, Barred baril	**26**	*Barilius barila*	Barred baril
27	*Barilius barna*	Chhipra, Barna baril	**28**	*Barilius bendelisis*	Khasray, Jay
29	*Barilius bendelisis*	Khasray	**30**	*Barilius bendelisis chedra*	Chaley
31	*Barilius shacra*	Shacra baril	**32**	*Barilius shaera*	Koksha
33	*Barilius tileo*	Tileo baril	**34**	*Barilius vagra*	Chirkay ,Koksa (Variety)
35	*Barilius vagra*	Chirkay ,Koksa (Variety)	**36**	*Batasio batasio*	Tista batasio
37	*Batasio tengana*		**38**	*Botia derio*	
39	*Botia lohachata*	Y-loach	**40**	*Botia rostrata*	
41	*Brachydanio rerio*		**42**	*Catla catla*	Katla
43	*Catla eatla*	Katla	**44**	*Canthophrys gongota*	Jaguar loach
45	*Caraglanis Kishinouvei*	Kimura's Goonh	**46**	*Chaca chaca*	
47	*Chagnnius chaguneo*	Darangi, Chaguni	**48**	*Chanda nama*	
49	*Chanda ranga*		**50**	*Channa gachua*	Cheng
51	*Channa marulius*	Murrel, Sal / Gajari	**52**	*Channa orientalis*	Hilay
53	*Channa punctatus*	Lata, Lasa Taki	**54**	*Channa stewartii*	
55	*Channa striata*		**56**	*Channa striatus*	Shol
57	*Chela baeaila*	Chela	**58**	*Chela laubuca*	
59	*Cirrhina reba*	Raicheng	**60**	*Clarius batrachus*	Magur
61	*Clupisoma bhandari*	Jalkapur	**62**	*Clupisoma garua*	Garua bacha
63	*Clupisoma montana*	Kocha garua	**64**	*Colisa chuna*	
65	*Colisa fasciata*		**66**	*Colisa lalia*	
67	*Crossocheilus latius latius*	Lohori Buduna, Gangetic latia	**68**	*Crossocheilus latius latius*	Lohori Buduna, Gangetic latia

69	*Cyprinion semiplotum*	Assamese kingfish	**70**	*Danio aequipinnatus*	Bhitti, Chhebly
71	*Danio dangila*	Nipati	**72**	*Danio dangila, D.aeguipinnatus & D.rerio*	Elanga
73	*Danio devario*	Laupati (Mech)	**74**	*Danio naganensis*	Bhitti
75	*Danio rerio*	Anju	**76**	*Devario acuticephala*	
77	*Devario aequipinnatus*	Giant danio	**78**	*Devario devario*	*Sind danio*
79	*Doryichthys deocata*	Pipe Fish	**80**	*Esomus danricus*	Darica
81	*Euchiloglansis hodgarti*	Lulay	**82**	*Eutropiichthys vacha*	Bacha
83	*Gagata cenia*	Clown catfish	**84**	*Gagata cenis*	
85	*Garra annandalei*	Lulay	**86**	*Garra gotyla*	Kusuma
87	*Garra gotyla gotyla*	Nakkatua Buduna, Sucker head	**88**	*Garra gotyla stenorhynchus*	Buduna
89	*Garra lamta*	Buduna, Lamta Garra	**90**	*Garra mcclellandi*	Buduna
91	*Garra mullya*	Buduna	**92**	*Glossogobius giuris*	
93	*Glyptothorax basnetti*	Dhodray	**94**	*Glyptothorax bhutiai*	Kanray
95	*Glyptothorax cavia*	Banded torrent catfish	**96**	*Glyptothorax conirostris*	Kanray, Torrent catfish
97	*Glyptothorax deyi*	Kanray	**98**	*Glyptothorax gracilis*	Kanray
99	*Glyptothorax indicus*		**100**	*Glyptothorax pectinopterus*	River cat
101	*Glyptothorax sinense manipurensis*	Kanray	**102**	*Glyptothorax telchitta*	
103	*Glyptothorax trilineatus*	Kanray	**104**	*Gogangra viridescens*	Huddah nangra
105	*Hara hara*		**106**	*Hara horai*	
107	*Heteropneustes fossilis*	Singi	**108**	*Labeo angra*	
109	*Labeo angra and Labeo gonius*	Kursha (Chandan and Pani)	**110**	*Labeo boga*	Boga labeo
111	*Labeo calbasu*	Kalbose	**112**	*Labeo dero*	Gardi, Korusa, Kalabans
113	*Labeo dyocheilus*	Brahmaputra labeo	**114**	*Labeo ealbusa*	Kalbus
115	*Labeo pangusia*	Theyr, Denkara	**116**	*Laguvia riberio jorethanensis*	Gona Machha
117	*Laguvia riberio riberio*	Gona Machha	**118**	*Labeo rohita*	Rohu
119	*Lepidocephalichthys annandalei*	Poia	**120**	*Lepidocephalichthys berdmorei*	
121	*Lepidocephalichthys gangota*	Gutum / Poia	**122**	*Lepidocephalichthys guntea*	*Guntea loach*
123	*Lepidocephalus thermalis*		**124**	*Macrognathus aral*	
125	*Macrognathus pancalus*		**126**	*Mastacembelus armatus*	Baim
127	*Mastacembelus pancalus*	Turi or Pakal	**128**	*Mastacembelus pankala*	Pankal
129	*Mastaeembelus paneaus*	Pakal	**130**	*Monopterus cuchia*	Kuchia
131	*Monopterus hodgarti*		**132**	*Mystus bleekeri*	
133	*Mystus menoda*	Khorsola	**134**	*Mystus seenghala*	Tengra
135	*Mystus tengara*		**136**	*Nandus nandas*	Bheda
137	*Nemacheilus beavani*		**138**	*Nemacheilus botia aureus*	Mottled loach
139	*Nemacheilus devdevi*	Olivaceous loach	**140**	*Nemacheilus multifasciatus*	Many banded loach
141	*Nemachelus savona*	Loach	**142**	*Neolissochilus hexagonolepis*	Katley, Copper mahseer
143	*Neolissochilus hexastichus*	*boker*	**144**	*Noemacheilus beavani*	Gadela
145	*Noemacheilus carletoni*	Gadela	**146**	*Noemacheilus corica*	Gadela
147	*Noemacheilus devdevi*	Gadela	**148**	*Noemacheilus kangjupkhulensis*	Gadela
149	*Noemacheilus*	Gadela	**150**	*Noemacheilus rupicola*	Ingilis's Loach

	multifasciatus			var inglist	
151	*Noemacheilus scaturigina*	Gadela	**152**	*Noemacheilus sikkimensis*	Gadela
153	*Noemacheilus spilopterus*	Gadela	**154**	*Notopterus chitala*	Chital
155	*Notopterus notopterus*	Moh	**156**	*Olyra kempi*	
157	*Olyra longicaudata*	Himalayan olyra	**158**	*Ompok pabda*	Pabda
159	*Oreinus plagiostomus*	Ingilis's Loach	**160**	*Oxygaster gora/ Chela bacaila*	Chela
161	*Pangasius pangasius*	Not known	**162**	*Pangio pangia*	Coolie loach
163	*Parachiloglanis hodgarti*	Torrent Catfish	**164**	*Parambassis lala*	
165	*Parambassis ranga*		**166**	*Pethia phutunio*	
167	*Pethia ticto*		**168**	*Pseudecheneis sulcata*	
169	*Psedudecheneis sulcatus*	Kabrey, Sucker throat catfish	**170**	*Pseudeutropius atherinoidea*	Batasi
171	*Pseudolaguvia foveolata*		**172**	*Pseudolaguvia ribeiroi*	
173	*Pseudolaguvia shawi*	Cheetah catfish	**174**	*Psilorhynchus balitora*	Balitora minnow
175	*Psilorhynchus pseudoechesis*	Tatati	**176**	*Psilorhynchus sucatio*	River stone carp
177	*Puntius chola*	Chola Punti	**178**	*Puntius conchonius*	Kanchan Punti, Rosy barb
179	*Puntius gelius*	Golden dwarf barb	**180**	*Puntius n.sp*	Punti
181	*Puntius phutunio*		**182**	*Puntius sarana*	
183	*Puntius sophore*		**184**	*Puntius terio*	
185	*Puntius ticto*	Puti, Ticto barb	**186**	*Raiamas bola*	Indian trout
187	*Rasbora daniconius*	Dankoni, Danrika	**188**	*Rasbora rasbora*	
189	*Salmo spp*	Salmonfish	**190**	*Salmo trutta fario*	Kashmiri macha
191	*Salmophasia bacaila*	Large razor belly minnow	**192**	*Salmophasia phulo*	
193	*Salmostoma bacalia*		**194**	*Schistura beavani*	Creek loach
195	*Schistura corica*		**196**	*Schistura devdevi*	
197	*Schistura rupicola*	Banded loach	**198**	*Schistura savona*	
199	*Schistura scaturigina*	Victory loach	**200**	*Schizopyge progastus*	Chuchay Asala, Point nosed snow trout
201	*Schizothroraichthys progastus*	Snow-trout	**202**	*Schizothorax richardsonii*	Dothey Asala, Blunt, nosed snow trout
203	*Semiplotus semiplotus*	Chepti	**204**	*Setniplotus semiplotus*	Chepti (Badangi)
205	*Sisor rhabdophorus*	Whiptail Catfish	**206**	*Somileptes gangota*	Gharpoa
207	*Tetraodon cutcutia*	Tepa	**208**	*Tor putitora*	Mahseer, Golden mahseer
209	*Tor tor*	*Turia mahseer*	**210**	*Trichogaster fasciata*	
211	*Trichogaster lalius*		**212**	*Wallago attu*	Bowali, Boal
213	*Xenentodon cancila*	Kekley			

Appendix 5A.11 Biodiversity and transboundary significance and conservation challenges of protected areas of Khangchendzonga landscape, India

Name Protected Area and location [Lat, long and Altitude (m, asl)]	**General description**	**Trans-boundary significance**	**Biogeographic province and major Forest types**	**Floral significance (important Endemism, Threatened, Flagship species)**	**Faunal significance (important Endemism, Threatened, Flagship species**	**Major Conservation challenge**
Khangchendzonga BR, Sikkim, 2620 km^2, $88^o27'$ to	Maximum altitudinal amplitude amongst PAs of	Transboundary movements are observed in cross-country	Lies partly within bio-geographic province IC, the Sikkim Trans-	Represents many species of *Primula*, rhododendrons and orchids of the	Habitat of Snow Leopard, Red Panda, Musk Deer, Himalayan	Tourism and Trekking, transboundary grazing issues

88°33' E, 27°33' to 27°40' N, 1220-8586 m (the core zone is the Khangchendzonga National Park, covering 1,784.00 km2 area)	India, covers over 40% geographical area along north and west districts of Sikkim In 2010, a separate transition zone was notified	grazing activity and illegal trade. Contiguous to Kanchenjunga Conservation area in Nepal and Singalila National Part in West Bengal, acts as a catchment to the river Rangit	Himalaya and largely within bio-geographic province 2 C, the Central Himalaya (1 B and 2 C Sub-Alpine Forest, Subalpine scrubland, Montane Wet Temperate Forest, Moist Deciduous Forest, etc)	region. Threatened and CITES scheduled plants, e.g., species of *Aconitum*, *Orchis, Podophyllum*, Jatamansi, *Cordyceps*, etc.	Black Bear, Argali, Tibetan Antelope, wild Dog, particolored flying squirrel and the very rare Dhole. BNHS-Birdlife International have also declared the it core zone (NP) as an "Important Bird Area"	
Barsey Rhododendron Sanctuary 104 km^2, 27°11.65'N 88°7.10'E	PA is dominated by temperate biotic representation. It has unique stand of pure *Rhododendron arboretum, R. falconeri* and *R. Grande*	Contiguous to Kanchenjunga Conservation Area (Nepal). Illegal traffic of forest products, hunting poaching, grazing, etc. are recorded	Subtropical Moist Deciduous Forests, Wet Temperate Forests, Moist Temperate Forests, Sub- alpine Forests and Alpine meadows	*Quercus, Castanopsis, Rhododendron* and *Machilus* spp. are the dominants. PA is better known for its pure rhododendron stands	Habitat of Leopard, Leopard Cat, Yellow-throated Marten, Masked Palm Civet, Goral, Barking Deer, Asian Black Bear, Red Panda, Crestless Porcupine, and Himalayan Mouse- Hare	Grazing from the Nepalese herds, forest fires, tourism activities, resource extraction at lower reaches
Fambonglho WLS, Sikkim, 88° 51.76 km^2, 29' to 88° 35' E, 27° 10' to 27° 23' N , 1524-2749 m	Renowned for its bird life, the PA represents upper temperate biota in the fringe of capital town Gangtok	Not significant to transboundary activities due to its location	2 C Moist Deciduous Forest, Montane Wet Temperate Forest, Sub-Alpine Forest	Significant epiphytic and climber genera as well as wild edible plants. Dominated by *Quercus, Castanopsis, Machilus* and *Michelia* species.	Habitat of Binturong, Red Panda, Clouded Leopard, Serow, Himalayan Black Bear	Fringe villages pressure, evolving tourism activities
Kyangnosla Alpine Sanctuary, 31 km^2 , 88° 21' to 88° 25' E, 27°22'-27°24', 3292-4116 m	Representative of exclusively alpine and sub-alpine biota	Not directly a transboundary, but very close to international border with China	Montane Wet Temperate Forest, Sub-Alpine Forest	Alpine and sub-alpine herbal plants, notably *Orchis latifolia, Berberis aristata* and *Podophyllum hexandrum*	Habitat of Red panda, Asiatic Wild Dog, Goral, Snow Leopard, Musk Deer, Serow, Himalayan Black Bear	Increased tourism activity
Maenam WLS 35.34 km^2, 88°21' to 88°25' E, 27 43' to 27 48' N, 2000 -3263 m	Representative of upper and lower temperate biota	Not significant to transboundary	2C Moist Deciduous Forest, Montane Wet Temperate Forest, Sub-Alpine Forest	Threatened plants recorded	Habitat of Binturong, Red Panda, Musk Deer, Clouded Leopard, Pika	Fringe settlement pressure
Pangolakha WLS128 km, 88°35' to 88°51'E, 27°09' to 27°22'N, 1760 -4390 m	Contiguous to Torsa Strict Nature Reserve in Bhutan it is a typical of high altitude flora and fauna	A tri-junction of India with Bhutan and China (Autonomous Region of Tibet), highly significant	2C Tropical Moist Deciduous Forest, Moist Deciduous Forest, Montane Wet Temperate Forest, Sub-Alpine Forest	PA is renowned for temperate and sub-alpine herbal resource	Red Panda, Musk Deer, Goral, Serow, Clouded Leopard, Marbled Cat, Himalayan Black Bear	Increasing sign of tourism activity
Singba Rhododendron	Rich pool of rhododendrons,	Not significant to transboundary	2C Montane Wet	Home of the threatened	Red Panda, Clouded Leopard	Highly crowded

Sanctuary 43 km^2, 88° 43' to 88°46' E, 27°43' to 27°48' N, 88° 43' to 88° 46' E, 27 43' to 27 48' N, 1400 - 8598 m	representative of internal Himalayan biota		Temperate Forest, Sub-Alpine Forest	*Rhododendron niveum*, state tree of Sikkim. Richest PA of Himalayan rhododendrons		tourist destination, extraction of nature resources
Kitam Bird Sanctuary 6 km^2, 88° 20' to 88^o 22' E, 27^o 06' to 27° 07 N, 320- 875 m	Rich avian assembly (resident/ migratory)	Not significant to transboundary	Northern tropical moist deciduous forests, Tropical Moist Deciduous Forest	The PA is represents Sub-tropical plant species	Habitat of Clouded Leopard, Assamese Monkey, Himalayan Black Bear	Surface erosion stability and fire issues;
Gorumara National Park, north Bengal. 26°42'N 88°48'E, average elevation of 2800 ft.	PA is entirely composed of North Indian Moist Tropical Forest. However, it displays tremendous range in forest sub-types. Rich diversity of herbals	Not significant to transboundary activity due to its location	North Indian Moist Tropical forest made up of Riverine Forests, Sal Forests, Wet Mixed Forests, Savannah Forests and its varied sub-types	The PA is dominated by *Shorea robusta, Schima wallichii, Chukrassia tabularis, Michelia champaca* and *Terminalia belerica* which are key economic species of the region	Habitat of Indian One horned rhinocerous, Gaur, Asian elephant, Sloth Bear, Sambar Deer, Barking Deer, Wild Boar	Fringe settlement pressure, man-animal conflict, increase in tourism activities
Jaldapara National Park (216.5 Km^2), 25º 58' N and 27º 45' N latitude and 89° 08' E and 89° 55' E long, 61m asl	Expansive grassland, 91 grass species, rhinoceros habitat	Significant to transboundary activity with Bhutan	Riverine Forests, Sal Forests, Wet Mixed Forests, Savannah Forests, Semi-Evergreen Forests, Evergreen Forests	Plant species: 585; *Shorea robusta, Schima wallichii, Lagerstroemia parviflora*, *Terminalia myriocarpa*, *Duabanga sonneratioides*, *Amoora wallichi*, *A. rohituka*, *Bischofia javanica*, *Bombax ceiba*, *Acacia catechu*, *Dalbergia sissoo* and *Albizzia* spp. About 28 rare species under severe pressure and threat of extermination	Important habitat of Indian One-Horned Rhinoceros, hog deer and spotted deer., Tiger, Asian Elephant, Sambar deer, Barking Deer, Wild Dogs (Dhole), Bison	Proliferation of newer weeds endangering rhino grazing area
Neora Valley National Park 27°52'03''-27°07'35''N, 80°45'-80°55' E, 88 km^2, 183-3200 m	Park covers areas from the Duars foothills to the sub-alpine region, rich repository of flora and fauna of North Bengal. Consists one of the oldest Reserve Forest in India	Contiguous to Pangolakha Wildlife Sanctuary in Sikkim and the Toorsa Strict Reserve of Bhutan	Dry mixed forest, Wet mixed forest, Lauraeeous Forest, Buk-Oak Forest, High level oak Forest, Coniferous Forest, Himalayan Moist Temperate Forest and Rhododendron forest	Floristic: angiosperm-680 species; pteriodphytes-23 species; gymnosperm- 4 species. Approx 20% of total species –extremely rare and many are threatened. The orchid *Cymbidium whiteae* is endemic	The only temperate PA visited by elephants (up to 10,000 ft elevation). Red Panda, Goral, Serow, Tiger, Clouded Leopard	About 20 % of the total species found in the PA are extremely rare and many of those face the threat of extinction

				to the region.		
Singalila National Park, 78.6 km^2, 27°07'N 88°04'E, 1800-3500 m	Mainly representing upper temperate and sub-alpine biota of the region	Contiguous to Kanchenjunga Conservation Area (Nepal). Transboundary movement is observed in cross-country grazing activity and illegal trade	Upper Hill Forests, Eastern Himalayan subalpine conifer forests, Eastern Himalayan broadleaf forests, Himalayan subtropical pine forests Oak Hemlock Forests, Alpine Forests	Rich concentration of Himalayan Cobra-Liliies (*Arisaema* spp.). Apart from orchid diversity notable genera are *Primula, Magnolia* and *Rhododendron*	Habitat of Red Panda, Clouded Leopard, Himalayan Thar, Himalayan Black Bear. One of the few habitats of endangered Red Panda (*Ailurus fulgens*)	Transboundary grazing issues predominate, resource extraction from the Park, forest fires, trekking and tourism activities
Mahananda Wildlife Sanctuary 26°28'52'N 88°15'50'E, 200-1000 m	Rich ecosystem comprising majority of seral stages and types of forests in KL-India region	Not significant to transboundary	Khair-Sissoo Forest, Simul-Siris Forests, Plains Sal Forests, Lower Hill Forests, Middle hill Forests	Distinct seral stages of vegetation covering grasslands to forests	Serow, Himalayan Black Bear, Gaur, Asian Elephant	Fringe settlement pressure, man-animal conflict, especially the elephant herd movement along Mechi river affecting villages.
Senchal Wildlife Sanctuary 38.6 km^2, 26°59'38'N 88°15'55'E, 1500-2600 m	Preponderance of upper temperate biota, the PA is catchment for water supply to Darjeeling township	Not significant to international transboundary aspect; however, Senchal forms a connectivity between Singalila National Park and the Mahananda Wildlife Sanctuary.	East Himalayan subtropical wet hill forest, Upper Hill Forests	Rich floral assemblage especially of the fern and fern allies; 380-400 flowering plants, Rhododendrons and Michelia	Red Panda habitat. Goral, Serow, Himalayan Black Bear, Pangolin, Barking Deer; rich butterfly and beetle diversity	Grazing and lopping issues as well damage from bears, deer and wild boar to forest resource
Chapramari Wildlife Sanctuary	A signature PA representing Dry Mixed Forest type	Not significant to transboundary aspects due to its location	Dry Mixed Forest	Rich pool of orchids and medicinal plants. Major floral elements are *Aphanamixis polystachia, Turpinia pomifera, Bauhinia* sp. *Schima wallichi, Stereospermum chelonoides, Terminalia belerica, Machilus* sp., *Mallotus phillippinensis, Terminalia tomentosa, Hollarrhena antidysenterica* which are known economic plants	Habitat of Asian Elephant, Tiger, Leopard, Gaur, Wild boar, Pangolin, Barking Deer, Sambar Deer	Damage to forest resource by resident faunal members
Buxa Tiger Reserve 760 km², 26°39'0"N 89°34'48"E	PA is known for its tiger habitat in the eastern Himalaya	The Phipsu Wildlife Sanctuary of Bhutan is contiguous to North of BTR, as	Northern Dry Deciduous, Eastern Bhabar and Terai Sal, East Himalayan Moist Mixed Deciduous Forest,	*Shorea robusta, Schima wallichii, Terminalia myriocarpa*, *Duabanga sonneratioides*,	Habitat of Tiger, Asian Elephant, Clouded Leopard, Gaur, Wild Boar, Sambar Deer	Man-Animal conflict, forest resource extraction

		significant TB protected area	Sub-Himalayan Secondary Wet Mixed Forest, Eastern Sub-Montane Semi-evergreen Forest, Savannah Woodland	*Bischofia javanica*, *Bombax ceiba*, *Acacia catechu*, *Dalbergia sissoo, Albizzia* spp., *Saccharum procerum, S.spontaneum, Phragmitis karka, Arundo donax* and *Imperata* spp.		
Jorepokhari Salamander Sanctuary 26°27'10"N/-87°59'30" E, 1350 m	Renowned for the habit of the rare Himalayan Salamander. Small fluvio-lacustrine basin (5000 m^2) at represents the actual habitat of the salamanders	Not significant to transboundary due to its location	Montane Wet Temperate Forest	*Castanopsis tribuloides, Machilus edulis, Macaranga pustulata, Ostoedes paniculatus* are the main representatives of floral significance	The only habitat of Himalayan Salamander (*Tylototriton verrucosus*) in Eastern Himalaya. The species is included in the Scheduled II of Indian Wildlife Protection Act, 1972	Tourist activity close to the habitat

Appendix 5A.12 List of vulnerable and endemic birds and other important birds having global representation in Khangchendzonga landscape, India

Vulnerable Birds

Common name	**Scientific name**
Baer's Pochard	*Aythya baeri*
Pallas's Fish-Eagle	*Haliaeetus leucoryphus*
Black-necked Crane	*Grus nigricollis*
Lesser Kestrel	*Falco naumanni*
Black-breasted Parrotbill	*Paradoxornis flavirostris*

Endemic Bird Area-130: Eastern Himalayas

Hoary-throated Barwing	*Actinodura nipalensis*
White-naped Yuhina	*Yuhina bakeri*
Black-browed Leaf-Warbler	*Phylloscopus cantator*

Biome-5: Eurasian High Montane (Alpine and Tibetan)

Himalayan Griffon	*Gyps himalayensis*
Snow Partridge	*Lerwa lerwa*
Tibetan Snowcock	*Tetraogallus tibetanus*
Tibetan Partridge	*Perdix hodgsoniae*
Solitary Snipe	*Gallinago solitaria*
Snow Pigeon	*Columba leuconota*
Long-billed Calandra-Lark	*Melanocorypha maxima*
Rosy Pipit	*Anthus roseatus*
Grey-backed Shrike	*Lanius tephronotus*
Alpine Accentor	*Prunella collaris*
Altai Accentor	*Prunella himalayana*
Robin Accentor	*Prunella rubeculoides*
Plain-backed Thrush	*Zoothera mollissima*
Hodgson's Redstart	*Phoenicurus hodgsoni*
Grandala	*Grandala coelicolor*
Smoky Warbler	*Phylloscopus fuligiventer*
Tickell's Warbler	*Phylloscopus affinis*

Wallcreeper	*Tichodroma muraria*
Hodgson's Mountain-Finch	*Leucosticte nemoricola*
Black-headed Mountain-Finch	*Leucosticte brandti*
Streaked Great Rosefinch	*Carpodacus rubicilloides*
Common Great Rosefinch	*Carpodacus rubicilla*
Red-fronted Rosefinch	*Carpodacus puniceus*
Yellow-billed Chough	*Pyrrhocorax graculus*

Biome-7: Sino-Himalayan Temperate Forest

Common Hill-Partridge	*Arborophila torqueola*
Blood Pheasant	*Ithaginis cruentus*
Satyr Tragopan	*Tragopan satyra*
Himalayan Monal	*Lophophorus impejanus*
Speckled Wood-Pigeon	*Columba hodgsonii*
Yellow-rumped Honeyguide	*Indicator xanthonotus*
Darjeeling Pied Woodpecker	*Dendrocopos darjellensis*
Nepal House-Martin	*Delichon nipalensis*
Rufous-breasted Accentor	*Prunella strophiata*
Maroon-backed Accentor	*Prunella immaculate*
Long-tailed Thrush	*Zoothera dixoni*
Greater Long-billed Thrush	*Zoothera monticola*
White-collared Blackbird	*Turdus albocinctus*
Gould's Shortwing	*Brachypteryx stellata*
Indian Blue Robin	*Luscinia brunnea*
Golden Bush-Robin	*Tarsiger chrysaeus*
White-browed Bush-Robin	*Tarsiger indicus*
Rufous-breasted Bush-Robin	*Tarsiger hyperythrus*
White-throated Redstart	*Phoenicurus schisticeps*
White-throated Laughingthrush	*Garrulax albogularis*
Striated Laughingthrush	*Garrulax striatus*
Scaly Laughingthrush	*Garrulax subunicolor*
Black-faced Laughingthrush	*Garrulax affinis*
Slender-billed Scimitar-Babbler	*Xiphirhynchus superciliaris*
Greater Scaly-breasted Wren-Babbler	*Pnoepyga albiventer*
Green Shrike-Babbler	*Pteruthius xanthochlorus*
Bar-throated Minla	*Minla strigula*
Red-tailed Minla	*Minla ignotincta*
Gold-breasted Tit-Babbler	*Alcippe chrysotis*
White-browed Tit-Babbler	*Alcippe vinipectus*
Rufous Sibia	*Heterophasia capistrata*
Stripe-throated Yuhina	*Yuhina gularis*
Rufous-vented Yuhina	*Yuhina occipitalis*
Myzornis	*Myzornis pyrrhoura*
Brown Parrotbill	*Paradoxornis unicolor*
Chestnut-headed Tesia	*Tesia castaneocoronata*
Chestnut-crowned Bush-Warbler	*Cettia major*
Aberrant Bush-Warbler	*Cettia flavolivacea*
Grey-sided Bush-Warbler	*Cettia brunnifrons*
Orange-barred Leaf-Warbler	*Phylloscopus pulcher*
Grey-faced Leaf-Warbler	*Phylloscopus maculipennis*
Large-billed Leaf-Warbler	*Phylloscopus magnirostris*
Grey-cheeked Flycatcher-Warbler	*Seicercus poliogenys*
Slaty-backed Flycatcher	*Ficedula hodgsonii*
Orange-gorgeted Flycatcher	*Ficedula strophiata*

Slaty-blue Flycatcher	*Ficedula tricolor*
Rufous-bellied Niltava	*Niltava sundara*
Rufous-fronted Tit	*Aegithalos iouschistos*
Rufous-bellied Crested Tit	*Parus rubidiventris*
Brown Crested Tit	*Parus dichrous*
Green-backed Tit	*Parus monticolus*
White-tailed Nuthatch	*Sitta himalayensis*
Rusty-flanked Tree-Creeper	*Certhia nipalensis*
Yellow-bellied Flower-pecker	*Dicaeum melanoxanthum*
Fire-tailed Sunbird	*Aethopyga ignicauda*
Yellow-breasted Greenfinch	*Carduelis spinoides*
Tibetan Siskin	*Serinus thibetanus*
Dark-breasted Rosefinch	*Carpodacus nipalensis*
Dark-rumped Rosefinch	*Carpodacus edwardsii*
White-browed Rosefinch	*Carpodacus thura*
Scarlet Finch	*Haematospiza sipahi*
Brown Bullfinch	*Pyrrhula nipalensis*
Red-headed Bullfinch	*Pyrrhula erythrocephala*
Collared Grosbeak	*Mycerobas affinis*
White-winged Grosbeak	*Mycerobas carnipes*
Gold-naped Black Finch	*Pyrrhoplectes epaulette*
Yellow-billed Blue Magpie	*Urocissa flavirostris*
Slaty-headed Parakeet	*Psittacula himalayana*
Golden-throated Barbet	*Megalaima franklinii*
Black-winged Cuckoo-Shrike	*Coracina melaschistos*
Short-billed Minivet	*Pericrocotus brevirostris*
Black Bulbul	*Hypsipetes leucocephalus*
Grey-winged Blackbird	*Turdus boulboul*
White-tailed Robin	*Myiomela leucurum*
Green Cochoa	*Cochoa viridis*
Grey-sided Laughingthrush	*Garrulax caerulatus*
Rusty-cheeked Scimitar-Babbler	*Pomatorhinus erythrogenys*
Red-billed Leiothrix	*Leiothrix lutea*
Cutia	*Cutia nipalensis*
Rufous-bellied Shrike-Babbler	*Pteruthius rufiventer*
Rusty-fronted Barwing	*Actinodura egertoni*
Blue-winged Minla	*Minla cyanouroptera*
Yellow-throated Tit-Babbler	*Alcippe cinerea*
Nepal Tit-Babbler	*Alcippe nipalensis*
Black-chinned Yuhina	*Yuhina nigrimenta*
Grey-headed Flycatcher-Warbler	*Seicercus xanthoschistos*
Black-faced Flycatcher-Warbler	*Abroscopus schisticeps*
Small Niltava	*Niltava macgrigoriae*
Red-headed Tit	*Aegithalos concinnus*
Black-spotted Yellow Tit	*Parus spilonotus*
Black-throated Sunbird	*Aethopyga saturate*
Maroon Oriole	*Oriolus traillii*
Grey Treepie	*Dendrocitta formosae*
Lesser Necklaced Laughingthrush	*Garrulax monileger*
Greater Necklaced Laughingthrush	*Garrulax pectoralis*
Sultan Tit	*Melanochlora sultanea*

Appendix-5A.13: Threatened plants of Khangchendzonga landscape (India) with species description

Species (Family)	Conservation status	Species description
Acer sikkimense Miq. ACERACEAE	Data Deficient	A temperate tree reaching up to 16 m in height. Holo type collected by Thomas Anderson in October 1862 in Sikkim. No further collection from its Type locality or from elsewhere in Sikkim and Darjeeling or other states is reported till date. Cited as DD (Data Deficient) in the IUCN Red List of Maples (2009) with the notes "...considered V (Vulnerable) in China, but also found in additional countries where its conservation status is unknown."
Acer osmastoni Gamble ACERACEAE	Endangered	A natural hybrid of *Acer laevigatum* Wall. and *Acer campbelli* Hook. f. et Thomson ex Hiern, it has been reported only 4 times (1904, 1915, 1958 and 1972) since its discovery by B.B. Osmaston in 1903. The species is unique in its bearing, as it is the only natural hybrid occurring among the Indian maples.
Acer stachyophyllum Hiern ACERACEAE	Rare	A rare deciduous tree growing up to 15 m, deciduous. Found between 1400-3500 m amsl under mixed temperate to lower alpine forests. Flowers during Apr-May, samaras appear between Sep-Oct.
Aconitum ferox Wall. ex Ser. RANUNCULACEAE	Endangerd	Excessive collection as a medicinal herb in the earlier days has led to a drastic reduction in its number. Very few individuals are found in the location where population thrived in the past (3300-5000 m amsl).
Acronema pseudotenera P.K.Mukh. APIACEAE	Indeterminate	A naturally rare biennial rhizomatous herb. Reported from Yumay Samdong in North Sikkim. This is a taxonomic- ally complex genus with often indistinct species boundaries and problematic generic delimitation with Sinocarum.
Aleuritopteris argentea (S.G.Gmel.) Fée PTERIDACEAE	Very rare	Not seen again in 150 years in India and possibly requiring reaffirmation in case it was collected later during Hooker's onward journey in Sikkim (Chandra et al. 2008).
Angelica nubigena (C.B.Clarke) P.K.Mukh. APIACEAE	Indeterminate	Originally described under Heracleum (Clarke 1879) it was later transferred to genus Angelica by P.K. Mukherjee in 1983. Represented in herbaria by only two or three specimens it is considered a poorly worked out species. Recorded from Chola and Yakla passes at ca. 3800 m amsl.
Aphyllorchis parviflora King & Pantl. ORCHIDACEAE	Rare	In India this species is found only at two locations in the Himalaya. It was first collected from Lachen and Yumthang in northern Sikkim (1896) and in due time it has become remarkably rare. Also reported from Nepal and South-East Tibet between 3200-3400 amsl.
Arenaria thangoensis W.W. Sm. CARYOPHYLLACEAE	Endemic	The taxon has not been sighted since its collection made in 1912. It is endemic to Sikkim and is found at Thango (4200 m amsl) and Chugya (4500 m amsl).
Asplenium delavayi (Franch.) Copel. ASPLENIACEAE	Very rare	Very rare fern reported from Sikkim apart from Western Nepal, Bhutan and Manipur (Chandra et al. 2008).
Asplenium pelltucidum L. ASPLENIACEAE	Very rare	(Chandra et al. 2008). Recorded from South Sikkim (Lingtam). Also reported from Silent Valley, Kerala.
Athyrium repens (Ching) Fras.-Jenk. WOODSIACEAE	Very rare	Very rare in Sikkim Himalaya (Chandra et al. 2008). Also recorded from Nepal, Bhutan and South-West China
Athyrium roseum Christ WOODSIACEAE	Very rare	Reported from North-East India (Darjeeling, Palmajua) and Central Nepal. Previously unrecorded from the Indian subcontinent (Chandra et al. 2008).
Begonia rubella Buch.-Ham. ex D.Don BEGONIACEAE	Rare	The species has medicinal properties and as such is valued. It is naturally found in very small numbers. The species was first collected by Wallich in 1821 from Eastern Himalaya (Darjeeling, Sikkim). The plant has a distinction of being an interesting species of disjunctive distribution.

		Three populations of B. scutata were located near Yang yang in Tista Valley and Legship in Rangit Valley at altitudes between 300-1200 m (Nautiyal et al. 2009).
Begonia satrapis Clarke BEGONIACEAE	Rare	Located earlier in a very limited growing area (slopes of Rangit Valley below Badamtam at an altitude of 700 m) this was reported in 1879. It is of horticultural value and presently very scarcely seen. Recently a few populations were located at Sumbuk and Kitam in Rangit Valley, South Sikkim at 550-1100 m amsl (Nautiyal et al. 2009).
Calamus inermis T. Anderson ARECACEAE	Endangered	This cane is under considerable threat. Populations at the roadsides were the first to go because of the set transport facilities. The species is now represented with a few clumps in Latpanjar hill near Kurseong, West Bengal. Recently, it has been reported from Arunachal Pradesh and Manipur as well as from Dzongu in north Sikkim.
Calanthe alpina Hook.f. ex Lindl. ORCHIDACEAE	Rare	Terrestrial plants growing up to 25-50 cm. It is found in forest fringes and grassy slopes between 1500-3500 m elevations. Destruction of its habitats has rendered the species to become rare. It is one of the few Calanthes found in the subalpine region.
Calanthe manni Hook.f. ORCHIDACEAE	Rare	Small populations and much localized this species is a natural rarity. It is also a species of horticultural value attracting all sorts of collectors and nurserymen
Calanthe chloroleuca (Lindl.) ORCHIDACEAE	Very rare	Few details exist.
Carex kingiana C.B.Clarke CYPERACEAE	Indeterminate	This plant is known only from its Type collection made at Phodong in northern Sikkim. The species is comparatively new to plant science but due to habitat damage it has suddenly become very scarce. Gradual drying up of the habitat may be one of the causes of its getting scarce.
Ceropegia hookeri C.B.Clarke. ex Hook.f. ASCLEPIADACEAE	Endangered	This is a little known taxon and probably grows in area ranging between 3000-4000 m amsl at alpine grassy meadows. Reported from the Zemu Valley in northern Sikkim it is a very scarce species. Habitat loss and tourism practices are reported as the major threats to its survival. Recently a population has been reported from Lachen at 2700 m amsl (Nautiyal et al. 2009).
Ceropegia lucida Wall. ASCLEPIADACEAE	Endangered	Endangered or possibly extinct in India Throughout the last 100 years no collection has been made of this plant. Recently two populations of C. Lucida were rediscovered near Lachung village in north Sikkim at 1750 m (Nautiyal et al. 2009). The Red Data Book suggests intensive search in its habitat, which is river Reyang in Sikkim.
Cinnamomum glanduliferum Meissn. LAURACEAE	Rare	A rare evergreen tree of ca. 12 m height and growing in evergreen broad-leaved forests between 1500-2600 m amsl. The leafy branch lets contain volatile oil and camphor. The wood is used for furniture and the bark and roots are reportedly used in herbals.
Cissus spectabilis Planch. VITACEAE	Endemic	Large lianas, branch lets terete with longitudinal ridges. Grows in forests or shrub lands by the rivers between 200-1600 m amsl. Endemic to Sikkim and West Bengal.
Codonopsis affinis Hook.f & Thomson CAMPANULACEAE	Rare	Rare Roots much thickened, fusi form, branched. Stems twining, yellow-green or green, more than 2 m. Leaves on main stems and major branches alternate, those on branch lets sub opposite. Reported from Darjeeling and Sikkim between 1830-3335 m amsl.
Coelogyne treutleri Hook.f. ORCHIDACEAE	Possibly extinct	Possibly extinct Epiphytic on tree trunks in dense forests at around 2000 m amsl. First collected in 1875 by Treutler on the basis of which Hooker described the species in the Flora of British India. Since then it has never been sighted. Also reported from North-Western Yunnan.
Cotonester simonsi Hort. ex Baker ROSACEAE	Endemic	This is represented by only four specimens in the Central National Herbarium (CAL) which were from the Lachung Valley at 3150 m amsl in the northern Sikkim. The species is of immense horticultural value, here

		and abroad. Endemic to Sikkim Himalaya.
Cyathea andersoni (J.Scott ex Bedd.) Copel. CYATHEACEAE	At Risk	(Chandra et al. 2008) in Sikkim Himalaya. Also reported from North-Eastern India Arunachal Pradesh (including the Duphla Hills), Meghalaya and Bhutan.
Cyathea brunoniana (Wall. ex Hook.) C.B.Clarke & Baker CYATHEACEAE	At Risk	(Chandra *et al.,* 2008). Found in Darjeeling and Sikkim hills, Arunachal Pradesh, Manipur, Nagaland and Meghalaya.
Cyathea chinensis Copel. CYATHEACEAE	At Risk	(Chandra *et al.,* 2008). Reported from Darjeeling, Sikkim, Arunachal Pradesh, Manipur, Nagaland and Meghalaya.
Cyathea contaminans (Wall. ex Hook.) Copel. CYATHEACEAE		(Chandra *et al,.* 2008). Reported from Darjeeling, Sikkim, Arunachal Pradesh, Manipur and Meghalaya.
Cycas pectinata Griff. CYCADACEAE	Vulnerable	Foothills to 900 m elevations, the central pith is full of starchy granules and gives coarse sago. For this the plant was of value earlier to the tribal people. Few small populations or scattered individuals remain at present. This is the only species of Cycadaceae from the region. Listed in Appendix II of the CITES List.
Cymbidium eburneum Lindl. ORCHIDACEAE	Vulnerable	Due to over-exploitation and habitat destruction the species has become very scarce. It is included in the Appendix II of CITES. Endemic to Eastern Himalaya and North Eastern India the species is found between1000-1500 m amsl.
Cymbidium hookerianum Rchb.f. ORCHIDACEAE	Vulnerable	Species is recorded under Appendix II of CITES. Though it has a distribution from Eastern Nepal to Bhutan it is vulnerable at each of the locations. In the earlier days it was much common between 1700-2500 m amsl. Be- came vulnerable due to collection by nurserymen as well as the common people.
Cymbidium whiteae King & Pantl. ORCHIDACEAE	Endangered	This has an extremely limited growing area hardly spreading 1 km^2. Not reported for a long time from its original habitat (Gangtok, 1750 m amsl) which is now largely disturbed. Rediscovered at Rumtek.
Cypripedium elegans Rchb.f. ORCHIDACEAE	Rare	Rare Particularly in Sikkim this species has become extremely rare and all likelihood to become an endangered species. It has a scattered distribution of small populations in the subalpine region of Sikkim between 3300-4200 m amsl.
Cypripedium himalaicum Rolfe ex Hemsl. ORCHIDACEAE	Rare	Rare Grows in similar location as C. elegance and is found quite occasionally. This is the second lady's slipper orchid from Sikkim out of three recorded Cypripedium species. Cypripedium himaliacum is found growing on limestone boulders, crevices, and slopes between 2800 to 4900 m amsl.
Dendrobium praecinctum Rchb.f ORCHIDACEAE	Very rare	Little information available.
Didiciea cunninghami King et Prain ORCHIDACEAE	Endangered	First discovered in the Lachen Valley of northern Sikkim it is now hardly seen in the wild. This is one of the few monotypic orchids of India. Plants 10-20 cm tall. Pseudobulbs often connected in clumps or rows.
Diglyphosa macrophylla King & Pantl. ORCHIDACEAE	Monotypic	Plants between 25-40 cm tall and flowering in June at damp places in forests, along valleys at ca.1200 m elevation.
Diplazium heterophlebium (Mett. ex Baker) Diels WOODSIACEAE	At Risk	Reported from Darjeeling and Sikkim. Very rare or perhaps extinct in the Darjeeling area (Chandra et al. 2008).
Diplomeris hirsuta (Lindl.) Lindl. ORCHIDACEAE	Vulnerable	This species is included in the IUCN Red Data Book and its export presently is banned under CITES Appendix II. The plant is of considerable horticultural value and of botanical interest. It is vulnerable and likely to

		disappear soon due to landslides and habitat encroachment. Its vulnerability was first recorded in the mid-70s by two orchid specialists from Kalimpong, namely, G.M. Pradhan (1974) and U.C. Pradhan (1974).
Dryopteris alpestris Tagawa DRYOPTERIDACEAE	Very rare	(Chandra et al. 2008). Reported also from Nepal, North-East India (Sikkim) and Tibet.
Dryopter is angustifrons (T. Moore) Kuntze DRYOPTERIDACEAE	Very rare	(Chandra et al. 2008). Probably extinct in Nepal and India (Sikkim).
Dryopteris assamensis (C.Hope) C.Chr. & Ching DRYOPTERIDACEAE	Very rare	Reports from Darjeeling Terai, Dulkajhar, near Naxalbari. Very probably extinct in West Bengal due to the draining and cultivation of Dulkajhar, which was formerly a marshy grassland (Chandra *et al.,* 2008).
Dryopteris costalisora Tagawa DRYOPTERIDACEAE	Very rare	Reported from the Tonglo Peak in Darjeeling. It may be expected further east in North-East India, but has not so far been collected elsewhere in the area (Chandra et al. 2008).
Dryopteris nobilis Ching DRYOPTERIDACEAE	Very rare	Records from Darjeeling, Kurseong area and perhaps now extinct in Kurseong due to habitat encroachment. Sikkim at B2 Bridge, North of Gangtok (Chandra *et al.,* 2008).
Juncus sikkimensis Hook.f. JUNCACEAE	Rare	A perennial herb so far known only from the Sikkim Himalaya. The first record was made by Hooker in 1892. Nothing whatsoever is known over its growing conditions. Found in temperate semi-evergreen forests, rhododendron forests, wet grasslands slopes, swamps, bogs and wet places by streams between 4000-4500 m asl.
Lactuca cooperi Anthony ASTERACEAE	Endangered	Endemic to Sikkim Himalaya and known only from the Type collection made in September 1913 from alpine and subalpine regions at ca. 5000 m elevation. Intensive field surveys in the type locality are the proposition made in Red Data Book (Nayar and Sastry 1987, 1988, 1990).
Lagerstroemia minuticarpa Debberm. ex P.C.Kanjilal LYTHRACEAE	Rare	Classified as rare by Nayar and Sastry (op cit.) and known only from two localities, i.e, Garampani in Assam and Singtam in Sikkim. The species is classified as Endangered under IUCN threatened status. Recently few populations have been located in Arunachal Pradesh where it is under threat due to shifting cultivation and dam construction.
Livistona jenkinsiana Griff. ARECACEAE	Not very common	An endangered fan palm of 6-10 m height. Not very common, chiefly found in the Tista valley. Earlier used for thatching and umbrella purpose.
Lloydia himalensis Royle LILIACEAE	Rare	The species is sporadic in distribution and represented by a few specimen collected from the Himalayan region only (3695-3810 m amsl). In Sikkim it is localized in the Tsomgo lake area, a high altitude tourist destination.
Loxogramme grammitoides (Baker) C.Chr. POLYPODIACEAE	Very rare	Reported from Gairibas, near Maneybhanjyang, Darjeeling
Malaxis saprophyllum (King & Pantl.) Tang & Wang ORCHIDACEAE	Very rare	Little information exists.
Matteuccia orientalis (Hook.) Trevis. WOODSIACEAE	Very rare	Not collected for many years. Replaced in the Western, Central and Eastern Indo-Himalaya, including Sikkim, by the uncommon (though not very rare) M. intermediate C. Chr., which has strongly narrowed frond-bases, especially noticeable in sterile fronds (Chandra *et al.,* 2008).
Nardostachys grandiflora DC. VALERIANACEAE	Vulnerable	Vulnerable Known commercially as the Jatamashi it has been incessantly collected from the subalpine tracts of Sikkim. But now the supply has trickled down to a few quintals, which shows that the species is gradually entering the next higher level of threatened status.
Oberonia micranthus	Very rare	Few details exist.

King & Pantl. ORCHIDACEAE		
Ophiorrhiza lurida Hook.f. RUBIACEAE		Naturally rare herbs, procumbent to ascending, to 20 cm tall. Found in broad-leaved forests and Tsuga forests between 1800-2300 m amsl.
Oreopteris elwesi (Bak.) Holtt. THELYPTERIDACEAE	Rare	The rarity status is believed to be due to its habitat destruction. The first description of this species was made by Baker from Lachen Valley, northern Sikkim in 1874. It was rediscovered in 1985 but the status is very scarce. Grows between 2700-4200 m amsl at Lachen, Lachung and Kataw area which are exposed to tourist incursions. IUCN listing identifies it from Sikkim only, however, it is reported from SW China also (Chandra *et al.*, 2008).
Panax pseudoginseng Wall. ARALIACEAE	Endangered	Medicinal properties attached to it make it a commercial prize and extensive collections in the region in the past have made this an endangered species. Of the three varieties of *P. pseudo-ginseng*, viz., var. angustifolium (Burkill) Li, var. bipinnatifidus (Seem) Li and var. himalaicus Hara, the second one has become extremely rare. In some aspects, the therapeutic value of P. pseudo-ginseng is reported to be even better than the Korean ginseng (*P. ginseng*).
Paphiopedilum venustum (Wall. ex Sims) Pfitz. ORCHIDACEAE	Vulnerable	An ornamental species of considerable value this was earlier collected in quantity. Compounded with the destruction of its natural habitats the species is in grave danger of annihilation. Found in the Tista valley often near to streams. Included in the Appendix I of CITES which restricts its export.
Phoenix rupicola T. Anderson ARECACEAE	Rare	The species is naturally rare and occurs sporadically at subtropical levels at around 450 m amsl in the Tista and Mahanadi valleys. Generally grows on rocky areas and especially on very steep cliffs on both sides of the Tista above Sevoke. Stem grows to 4.5-6 m high and leaves are ca. 3 m long. Leaflets bright green, shiny and all in one plane. The inner part of the stem was eaten earlier by Lepcha tribe. The plant being dioeciously also has a strong bearing on its re- production making the regeneration process fraught with difficulties.
Phymatopteris nigrovenia (Christ) Pic.Serm. POLYPODIACEAE	Very rare	Reported from Darjeeling and Sikkim and also from Nepal. This species is closely related to *P. veitchi* (Baker) Pic.Serm. from Japan and to *P. shensiense* (Christ) Pic. Serm. from China.
Phymatopteris tibetana (Ching & S.K.Wu) W.M.Chu POLYPODIACEAE	Very rare	Reported only from Sikkim and Nepal.
Picrorhiza kurrooa Royle ex Benth. SCROPHULARIACEAE	Vulnerable	A plant with age-old herbal repute this is collected from its native habitat in bulk. The total harvest of *P. kurrooa* in 1990-1991 from Sikkim was 6200 kg (Rai and Sharma 1994). This over-exploitation and disturbance to its growing site has made the plant scarce at present. From the Darjeeling hills no collection has been made from the past many years which mean it is scarce and thereby not economically viable to the collectors. Grows between 3300-5000 m amsl at open slopes and forest fringes.
Pimpinella tongloensis P.K.Mukh. APIACEAE	Endangered	Endangered, if not extinct already After its collection made in the years 1857 and 1968 no collection record is available. The species has a very small growth pocket in the Singhalila Ridge in the Sikkim Himalaya.
Pimpinella wallichi Clarke APIACEAE	Endangered	First collected in 1870 by Clarke and no sighting has been recorded till date. Southern district of Sikkim at Heeloo and Hee.
Podophyllum hexandrum Royle PODOPHYLLACEAE		A medicinal plant of importance it was extracted from the wild in quantity in the past and very few populations exist today.
Polystichum glaciale	Very rare	(Chandra *et al.,* 2008). Reported from North-East India (Sikkim), Bhutan,

Christ DRYOPTERIDACEAE		Tibet and China.
Pteridrys cnemidaria (Christ) C.Chr. & Ching DRYOPTERIDACEAE	Very rare	(Chandra *et al.,* 2008). Reported from North-East India (Darjeeling, not collected for many years; Assam, Meghalaya and possibly in Sikkim).
Pteris barbigera Ching PTERIDACEAE	Very rare	(Chandra et al. 2008). Record from North-East India (Rungbi, below Mongpo, West Bengal). Not seen in India for ca. 130 years.
Pyrrosia boothi (Hook.) Ching POLYPODIACEAE	Very rare	Reported from North-East India (West Bengal- Darjeeling; Sikkim) and Bhutan (Chandra *et al.,* 2008).
Pternopetalum radiatum (W.W.Sm.) Mukh. APIACEAE	Indeterminate	This is also known as Pimpinella radiata W.W. Smith. Found in north Sikkim at Yumthang and Shebu Valley at an altitude of ca. 3500 m. It has not been observed or collected since 1892. Endemic.
Rhododendron baileyi Balf.f. ERICACEAE	Localized-highly	First report made in 1919 by Balfour from River Tsangpo in southern Tibet. This is a much localized species and found only between Lachung-Yumthang at 3600 m amsl. It is one of the highly localized species of rhododendron in Sikkim Himalaya. Easy access through pliable roads and low availability makes this one a species to be taken in for serious conservation.
Rhododendron barbatum Wall. ex G.Don ERICACEAE	Vulnerable	Discovered by Wallich from Gosainthan, Nepal and described by G.Don in 1834. Much similar to *Rhododendron arboreum* this one also grows close to human habitations, however, because of small populations compared to *R. arboreum* this species is under considerable threat. Vulnerable status (VU) under The Red List of Rhododendrons (IUCN) it is noted as "…under significant pressure from forest loss, habitat degradation and firewood collection".
Rhododendron glaucophyllum Rehder ERICACEAE	Data deficient	A shrub growing up to 1.5 m in height. In the region it is found in small and scattered populations at disturbed area. The holotype was recorded from Lachen and Lachung at ca. 3300 m amsl and named as *Rhododendron glaucum* Hook.f. By Hooker (1849). Reported as DD in the IUCN Red List of Rhododendrons.
Rhododendron campanulatum subsp. aeruginosum (Hook.f.) Chamb. ERICACEAE	Endemic	First report made by Hooker in 1849 from Lachen and Lachung. Earlier it was known as *Rhododendron aeruginosum* Hook. f. but lately, Chamberlain (1982) has assigned it to *Rhododendron campanulatum* subsp. aeruginosum (Hook.f.) Chamb. Found between 3800-4300 m elevations the populations are rather scattered and at largely vulnerable areas. It survives well on level grounds as well as on rockeries at moist slopes.
Rhododendron dalhousiae subsp. tashi Pradhan & Lachungpa ERICACEAE	Endemic	Found so far only from the Pangthang hills (2000 m asl) in eastern Sikkim this one is a naturally scarce species. It is an epiphyte and found in the temperate oak-chestnut forests. Because of scattered presence within its growing range no compact populations are noticed.
Rhododendron decipiens Lacaita ERICACEAE	Natural hybrid	Reported from Chiabhanjyang, Singalila Ridge (western Sikkim) and Shingba and Chachuzak (northern Sikkim). *R. decipiens* growing sites in the region are small and characterized usually by a canopy cover, humus-rich substrata, low daylight and moist condition. First report from Sikkim in 1916 by Lacaita (collected between Chiabhanjyang and Sin- glalila ridge at 3300 m asl). Considered by Balfour to be a natural hybrid of *R. falconeri* and *R. hodgsoni.*
Rhododendron griffithianum Wight ERICACEAE	Data Deficient	Recorded from several places, namely, Chungthang, Lachen, Lachung (northern Sikkim), Rathong Chhu (western Sikkim) and Jaubari, Kalapokhri (Darjeeling hills) between 2000-2800 m amsl. However, as individual plants are widely scattered the number is less although the area covered is extensive. Grows within open woodland but favours sloping land. Reported as DD in the IUCN Red List of Rhododendrons.

Rhododendron maddeni Hook.f. ERICACEAE	Questionable on rarity and endangerment	First report from Chungthang (northern Sikkim at 1300 m amsl) in 1849 by Hooker. This one is taxonomically a very complex and variable species. Reported also from Ratey Chu catchment at 2400 m by Pradhan & Lachungpa (1990). Shows a wide altitudinal range (1300 to 2900 m) in its distribution, however, it was found to be growing and producing flowers at 900 m also (forced acclimatization). Badola and Pradhan (2010b) discovered huge population and questioned on its rarity and endangerment
Rhododendron niveum Hook.f. ERICACEAE	VU in IUCN Red List of Rhododendrons	Reported earlier from Lachung, Lachen and Chola Range (northern Sikkim) between 3000-3600 m elevations. The original material for holotype was collected from Yakchay (ca. 3000 m amsl, northern Sikkim) by Hooker in 1853. It is endemic to Sikkim and Bhutan, and collected only once in Lao at 3100 m in central Bhutan by Ludlow and Sheriff in May 1949. A recent report of a new habitat at Khangchendzonga National Park in Sikkim was made by Badola ad Pradhan (2010a). Found in rocky valleys, mixed forests at 3000-3600 m asl.
Rhododendron pendulum Hook.f. ERICACEAE	Very scarce	Epiphytic shrub up to 1.3 m. Small patches of scattered populations is found at Yakchay, Dombang, Lachen, Phedang and Dzongri. First report (Holotype) from Lachen by Hooker in 1849 but recorded also at eastern Nepal, Bhutan and south-east Tibet. Reported very scarce from the latter areas also (Pradhan & Lachungpa, 1990).
Rhododendron pumilum Hook.f. ERICACEAE	Rare	First report made by Hooker in 1849. This is by far a scarce species found only at the vicinity of Bhirum lake (4600 m) and a few at Chachuzak (3800) (Pradhan and Lachungpa, 1990). First report made by Hooker in 1849. Rare in Sikkim it is found only in remote areas of Zemu, Lhonak and Bhirum lake at around 4600 m asl. A much dwarf-sized rhododendron it grows in the alpine region over sandy or gravelly soil or on avalanche slopes.
Rhododendron sikkimense Pradhan & Lachungpa ERICACEAE	Endemic to Sikkim.	Quite rare species found so far only from Yumthang at ca. 3700 m elevations (northern Sikkim). Grows on level ground within *Rhododendron campanulatum* D.Don community. Scattered presence and not forming compact com- munity or uniform population.
Rhopalocnemis phalloides Jungh. BALANOPHORACEAE	Rare	This root parasite grows under diffused sunlight in dense evergreen virgin forests and thickets between 1000-2700 m asl. The main cause of its rarity is ascribed to the loss of the host plants through disturbance to its natural habitats. The host plants are mostly species of Araliaceae (Dendropanax), Euphorbiaceae, Fagaceae, and Moraceae.
Rhynchospora rugosa subsp. browni (Roem. & Schult.) T.Koyama CYPERACEAE	Endemic	A grass of the marshy habitat this species is endemic to Sikkim. Only three growing spots are reported from the Khechopalri lake area in western Sikkim.
Risleya atropurpurea King & Pantl. ORCHIDACEAE	Naturally rare and monotypic.	Plants 6-21 cm tall. Rhizome narrowly conic to cylindric, flowers dark purple blooms during Jul-Aug. Found in Picea forests or thickets between 2900-3700 m asl.
Selliguea tricuspis (Hook.f) Fras.-Jenk. POLYPODIACEAE	Endemic	Indeterminate As per the Red Data Book, it is probably depleted from the type locality in Darjeeling due to deforestation and change in habitat. Endemic to Sikkim and Darjeeling it was described by Hooker in 1864. The last collection is recorded in the year 1900 and afterwards sightings are nil. Considered very rare in Darjeeling and Sikkim, probably extinct in Darjeeling hills. (Chandra *et al.,* 2008).
Sphaeropteris brunoniana (Wall. ex Hook.) Tryon CYATHEACEAE	Rare	Rare tree fern of the higher hills reaching up to lower temperate level. Leaf rachis spiny. Earlier record shows its availability in Kalimpong and Darjeeling.
Taeniophyllum retro-	Very rare	Few details exist.

apiculatum (King & Pantl.) ORCHIDACEAE		
Taeniophyllum crepidiforme (King & Pantl.) ORCHIDACEAE	Very rare	Few details exist.
Trachycarpus martianus subsp. sikkimensis Lorek ARECACEAE	Very rare	A dioecious fan palm of the region reaching heights between 10-15 m. Naturally rare and very few individuals survive. Earlier used for edible pith by the tribal people. A patch is surviving at Rissom (Dumsong range, Darjeeling at ca. 2000 m asl. Also reported much earlier from Rungbong (Darjeeling at about 1200 m amsl) by Clarke but has not been rediscovered till now.
Vanda pumila Hook.f. ORCHIDACEAE	Rarest one among Vanda species from KL, India	Epiphytic orchid found on tree trunks and branches. Recorded between 500-1800 m amsl. Flowers come out during Mar-May.
Woodsia cycloloba Hand.-Mazz WOODSIACEAE	Very rare	Reported from North-East India (Sikkim), North-West India (Uttarakhand), Nepal and China (Chandra et al. 2008).
Zeuxine pulchra King & Pantl. ORCHIDACEAE	Endangered	Extinct possibly Terrestrial orchid from the Lachung Valley at around 2000 m amsl. Holotype was collected from Khedum, Lachung Valley at 2300 m asl.

Appendix-5A.14: Invasive alien plant species of Khangchendzonga landscape, India

Species name	**Family**	**Nativity**	**Mode of Introduction**
Adenostemma lavenia (Linnaeus) Kuntze	Asteraceae	S. America	Unintentional
Adiantum philippense Linnaeus	Adiantaceae	C. Asia	Unintentional
Ageratum conyzoides Linnaeus	Asteraceae	C. America	Ornamental
Agerantum houstonianum Miller	Asteraceae	Cent. America	Unintentional
Alternanthera sessilis (Linnaeus) DC.	Amaranthaceae	Trop. America	Unintentional
Anaphalis contorta (D.Don) Hooker f.	Asteraceae	C. Asia	Unintentional
Anaphalis margaritacea (Linnaeus) Bentham & Hooker f.	Asteraceae	N. America	Unintentional
Argemone mexicana Linnaeus	Papaveraceae	S. America	Unintentional
Arundo donax Linnaeus	Poaceae	S. America	Unintentional
Axonopus compressus (Swartz) P. Beauvois	Poaceae	S. America	Fodder
Bidens pilosa Linnaeus	Asteraceae	Trop. America	Unintentional
Brugmansia suaveolens (Willdenow) Berchtold & Pres1	Solanaceae	SE Brazil	Unintentional
Calceolaria tripartita Ruiz & Pavon	Scrophulariaceae	C. America	Ornamental
Cannabis sativa Linnaeus	Cannabaceae	C. Asia	Narcotic
Cestrum aurantiacum Lindley	Solanaceae	C. America	Ornamental
Cestrum elegans (Neumann) Schlechtendal	Solanaceae	Mexico	Ornamental
Chenopodium ambrosoides Linnaeus	Chenopodiaceae	C. America	Weed
Cissus javana DC.	Vitaceae	Java	Unintentional
Cleome rutidosperma DC.	Capparaceae	Trop. Africa	Weed
Clerodendrum japonicum (Thunberg) Sweet	Verbenaceae	Japan	Unintentional
Crassocephalum crepidioides (Bentham) S. Moore	Asteraceae	Trop. America	Weed
Cynodon dactylon (Linnaeus) Persoon	Poaceae	Africa	Unintentional

Drymaria villosa Chamisso & Schlechtendal	Caryophyllaceae	Trop. America	Weed
Elephantopus scaber Linnaeus	Asteraceae	C. Asia	Unintentional
Emelia sonchifolia (Linnaeus) DC.	Asteraceae	Africa	Unintentional
Erigeron karvinkianus DC.	Asteraceae	C. America	Weed
Eupatorium adenophorum Sprengel	Asteraceae	Mexico	Weed
Eupatorium odoratum Linnaeus	Asteraceae	N. America	Weed
Fagopyrum dibotrys (D. Don) Hara	Polygonaceae	SW. China	Unintentional
Fragaria nubicola (Hooker f.) Lacaita	Rosaceae	Temp. Europe	Unintentional
Galinsoga parviflora Cavanilles	Asteraceae	Trop. America	Weed
Gamochaeta pensylvanicum (Willdenow) Cabreara	Asteraceae	N. America	Unintentional
Hyptis suaveolens (Linnaeus) Poiteau	Lamiaceae	S. America	Ornamental
Lantana camara Linnaeus	Verbenaceae	Trop. America	Ornamental
Mikania micrantha Kunth	Asteraceae	America	Weed
Mimosa pudica Linnaeus	Fabaceae	C. America	Unintentional
Nicandra physalodes (Linnaeus) Scopoli	Solanaceae	Peru	Ornamental
Oxalis corniculata Linnaeus	Oxalidaceae	Europe	Unintentional
Oxalis corymbosa DC.	Oxalidaceae	S. America	Ornamental
Oxalis latifolia Humboldt, Bonpland & Kunth	Oxalidaceae	Trop. America	Ornamental
Parthenium hysterophorus Linnaeus	Asteraceae	N. America	Unintentional
*Pennisetum clandestinum*Hochstetter ex Chiovenda	Poaceae	E. Africa	Fodder
Peperomia pellucida (Linnaeus) Kunth	Piperaceae	Trop. America	Unintentional
Persicaria chinensis (Linnaeus) H. Gross	Polygonaceae	China	Unintentional
Physalis peruviana Linnaeus	Solanaceae	Trop. America	Unintentional
Plantago erosa Wallich	Plantaginaceae	Mediterranean	Unintentional
Rubus ellipticus Smith	Rosaceae	Trop. America	Unintentional
Senna alata (Linnaeus) Roxburgh	Fabaceae	S. America	Ornamental
Senna tora (Linnaeus) Roxburgh	Fabaceae	S. America	Unintentional
Sida acuta Burman f.	Malvaceae	Trop. America	Unintentional
Solanum torvum Swartz	Solanaceae	West Indies	Unintentional
Solanum viarum Dunal	Solanaceae	Trop. America	Unintentional
Sonchus asper (Linnaeus) Hill	Asteraceae	Mediterranean	Unintentional
Stellaria media (Linnaeus) Villars	Caryophyllaceae	Mediterranean	Unintentional
Stephania japonica (Thunberg) Miers	Menispermaceae	Japan	Unintentional
Synedrella nodiflora (Linnaeus) Gaertner	Asteraceae	West Indies	Unintentional
Tiarella polyphylla D. Don	Saxifragaceae	China	Unintentional
Tithonia diversifolia (Hemsley) A. Gray	Asteraceae	Trop. America	Ornamental
Torenia thouarsii (Chamisso & Schlechtendal) Kuntze	Scrophulariaceae	Trop. America	Unintentional
Tridax procumbens Linnaeus	Asteraceae	C. America	Unintentional
Trifolium repens Linnaeus	Fabaceae	Europe	Fodder
Triumfetta rhomboidea Jacquin	Tiliaceae	Trop. America	Unintentional
Tropaeolum majus Linnaeus	Tropaeolaceae	S. America	Ornamental
Urena lobata Linnaeus	Malvaceae	Trop. America	Unintentional
Youngia japonica (Linnaeus) DC.	Asteraceae	S. America	Unintentional
Zephyranthes carinata Hervert	Liliaceae	Mexico	Ornamental

Appendix 5A.15: Important weeds in Khangchendzonga landscape, India

S. No	Species name	Family	Habit	Availability	Country
1.	*Achyranthes bidentata* Chirchitta	Amaranthaceae	Herb	To 2400 Singtam, Chungthang, Gyalzing, Darjeeling, Jalpaiguri	Java
2.	*Ageratum conyzoides* Ilamay	Asteraceae	Herb	To 2700 Sangklang, Chungthang, Chhaten, Lachen, Darjeeling, Jalpaiguri	Mexico
3.	*Artemisia nilagirica* Titaypati	Asteraceae	Herb	To 2000 Chungthang, Lachung, Darjeeling, Jalpaiguri	South America
4.	*Bidens biternata* Kuro	Asteraceae	Herb	To 2500 Rangpo Khola, Gangtok, Darjeeling, Jalpaiguri	Africa
5.	*Cynodon dactylon* Dubo	Poaceae	Herb	To 2000 Singtam, Tarko, Legship, Darjeeling, Jalpaiguri	South Africa
6.	*Cestrum aurantiacum*	Solanaceae	Shrub	To 2000 Gangtok, Darjeeling, Jalpaiguri	Guatemala
7.	*Cestrum fasciculatum*	Solanaceae	Shrub	To 1800 Gangtok, Darjeeling, Jalpaiguri	Mexico
8.	*Crassocephalum crepediodes* Mudaful	Asteraceae	Herb	To 1200 Mangalbari, Tazko, Selem, Legship, Darjeeling, Jalpaiguri	Africa
9.	*Cuscuta reflexa* Akasbel	Cuscutaceae	Climber	To 1800 Mangalbari, Selem, Darjeeling, Jalpaiguri	Cosmopolitan
10.	*Conyza bonariensis* Kumen	Asteraceae	Herb	2000 Mangalbari, Chakung Chhu, Darjeeling, Jalpaiguri	Europe
11.	*Chenopodium album* Betu	Chenopodiaceae	Herb	To 2500 Rangpo, Singtam, Gangtok, Darjeeling, Jalpaiguri	N. temp
12.	*Dahlia imperilis* Delia	Asteraceae	Herb	To 2000 Gangtok, Darjeeling, Jalpaiguri	Me-xico
13.	*Datura stramonium* Dhaturo	Solanaceae	Herb	To 2000 Tarko, Chakung Chhu, chungthang, Darjeeling, Jalpaiguri	North America
14.	*Eleusine indica* Jangali kodo	Poaceae	Herb	2700 Selem, Chungthang	Africa
15.	*Emilia sonchifolia* Hirankuri	Asteraceae	Herb	To 1200 Mangan, Dikchu, Darjeeling, Jalpaiguri	Africa
16.	*Eragrostis curvula* Weeping Herb	Poaceae	Herb	To 1200 Rangpo khola, Singtam, Darjeeling, Jalpaiguri	South Africa
17.	*Erigeron karvinskianus* Dhungrijhar	Asteraceae	Herb	To 1800 Chakung Chhu, Chungthang, Darjeeling, Jalpaiguri	Mexico to Panama
18.	*Eupatorium adenophorum* Kalobansu	Asteraceae	Shrub	To 2000 Rarko, Rangpo, Tong, Darjeeling, Jalpaiguri	Mexico
19.	*Eupatorium odoratum* Bikhjhar	Asteraceae	Shrub	To 1800 Rangpo Khola, Lower Dzongu, Chunghtnag, Darjeeling, Jalpaiguri	Mexico
20.	*Fagopyrum sp*. Banbhande	Polygonaceae	Herb	2500 Mangan, Chungthang, Lachung	Europe & Northern Asia
21.	*Galinsoga parviflora* Kumain	Asteraceae	Herb	2400 Gyalzing, Gangtok, Chungthang	Trop. America
22.	*Galium aparine* Kuriya	Rubiaceae	Herb	3000 Dikchu, Chungthang, Lachung,	South America
23.	*Gnaphalium affine* Gublu	Asteraceae	Herb	1200 Gangtok, Chungthang	Europe

24.	*Jasminum mesnyi* Juhi	Oleaceae	Shrub	To 2000 Gangtok, Darjeeling, Jalpaiguri	Western China, Yunnan
25.	*Laggera alata*	Asteraceae	Herb	To 1500 Jorethnag, Singtam, Darjeeling, Jalpaiguri	Egypt
26.	*Lantana camara* Kuri, Boksikaanra	Verbenaceae	Shrub	To 1800 Tarko, Legship, Tong, Darjeeling, Jalpaiguri	Tropical America
27.	*Nicandra physaloides* Apple of Peru	Solanaceae	Herb	2000 Singtam, Gangtok	Peru
28.	*Ricinus communis* Arandi	Euphorbiaceae	Shrub	2000 Gangtok, Rangpo, Chungthang, Darjeeling, Jalpaiguri	Africa
29.	*Swertia bimaculata* Bhale chireto	Gentianaceae	Herb	1600 Chungthang, 2000 Lachung	Temperate Asia
30.	*Rubia sikkimenis* Majito	Rubiaceae	Climber	600 Dikchu, Mangan, 1600 Chungthang	Asia
31.	*Tropeolum majus* Nasturtium	Tropaeoleaceae	Climber	2000 Gangtok, Gyalzing	Peru, Brazil
32.	*Tibouchina semidecandra* Glory Bush	Melastomaceae	Shrub	2500 Gangtok	China
33.	*Zantedehschia aethiopica* Darsanay	Araceae	Herb	1800 Rangpo, Singtam, Rumtek, Gangtok	South Africa

Appendix- 5A.16: Important ethnomedicinal plants of Khangchendzonga landscape, India-representative species use for Sikkim and north Bengal

Scientific name (Family)	**Part used**	**Medicinal uses**	**Location distribution**
***Abies densa* Griff.** (Pinaceae)	Leaf and wood	Asthma, bronchitis, stomach pain, fever, expectorant, sore throat, tuberculosis	Sikkim and Darjeeling
Abroma augusta (Sterculiaceae)	Roots, leaves, seeds and fibre	Menstrual disorder, snakebite	Darjeeling
Acacia catechu (Mimosoideae)	Resin and steam	Bodyache, fracture, Stomach ache	Darjeeling, Jalpaiguri and Alipurduar
Aconitum ferox Wall ex Ser. (Ranunculaceae)	Rhizome	During food poison, diarrhea, cough, cold, fever, skin diseases and to relieve gout pain.	Sikkim
Aconitum heterophyllum (Ranunculaceae)	Rhizome	To relieve body-ache, fever, cold, cough, nose discharge etc.	Sikkim
***Aconitum spicatum* Stapf.** (Ranunculaceae)	Rhizome and leaf	During food poison, diarrhea, cough, cold, high fever, headache, inflammation of intestine, stomach trouble, rheumatism, diabetes.	Sikkim and Darjeeling
Acorus calamus Linn. (Araceae)	Rhizome and roots	Cough and cold, toothache, headache, throat pain, measles, fever, bronchitis, diarrhea , dyspepsia, Gastritis, stomach pain, skin diseases and rheumatism	Sikkim and Darjeeling
Ageratina adenophora (Asteraceae)	Leaves and roots	Cuts and wounds, jaundice, rheumatism, dyspepsia.	Darjeeling
Amaranthus spinosus (Amaranthaceae)	Whole plant parts with roots	Fever, stimulant, stomach colic, aphrodisiac, gonorrhea	Darjeeling
Amomum subulatum Roxb. (Zingeberaceae)	Seeds	Used to gargle during teeth and gum infection and urinary infection in cattle.	Sikkim
Artemesia vulgaris Linn.	Crushed leaves	Stop nose bleeding, mouth ulcers, skin	Sikkim

(Asteraceae)		allergy	
Asparagus officinalis (Asparagaceae)	Roots	Jaundice, rheumatism, gout, contraceptive and as laxative	Darjeeling
Azadirachta indica A. Juss. (Meliaceae)	Stem bark, flowers, seeds and leaf	Malaria fever, blood purification, Dyspepsia, vermifuge, controls diabetes	Sikkim, Darjeeling, Jalpaiguri and Alipurduar
***Bergenia ciliata* (Haw.) Sternb.** (Saxifragaceae)	Whole plant	Tonsillitis, toothache, cut and wounds, opthalmia, dysentery, diarrhea and cough	Sikkim and Darjeeling
***Bombax ceiba* Linn.** (Bombaceae)	Root, Latex, leaves and flowers	Diarrhea, dysentery; also as astringent, stimulant, piles.	Sikkim, Darjeeling, Jalpaiguri and Alipurduar
Calotropis gigantea (Asclepiadaceae)	Latex, leaves, flowers, bark, roots	Joint pain, sprain, bone dislocation, septic wounds, asthma, Sores & skin disease, leprosy, leucoderma, ulcers.	Darjeeling, Jalpaiguri and Alipurduar
Cannabis sativa Linn. (Cannabaceae)	Seeds, Mature leaves, & inflorescence	Used in hysteria, asthma, neuralgia, stomachic, astringent, alterative, hypertension, diabetes, spasmodic cough, indigestion	Sikkim, Darjeeling, Jalpaiguri and Alipurduar
Castanopsis indica (Fagaceae)	Trunk bark and seeds	Tonic, antibacterial, anti-inflammatory, diuretic, digestive; diabetes, pneumonia, diarrhea, dysentery, jaundice, constipation, leucorrhoea	Darjeeling, Jalpaiguri and Alipurduar
Catharanthus roseus (Apocynaceae)	Roots and leaf	Hypertension, blood dysentery, anxiety, cough, ulcer and cancer	Darjeeling
Centella asiatica (Apiaceae)	Whole plant	Diarrhea, dysentery, tonic, antibacterial, anti-inflammatory, diuretic, digestive; diabetes, pneumonia, jaundice, constipation, leucorrhoea, Tonsillitis and memory improvement.	Darjeeling, Jalpaiguri and Alipurduar
Cinnamomum tamala (Buch.-Ham.) Nees. & Eberm. (Lauraceae)	Stem bark and leaves	Memory enhancer, diarrhoea, ophthalmia, gonorrhea, rheumatism and scorpion bites.	Sikkim and Darjeeling
Costus speciosus Smith. (Zingiberaceae)	Rhizomes, roots and stem	Burning urination, jaundice, diabetes, kidney diseases, anti-inflammatory, fever, biliuria, rheumatism, neuralgia	Sikkim, Darjeeling, Jalpaiguri and Alipurduar
Dactylorhiza hatagirea (D Don) Soo. (Orhidaceae)	Rhizome, Tubers and roots	Cut & bleeding wounds, ringworm, chronic fever, expectorant	Sikkim and Darjeeling
Datura stramonium (Solanaceae)	Fruits	Asthma, whooping cough, parkinsonism, bronchial and gastro intestinal problems, indigestion, neuralgia, rheumatic pain	Jalpaiguri and Alipurduar
Dioscorea bulbifera (Dioscoreaceae)	Tuberous roots and bulbils	Alternative, tonic, aphrodisiac, stomachic, expectorant, anthelmintic; dyspepsia, urinary discharge, bronchitis, leucoderma, piles, tumours, strangury, asthma, ulcers, Gastritis	Darjeeling, Jalpaiguri and Alipurduar
Elsholtzia blanda (Lamiaceae)	Young shoots, leaves and seeds	Diarrhea, sores, gastritis, cholera	Darjeeling
Ephedra gererdiana Wall. Ex Stapf (Ephedraceae)	Ripe fruit	Relief from altitude sickness and indigestion. Stem powder is inhaled to get relief from headache.	Sikkim
Evodia fraxinifolia Hook. f. (Rutaceae)	Ripe fruit and seeds	Applied on the forehead during giddiness and chutney form is taken during	Sikkim

		indigestion.	
Ficus benghalensis (Moraceae)	Whole plant	Astringent, tonic; ulcers, vomiting, fever, inflammation, leprosy, piles, diseases of nose, gonorrhea, syphilis, dysentery, liver problems, rheumatism, toothache, diabetes, gastritis.	Darjeeling, Jalpaiguri and Alipurduar
Gloriosa superba (Liliaceae)	Tubers and flowers	Ulcer, leprosy, rheumatic fever, skin diseases, piles and expectorant.	Darjeeling
Heracleum wallichii DC. (Apiaceae)	Mature seeds, dried fruits and fresh leaves	Treat sinusitis, influenza, vomiting, stomachache, Gastritis, bodyache, throat pain.	Sikkim and Darjeeling
Manihot esculenta (Euphorbiaceae)	Root	Ulcers	Jalpaiguri and Alipurduar
Moringa oleifera (Moringaceae)	Barks, flowers, seeds and fruits	Tumors, leucoderma, liver disorder, snake bite, heart complaints, body ache, Indigestion, flatulence	Darjeeling, Jalpaiguri and Alipurduar
Oroxylum indicum (L.) Kurz (Bignoniaceae)	Root bark, seeds, leaves and stem bark	Diabetes, rheumatic swellings, fever, bronchitis, vomiting, dysentery, leucoderma, asthma, piles, heart trouble, inflammation; anthelmintic, stomachic, tonic, carminative, purgative, appetizer, Jaundice, food poisoning, diabetes, ulcer, tonsillitis and pneumonia.	Sikkim, Darjeeling, Jalpaiguri and Alipurduar
Pandanus nepalensis St. John (Pandanaceae)	Tender leaves from upper part of the stem	Act as an antidote to snake poison/bite, Fresh leaves act as cockroach repellant.	Sikkim
Phytolacca acinosa Roxb. (Phytolaecaceae)	Fresh tap roots and leaves	Relieves body pain, Food poisoning and high blood pressure	Sikkim and Darjeeling
Picrorhiza kurrooa Royle ex Benth. (Scrophulariaceae)	Rhizome	Malarial fever, chronic fever, and respiratory disorders, cold and cough, stomach pain, diarrhea, dysentery, headache	Sikkim
Pouzolzia sanguinea (Urticaceae)	Roots, foliage	Bone fracture	Darjeeling
Rauvolfia serpentina (Apocynaceae)	Roots	Mental retardation, depression, snake bite, insomnia, epilepsy, Hypnotic, sedative, blood pressure scorpion sting.	Darjeeling, Jalpaiguri and Alipurduar
Rheum acuminatum Hook. f. & Thomson (Polygonaceae)	Root	applied on forehead during severe headache, dysentery and intestinal problems	Sikkim
Rhododendron arboreum Smith Ericaceae	Dried petal, Both fresh and dry flowers	Diarrhea, blood dysentery and throat pain, headache, tonsillitis, mouth sores.	Sikkim and Darjeeling
Ricinus communis (Euphorbiaceae)	Seeds, bark, leaves and roots	Constipation, intestinal worm, rashes, rheumatic pain, neuralgia, headache and fever	Darjeeling, Jalpaiguri and Alipurduar
Rubia cordifolia Roxb. ex Fleming (Rubiaceae)	Leaf and root	Fever, stomachache and dysentery, cure urinary infection, cuts and wounds.	Sikkim
Rubus ellipticus Smith (Rosaceae)	Roots and young shoots	Tonsillitis & diarrhea, colic pains, fever and gastritis	Sikkim, Jalpaiguri and Alipurduar
Rumex nepalensis Sreng. (Polygonaceae)	Roots & leaves	Constipation, stomach colic, syphilis, ulcer, ringworm	Sikkim and Darjeeling
Solanum nigrum	Mature fruits,	Fever, gonorrhea, piles, dysentery.	Darjeeling

(Solanaceae)	roots and leaves		
Swertia bimaculata (Gentianaceae)	Entire plant parts with roots	Cold, fever, body ache, headache and gastritis	Darjeeling
Swertia chirayita (Roxb. Ex Flem.) H. Karst. (Gentianaceae)	Whole plant parts with roots	Fever, malarial fever, body ache, diabetes, blood purifier, throat pain headache, back ache, cold, cough, diarrhea, and stomach-ache	Sikkim and Darjeeling
Viscum album Loranthaceae	Aerial plant parts	Bone fracture and body ache	Darjeeling
Woodfordia fruticosa Lythraceae	Fresh and dry flowers and stem bark	Dysentery, astringent tonic, piles, leprosy, disease of blood, toothache, leucorrhoea, menorrhagia, dysentery.	Darjeeling, Jalpaiguri and Alipurduar
Zanthoxyllum alatum Roxb. Rutaceae	Branchlet	Berries (2-3) taken to cure stomach ache and toothache	Sikkim

Appendix-5A.17: Genera and Species of Wild Edible Plants present in KL, India

S. No	Genera	No. Of species	S. No	Genera	No. Of species	S. No	Genera	No. Of species
1	*Abroma*	1	**2**	*Aconogonum*	1	**3**	*Actinidia*	2
4	*Aeer*	1	**5**	*Aegle*	1	**6**	*Agapetes*	1
7	*Agaricus*	1	**8**	*Aglaia*	1	**9**	*Allium*	2
10	*Amomum*	1	**11**	*Amorphophallus*	1	**12**	*Ampelocissus*	1
13	*Angiopteris*	1	**14**	*Annona*	1	**15**	*Antidesma*	2
16	*Ardisia*	2	**17**	*Arisaema*	2	**18**	*Artocarpus*	1
19	*Arundinaria*	1	**20**	*Baccaurea*	2	**21**	*Bauhinia*	3
22	*Begonia*	1	**23**	*Berberis*	2	**24**	*Bergenia*	1
25	*Bistorta*	1	**26**	*Boerhaavia*	1	**27**	*Bombax*	1
28	*Calamus*	2	**29**	*Callicarpa*	1	**30**	*Camellia*	1
31	*Canarium*	1	**32**	*Cardamine*	1	**33**	*Carissa*	1
34	*Caryota*	2	**35**	*Casearia*	1	**36**	*Cassia*	2
37	*Castanopsis*	2	**38**	*Cayratia*	1	**39**	*Celosia*	1
40	*Cephalostachyum*	1	**41**	*Chassalia*	1	**42**	*Chenopodium*	2
43	*Cinnamomum*	2	**44**	*Cissus adnata*	3	**45**	*Citrullus*	1
46	*Clausena*	2	**47**	*Colocasia*	1	**48**	*Cornus*	1
49	*Corylus*	1	**50**	*Cyathea*	1	**51**	*Cycas*	1
52	*Debregeasia*	1	**53**	*Decaisnea*	1	**54**	*Deeringja*	1
55	*Dendrocalamus*	1	**56**	*Dillenia*	2	**57**	*Dioscorea*	5
58	*Diospyros*	2	**59**	*Diplazium*	1	**60**	*Diploknema*	1
61	*Ehretia*	1	**62**	*Elaeagnus*	1	**63**	*Elaeocarpus*	3
64	*Emblica*	2	**65**	*Entada*	1	**66**	*Eriolobus*	1
67	*Eryngium*	1	**68**	*Eurya*	1	**69**	*Evodia*	1
70	*Fagera*	1	**71**	*Ficus*	9	**72**	*Flacourtia.*	1
73	*Flemingia*	1	**74**	*Floscopa*	1	**75**	*Fragaria*	1
76	*Garcinia*	2	**77**	*Garuga*	1	**78**	*Gaultheria*	1
79	*Girardinia*	1	**80**	*Glinus*	2	**81**	*Grewia*	6
82	*Gynocardia*	1	**83**	*Heracleum*	1	**84**	*Hippophae*	1
85	*Hodgsonia*	1	**86**	*Holboellia*	1	**87**	*Horsfieldia*	1
88	*Hottuynia*	1	**89**	*Hovenia*	1	**90**	*Hydrocotyle*	1
91	*Indigofera*	1	**92**	*Juglans*	1	**93**	*Kadsura*	1
94	*Lasia*	1	**95**	*Laurocerasus*	1	**96**	*Leea*	4

97	*Leoregeasia*	1	**98**	*Litsaea*	1	**99**	*llex*	2
100	*lndigofera*	1	**101**	*Machilus*	1	**102**	*Maesa*	1
103	*Mahonia*	1	**104**	*Malus*	1	**105**	*Mangifera*	1
106	*Manihot*	1	**107**	*Medicago*	2	**108**	*Melia*	1
109	*Mollugo*	1	**110**	*Momordica*	2	**111**	*Morus*	2
112	*Murdannia*	1	**113**	*Murraya*	2	**114**	*Musa*	1
115	*Mussaenda*	1	**116**	*Myrica*	1	**117**	*Nasturtium*	1
118	*Oenanthe*	1	**119**	*Oroxylum i*	1	**120**	*Oxalis*	1
121	*Oxyria*	1	**122**	*Paeonia*	1	**123**	*Pandanus*	1
124	*Parthennocissus*	1	**125**	*Pentapanax*	1	**126**	*Persicaria*	3
127	*Phlogacanthus*	1	**128**	*Phoenix*	2	**129**	*Phrunium*	1
130	*Phyllanthus*	1	**131**	*Phytolacca*	1	**132**	*Piper*	3
133	*Podophyllum*	1	**134**	*Polygomum*	2	**135**	*Portulaca*	2
136	*Prinsepia*	1	**137**	*Prunus*	2	**138**	*Pyrularia*	1
139	*Pyrus*	1	**140**	*Rheum*	2	**141**	*Rhododendron*	1
142	*Rhus*	1	**143**	*Rosa*	1	**144**	*Rubus*	3
145	*Rumex*	1	**146**	*Sapindus*	1	**147**	*Saurauia*	3
148	*Schizandra*	1	**149**	*Sesbania*	1	**150**	*Shorea*	1
151	*Smilacina*	1	**152**	*Sorbus*	2	**153**	*Spondias*	2
154	*Sterculia*	4	**155**	*Svzvaium*	1	**156**	*Swertia*	1
157	*Syzygium*	5	**158**	*Tamarindus*	1	**159**	*Taxus*	1
160	*Terminalia*	2	**161**	*Tetrastigma*	3	**162**	*Theropogon*	1
163	*Trachyspermum*	1	**164**	*Tupistra*	1	**165**	*Turpinia*	1
166	*Urtica*	1	**167**	*Vaccinium*	1	**168**	*Viscum*	1
169	*Wallichia*	1	**170**	*Zanthoxylum*	2	**171**	*Zingiber*	2
172	*Ziziphus*	2						

Appendix -5A.18: Wild Edible Plants of the Khangchendzonga Landscape, India

Plants	**Local Name**	**Plant Part Used**	**Availability**
Abroma augusta L.	Chuit	Roasted seed/seed oil	Oct-Jan
Aconogonum polystrachyum	Amldandi/Chuchi	Shoot	Jun-Sep
Actinidia callosa Hook.	Thekiphal	Fruit	Nov-Dec
Actinidia strigosa Hook.	Taksingrik	Fruit	Oct-Nov
Aeer caudatus Wall.	Kapashe	Sweet sap is relished	Jan-Dec
Aegle marmelos Corr.	Bel		-
Agapetes serpens (W) Sleumr	Harchur	Flower	Mar
Agaricus spp.	Chayao (4 varie.)	Fruiting body	Jun-Aug
Aglaia edulis A. Gray	Sanulahsune	Fruit	Mar-Jun
Allium caesium	-	Plant	Jul-Aug
Allium wallichii Kunth.	Dung-dunge	Whole plant	Jun-Jul
Amomum aromaticum Roxb.	-	-	-
Amorphophallus bulbifer (Roxb.) BI.	-	-	-
Ampelocissus lancifolius Planch.	-	Fruit	Jul-Aug
Angiopteris evecta (Forst.) Hoffm.	-	Rhizome	Jan-Dec
Annona reticulata L.	Sharip hal	-	-
Antidesma acidum Retz.	-	-	-
Antidesma acuminatum Wall.	Kalo Bilaune	Fruit	Dec-Jan
Ardisia crispa (Thunb.) DC.	Cham	Flower	Nov-Dec
Ardisia macrocarpa Wall.	Damaigera	Berries	Oct-Apr
Arisaema tortuosum (Wall.J Mart.ex	-	-	-

Schott.			
Arisaema utile Hook. f.	Banko	Root tuber	Jul-Aug
Artocarpus lakoocha Roxb.	Badar	Fruit	Jun-Aug
Arundinaria sp. Gamble	Malingo	Fruit	Oct
Baccaurea ramiflora Lour.	Kusum	-	-
Baccaurea sapida Roxb.	Kabum	Fruit	Apr-Jul
Bauhinia purpurea L.	Tanki	Pod/seed	Feb-Apr
Bauhinia vahlii Wt. & Am	Bhorla	Pod	Jan-Feb
Bauhinia variegate L.	Koiralo	Leaves, flower bud	Mar-Apr
Begonia hatacoa Buch-Ham-D.Don	-	Young leaves/Petole	Apr-May
Berberis asiatica Roxb.	Kissu	Berries	Sep-Oct
Berberis chitoia DC.	Chutro	Berries	Oct-Nov
Bergenia ciliata (Har.) Stenb.	Pakhanbhed	Leaf	Nov-Dec
Bistorta vivipara Linn.	Maslun	Leaves, new shoot	Jun
Boerhaavia diffusa L.	-	-	-
Bombax ceiba L.	Semal	Seed	Apr-Jun
Calamus ereetus Roxb.	Betphal	Fruit	Mar
Calamus flagellum Griff.	Betagainra	New bud/kernels	Mar-Apr
Callicarpa arborea Roxb.	Guyenylo	Fruit	Nov
Camellia kissi Wall.	Kissi	Leaves tea substitute	Jan-Dec
Canarium bengalense Roxb.	Marockpa	Fruit	Jan
Cardamine griffithii Hk. f. & T.	-	Plant	Jun-Aug
Carissa paucinervia A.DC.	-	-	-
Caryota urens L.	Rangbhang	Fruit	Jan
Caryota urens L.	Rangbhang	-	-
Casearia glomerata Roxb.	Barkunle	Foliage	Apr-May
Cassia fistula L.	Rajbriksh	Pulp/fruit	Apr-May
Cassia sophera L.	-	-	-
Castanopsis purpurella Balakr.	Katus	Nut	Nov-Dec
Castanopsis tribuloides (Sm)	Patle-katus	Nut	Oct-Dec
Cayratia carnos (Wall) Gagnep.	Amarbel	Berries	Sep-Dec
Celosia sp. L,	Lalisag	Leaves	Jan-Jun
Cephalostachyum capitatum Munro	Tama bans	New shoots	Apr-Aug
Chassalia ophioxyloides (Wall) Craib	-	Seed oil	Mar-Jul
Chenopodium album L.	Lattey sag	Plant	Jul-Aug
Chenopodium ambrosioides L.	-	-	-
Cinnamomum impressinervium Meissn.	Sissi	Leaves/bark as spices	Jan-Dec
Cinnamomum tamala Nees.	Tejpat, Sinkoli	Leaves/bark spices	Jan-Dec
Cissus adnata Roxb.	Charchare	Berries/Leaves	Feb
Cissus repanda Vahl.	Panilahera	Plant	Jun-Sep
Cissus repens Lamk.	Pureni	Berries	Sep-Oct
Citrullus colocynthis Schrad.	Indrani	Roasted seeds	Sep-Oct
Clausena dentata Burm.	-	Bud	May-Jun
Clausena willdenowii Wi & Am.	Sidemyok	Fruit	Jul
Colocasia esculenta (L.) Schott	Kochu	-	-
Cornus capitata Wall.	-	Pulp is relished	Sep-Oct
Corylus ferox Wall.	Thekiphal	Fruit	Jul-Nov
Cyathea brunoniana CBC& Baker	Pashien	Stem pith	Jan-Dec
Cycas pectinata Griff.	Thakal	Fruit	Dec-Jan
Debregeasia wallichiana Wedd.	Bahuni lahara	Fruit	Jul-Aug
Decaisnea insignis Hk. f. & T.	Bherasingh	Fruit	Oct
Deeringja amaranthoides (Lamk.) Merr.	Bakrisag	-	-
Dendrocalamus hamiltonii Arn.	Tamba	New shoots	Jun-Oct

Dillenia indica L.	Panchpal/Chalta	Fruit	Mar-April
Dillenia pentagyna Roxb.	Tautri	Fruit	April-un
Dioscorea bulbifera Br. L.	Bantarul	Tuber	Nov-Apr
Dioscorea oppositifolia Linn.	Githa	Tuberous root	Dec-Mar
Dioscorea pentaphylla L.	-	-	-
Dioscorea prazeri Prain & Burkill	-	-	-
Dioscorea puber BI.	-	-	-
Diospyros malabarica Kostel	-	-	-
Diospyros melanoxylon Roxb.	-	-	-
Diplazium esculentum (Retz.) SW.	Niguro	Shoot	Jan-Dec
Diploknema butyracea Roxb.	Churl	Fruit	May-Jun
Ehretia acuminata R.Br.	-	-	-
Elaeagnus latifolia L.	Goeli, Muslendi	Fruit	Mar-May
Elaeocarpus floribundus BI.	-	-	-
Elaeocarpus lancifolia Roxb.	Bhadrasey	Fruit	Sep
Elaeocarpus sikkimensis Mast.	Bhadrasey	Fruit	Jul
Emblica gamblei Kruz	Patiamala	Foliage	Jan-Dec
Emblica officinalis Gaertn	Amala	Fruit	Oct-Mar
Entada purseatha Benth.	Pangra	Soaked/boiled seeds	Oct-Jan
Eriolobus indica Schn	Mehel	Fruit	Jun-Feb
Eryngium foetidum L.	Brahmadhania	Leaves as pickle	Jan-Dec
Eurya acuminata DC	Jhingini	Flower/leaves as beverage	Jan-Dec
Evodia trichotoma (Lour) Planch	Khanakpa	Fruit	Oct-Nov
Fagera oxyphylla Edgew	Timur	Fruit	Oct-Jan
Ficus bengalensis Linn.	Bar	Fruit	Mar-May
Ficus benjamina L.	Kabra	Fruit	Mar-Apr
Ficus glomerata Roxb.	Dumri	Fruit	May-Jun
Ficus hirta Vahl	Khasreto	Fruit	Aug
Ficus hispida Linn.	Koksa	Fruit	Aug
Ficus hookerii Corner	Nebara	Fruit	Nov
Ficus roxburghii Roxb.	Nebara -	Fruit	Apr-May
Ficus semicordata Buch-Ham	Khaniu	Fruit	May-Jul
Ficus virens Ait	Kabra	Young leaves	Sep-Oct
Flacourtia jangomas (L.) Raeusch.	-	-	-
Flemingia macrophylla (Willd.)Merr.	-	-	-
Floscopa scandens Lour.	-	-	-
Fragaria vesca L.	Bhui aselu	Fruit	Jan-Feb
Garcinia kydia Roxb.	-	-	-
Garcinia unitoria (DC) Wt	Chunyel	Fruit	Mar-Apr
Garuga pinnata Roxb.	Dabdabe	Fruit	Aug-Sep
Gaultheria fragrantissima Wall.	Machino	Fruit	Sep-Oct
Girardinia palmata Gand.	Bhangre sisnoo	Young shoot	Mar-Jun
Glinus lotoides (O.Ktze.) L.	-	-	-
Glinus oppositifolius (L.) DC.	-	-	-
Grewia elastica Roxb.	Kunsung	Fruit	Feb-May
Grewia sapida Roxb.	Kuail	Fruit	Feb-Apr
Grewia subinaequalis DC.	-	-	-
Grewia tlllafolia Vahl.	-	-	-
Grewia vestita Roxb.	Syalphusrey	Flower bud	Apr-May
Grewla dlsperma Rottb.	-	-	-
Gynocardia odorata R.Br.	Bandre, Gante	Pulp	Nov-Jan
Heracleum wallichii DC.	Chimphing	Fruit in pickle	Oct
Hippophae rhamnoides Linn.	Chuma/Durchuk	Fruit	Mar-Apr

Hodgsonia macrocarpa (B1) Cogn.	Darsani	Seed oil	Jun-Nov
Holboellia latifolia Wall.	Gufla,Kuolrik	Fruit	Oct-Nov
Horsfieldia kingii Warb.	Runchepat	Fruit	Jan-Apr
Hottuynia cordata Wall.	Hiley-jhar	New leaves/twigs	Jul-Aug
Hovenia dulcis Thunb.	Bangikath	Shoot	Sep
Hydrocotyle javanica Thunb.	-	-	-
Indigofera hamiltonii Duthie	-	Pod	Jan-Feb
Juglans regia L.	Okhar	Fruit	Sep-Nov
Kadsura heteroclita T. ex Benth.	Saladorik	Fruit	Aug-Sep
Lasia spinosa (L.) Thw.	-	-	-
Laurocerasus undulata Roem.	Lekh arupate	Fruit	Sep-Oct
Leea asiatica (L.) Ridsd.	-	-	-
Leea indica (Burm.f.) Merr.	-	-	-
Leea macrophylla Roxb.	Bulyettra	Berries	Oct-Nov
Leea sambucina Willd	Galene	Berries	Aug-Oct
Leoregeasia wallichiana Wedd	-	Fruit	Sep
Litsaea citrata BI.	Siltimur	Fruit as pickle	Mar-May
llex insignis Hk. f.	Lise	Fruit	Oct
llex sikkimensis Hk. f.	Lise	Fruit	Sep-Oct
Indigofera cassioides Rottl	--	Pod	Jan-Apr
Machilus edulis King	Kawlo, Pumsi	Fruit	Jan-Mar
Maesa chisia D. Don	Bilaune	Fruit	Apr-Aug
Mahonia sikkimensis Takeda.	Chutro/Keshri	Berries	Mar-Apr
Malus sikkimensis	Aiphal	Fruit	Oct
Mangifera sylvatica Roxb.	Chuche anp	Fruit	Jul-Oct
Manihot esculenta Crantz	-	-	-
Medicago lupulina L.	-	-	-
Medicago polymorpha L.	-	-	-
Melia composita Willd.	Lapsi/Silotkung	Fruit	Jan
Mollugo pentaphylla L.	-	-	-
Momordica diolea Willd.	-	-	-
Momordica eochinchinensis Spreng.	Bon-karela	Fruit	Jun-July
Morus australis Poir.	Sanu-kimbu	Fruit	Apr-May
Morus laevigata Wall.	Kimbu	Fruit	May-Jun
Murdannia blumei (Hassk.) Brenan.	-	-	-
Murraya koenigii Spreng.	Mechia sag	Leaves in curries	Jan-Dec
Murraya paniculata (L.) Jack.	Mechiasag	-	-
Musa balbisiana Colla.	Bankera	Fruit	Jan-Dec
Mussaenda roxburghii Roxb.	Dobiphu	Foliage	Jun-Aug
Myrica gale L.	Kaphal	Fruit	Feb-Apr
Nasturtium officinale	Simrayo	Shoot	Jan-Dec
*Oenanthe javanica (*BI.) DC.	-	-	-
Oroxylum indicum	Totla	Flower, Buds, leaves	Jan-Dec
Oxalis corniculata L.	-	-	-
Oxyria digyna Hill	Amlu	Whole plant	Jul-Aug
Paeonia emodi Wall. ex Royal	Bhuma madrya	Young leaves	Mar-Jun
Pandanus nepalensis	Tarika	Fruit	Jun-Aug
Parthennocissus himalayana Planch.	Charchare	Fruit	Sep
Pentapanax leschenaultii Seem	Chindey	New shoot as pickle	Mar-May
Persicaria barbata	-	Leaf	Jun-Aug
Persicaria macrophylla D. Don	-	Leaf	May-Jun
Persicaria runcinata Ham.	-	Tender shoot	Jul
Phlogacanthus thyrsifloum Nees.	Chua	Flower	Jan-Mar

Phoenix acaulis Roxb.	Thakul, Schap	Fruit a betel nuts	Mar-May
Phoenix rupicola T. Anders.	Schap	Pith of stem	Jan-Dec
Phrunium Dubinere BI.	-	-	-
Phyllanthus emblica L.	Amla	-	-
Phytolacca acinosa Roxb.	Jaringo	Fruit	May
Piper longum L.	Pipli	-	-
Piper nepalense	Khorsani	Fruit	Oct
Piper peepu/oides Roxb.	-	-	-
Podophyllum emodi Wall.	Papri	Fruit	Jun-Jul
Polygomum molle D. Don	Thothne	Shoot	Jun-Jul
Polygomum plebium	Bethe	Whole plant	Mar-Apr
Portulaca oleracea L.	-	-	-
Portulaca pilosa spp.grandiflora Gessink	-	-	-
Prinsepia utilis Royal	Phekrey	Fruit	Mar-Apr
Prunus cerasoides D. Don	Paiyun	Fruit	Oct
Prunus nepalensis Koch.	Arupate	Fruit	Apr-May
Pyrularia edulis A. DC.	Amphi	Fruit	Jul-Oct
Pyrus pashia D. Don	Naspati	Fruit	Aug-Sep
Rheum nobile Hk. f. & Rhoms	Tohuka	Tender shoot	Mar-May
Rheum spiciforme Royle	Lachu	Root	Aug
Rhododendron arboreum Sm.	Gurans	Flower as beverage	Mar-Apr
Rhus semialata Murr.	Bhakimlo	Fruit as pickle	Oct-Dec
Rosa macrophylla Lindl.	Bangulab	Fruit	Nov-Dec
Rubus calycinus Wall.	Bin-Aselu	Fruit	Jul-Oct
Rubus elllipticus Smith	Aselu	Fruit	Jul-Nov
Rubus niveus Thunb.	Kalo aselu	Fruit	Apr-Jun
Rumex nepalensis Spreng.	Halhale	Leaves, petiole	Jul-Aug
Sapindus detergens Wall.	Ritha	Endosperm	Jan
Saurauia napaulensis DC.	Gogun	Fruit	Oct-Dec
Saurauia punduana Wall.	Safa	Fruit	Oct-Dec
Saurauia roxburghii Wall.	Dangsipha	Fruit	Feb
Schizandra grandiflora Hk. f. & T.	-	Fruit	Jun-Oct
Sesbania sesban (L.) Merr.	-	-	-
Shorea robusta Roxb.	Sakuwa	Seed oil	May-June
Smilacina oleracea Hk. f. & T.	-	Whole plant	Jun-Aug
Sorbus cupsidata Hedl	Tengra	Fruit	Nov-Dec
Sorbus hedlundi	Tengra	Fruit	Dec
Spondias axillaris Roxb.	Lapsi	Fruit	Oct-Dec
Spondias pinnata (L.f.) Kurze.	-	-	-
Sterculia fulgens Wall.	Labshi	Fruit	Jan-Dec
Sterculia hamiltonii (Kuntze) Adele	Chiuripat	Fruit	May-Jul
Sterculia pallens (Wall.) Stern	- -	Seed	May-Jun
Sterculia roxburghii Wall.	Churipat	Seed	May-Jun
Svzvaium lormosum {Wall.} Masamune	-do-	-	-
Swertia chirata (Roxb.) Karst	Chirauto	Whole plant as medicine	May-Oct
Syzygium claviflorum Wall.	Harejamun	Fruit	Aug-Oct
Syzygium cumini (L.) Skeels	Jamun	-	-
Syzygium jambos (L.) Alston.	-do-	-	-
Syzygium kurzii (Duthie) Balakr.	Ambakey	Fruit	Mar-Apr
Syzygium operculatum (Roxb.) Niedenzn.	Piamon	-	-
Syzygium tetragonum Wall.	Chamlane	Fruit	May-Jun
Tamarindus indica L.	Titri	Fruit	Mar

Taxus baccata L.	Cheongbu	Fleshy axil	Sep-Nov
Terminalia belerica Roxb.	Barra, Horitoki	Fruit as medicine	Dec-Jan
Terminalia chebula Retz.	Harra, Pitali	Fruit-rind	Dec-Jan
Tetrastigma bracteolatum Planch.	Toludorrik	Fruit	Dec-Jan
Tetrastigma lanceolarium (Roxb.) Planch.	Charchare	-	
Tetrastigma rumicispermum Planch.	Toludorrik	Fruit	Oct-Nov
Theropogon pallidus Maxim	-	Root bulb	Jul-Aug
Trachyspermum amni (L.) Sprague ex Turrill	-	-	-
Tupistra nutans Wall.	-	Whole plant	Sep
Turpinia nepalensis Wall. ex W&A	Thali, Nagpat	Fruit	Sep-Dec
Urtica dioica L.	Patle sishnu	New leaves	Jan-Dec
Vaccinium vacciniaceum	Cham	Flower	May
Viscum articulatum Burro.	Harchur	Plant as medicine	Jan-Dec
Wallichia disticha T. Anders.	Thakal	Pith as sago	Jan-Dec
Zanthoxylum nitidium (Roxb.) DC	Parpartimur	Fruit	Jan
Zanthoxylum rhetza (Roxb.) DC	Boketimur	Fruit as pickle	Jul-Aug
Zingiber roseum (Roxb.) Rosc.	-	-	-
Zingiber rubens Roxb.	-	-	-
Ziziphus mauritiana Lamk.	Ber	-	-
Ziziphus oenoplia (L.) Mill.	-	-	-

Appendix 5A.19 Most common species of mushrooms and their descriptions in the KL-India

Species	**Descriptions**
Auricularia auricular	Commonly known as black ear mushroom as it possesses ear like leathery and soft gelatinous cap of dark tan colour, usually found on cut logs or felled *Alnus* logs during rainy days. The stalk is very short or absent at times. It possesses a leathery texture and hence not much preferred by the locals.
Agaricus spp.	Mushrooms are sporadically found in the soils during the rainy season. They bear an almost round cap, usually white or brownish in colour with a smooth or sometimes scaly surface. The stalk is central, short and fleshy. It is attracted for its firm flesh. Some of the edible species commonly found are *Agarics Augustus, A. campest is, A. Caesarea.*
Lycoperdon spp.	These mushrooms are of globose to pyriform structures, borne singly or in clusters, creamy white in colour and slightly pubescent with small black bristle tips. Species like *L. elongatum* and *L. emodense* are inedible, grows amongst grasses, while *L. perlatum* and *L. pyriform* are edible at young stages growing on fallen leaf litter and decaying tree trunks respectively.
Pleurotus spp.	It is locally known as Kannae cheaoe or Kotuchae cheaoe. The pileus is central, broad, often sessile and smooth with colour varying in shades of white. The stalk is absent generally, when it present, it is short and lateral. *P. citrinopileatus* and *P. ostreatus* are commonly found growing on tree trunk and decaying wood, and are greatly preferred for the delicious taste.
Termitomyces clypeatus	It is found around the termite mounds, distinguished by the prominent cone like pointed, dark-coloured projection at the centre of the cap. The stalk is central, solid and long above ground. This is one of the most delicious mushrooms found in nature and its curry emits chicken like flavour during cooking. It is the most dominant species among all the wild edible mushrooms of Sikkim.
Termitomyces heimii	It is locally known as Kaloongae cheaoe and is associated with termite nests. A patch of veil is always present at the top of the pileus and the skin peels off easily. The stalk is long and swollen near the attachment with the cap. The portion of the stalk underground is longer than that above ground. The natives relish the taste of this

	delicious mushroom, which is similar to that of fried bamboo shoot.
Termitomyces mammiformis	It is most popular among the natives as Jharae cheaoe and emerges from sandy soil under bamboo trees. The pileus is white in colour with silvery, shinning and smooth surface. The stalk is white and solid. The mushroom is delicious but due to its small size, the volume is much reduced after cooking.
Termitomyces microcarpus	It is one of the most prevalent species of specific part of KL-India i.e. Sikkim and associated with colonies of ants and anthills, which grows profusely in bamboo grooves from beneath fallen bamboo leaves growing in clusters of enormous numbers like wild flowers. It becomes pulpy after cooking and with a meat-like taste, it is one of the best species (Kalita and Rathaiah, 1995).

(**Source***:* Borah and Rahman, 2011)

Appendix-5B.1: Some important horticultural crops including fruits and tubers grown in the marginal farming lands in Khangchendzonga landscape, India

S. No	Common name	Scientific name	Part used	S. No	Common name	Scientific name	Part used
1	Apple	*Molus sylvestris*	Fruit	**2**	Areca nut	*Areca catechu*	Fruit
3	Avocado	*Pesea americana*	Fruit	**4**	Banana	*Musa* spp.	Fruit
5	Bitter orange	*Citrus medica*	Fruit	**6**	Cassava	*Manihot esculenta*	Tuber
7	Coconut	*Cocus nucifera*	Fruit	**8**	Common pear	*Pyrus communis*	Fruit
9	Fox Grape	*Vitis acida*	Fruit	**10**	Grape fruit	*Citrus parasidis*	Fruit
11	Guava	*Psidium guajava*	Fruit	**12**	Indian Butter Tree	*Aesandra butyracea*	Fruit
13	Indian Gooseberry	*Embilica officinalis*	Fruit	**14**	Jackfruit	*Artocarpus heterophyllus*	Fruit
15	Lapsi	*Spondias auxillaris*	Fruit	**16**	Lime	*Citrus aurantiifolia*	Fruit
17	Litchi, lychee	*Litchi chinensis*	Fruit	**18**	Mandarin orange	*Citrus reticulata*	Fruit
19	Mango	*Mangifera indica*	Fruit	**20**	Marumi Kumquat	*Fortunella japonica*	Fruit
21	Money Jack	*Artocarps lakoocha*	Fruit	**22**	Papaya	*Carica papaya*	Fruit
23	Passion fruit	*Passiflora* sp.	Fruit	**24**	Peach	*Prunus persica*	Fruit
25	Pineapple	*Ananas comosus*	Fruit	**26**	Plum	*Prunus domestica*	Fruit
27	Pomegranate	*Punica granatum*	Fruit	**28**	Rough Lemon	*Citrus junos*	Fruit
29	Rough Lemon	*Citrus jambiri*	Fruit	**30**	Supari	*Areca catechu*	Fruit
31	Taro	*Colocasia* spp.	Tuber	**32**	Walnut	*Juglans regia*	Fruit
33	Wood-apple	*Aegle marmelos*	Fruit	**34**	Yam	*Dioscorea* spp.	Tuber

Based on: Sharma and Acharya, 2013

Appendix- 5B.2 Domestic animals and their importance within the KL, India

Sl. No.	Name	Breed	Domestic and farm use
1.	Banpale (Sheep)	Local breed (found in West Sikkim, Pokhari, Dzongri, Yambong, Narkhola)	Wool, meat, milk, procreation, rituals (sacrifice)
2.	Buffalo	Local	Milk, cheese, procreation, meat, skin
3.	Byanglung (Sheep)	Tibetan breed (found in North Sikkim, Tso-Lhamu, Lhonak, Muguthang)	Wool, meat, milk, procreation
4.	Cat	Local	Control of pests, especially rodents
5	Cow	Local (*Pahade*, *Siri*)	Milk, cheese, manure, butter, procreation, and meat
6.	Dog	Local breed	Guarding house, agriculture field against wild animals
7.	Dog	Tibetan Mastiff	Guard yak/sheep/goat herds (Greater and

			Trans Himalaya)
8.	Domestic fowl	Local	Egg and meat, customary rituals (sacrifice)
9.	Duck/Goose	Local	Egg and Meat, customary rituals (sacrifice)
10.	Dzo (yak-cow/male)	Male offspring (crossbreed of cow and yak)	Pack animal in Yuksam-Dzongri trekking trail, meat
11.	Dzomo/Urang	Female offspring (crossbreed of cow and yak)	Pack animal in Yuksam-Dzongri trekking trail, meat
12.	Goat	Chyangra (found in North Sikkim, Tsolhamu, Lhonak, Muguthang)	Meat, procreation, customary rituals (sacrifice), *khadgo-katne* (sacrifice during illness)
13.	Horse	Local	Pack animal
14.	*Lho-yak*	Yaks brought from Southern part of Tibet, i.e. Bhutan (Yumesamdong-Lachung)	Milk, cheese, butter, meat, fur, skin, procreation pack animal in high altitudes (Yuksam-Dzongri)
15.	Mule	Local	Pack animal
16.	Ox	Local (*Pahade*, *Siri*)	Draught animal, manure, breeding
17.	*Phe-Yak*	Original Tibetan breed (Trans Himalaya: Tso-Lhamu, Lhonak, Lashar, Muguthang)	Milk, cheese, butter, meat, fur, skin, procreation, pack animal in high altitudes (Thangu-muguthang)
18.	Pig	Local Sungur/Bangur	Meat
19.	Pigeon	Local	Meat, customary rituals (sacrifice)
20.	Yak	Nepalese breed (Greater Himalaya: Dzongri, Lhonak, Lashar, Muguthang)	Milk, cheese, butter, meat, fur, skin, procreation, pack animal in high altitudes (Yuksam-Dzongri)

Appendix 5B.3 On-farm crop diversity under existing traditional farming systems in Khangchendzonga landscape, India

Crops (scientific names)	**Local names**	**Landraces in practice**
Rice (*Oryza sativa*)	Dhan	Ghyya-dhan, Takmaru, Bhuindhan, Phudugey, Bachhi, Lalbachhi, Sanu-bachhi, Timmurey, Marshi, Nangkatwa, Krishnabhog, Tulashi, Bagheytulasi, Faramey-Tulashi, Sikrey, Tsungthangey, Kalchanti, Mansaro, Taprey, Nuniya, Kataka, Dudhkalam, Champasari, Bangi, Jhapaka, Phaudel, Thulo Attey, Maili Attey, Sanu Attey, Kanchi-Attey, Kalomarshi, Bhotangey, Chirankhey, etc.
Maize (*Zea mays*)	Makai	Seti-makai, Rato-makai, Panheli-makai, Kali-makai, Pangri-makai, Himali-makai, Murali-makai, Farashi-makai, etc.
Finger millet (*Eleucine coracana*)	Kodo	Pangdur, Mudkey, Chamligey, Bhadaurey, Kattikey, Mangshirey, Panchaunley, Nangkatwa, Tangsere etc.
Buckwheat (*Fagopyrum tataricum*)	Phaper	Mithey-phaper, Titey-phaper, Kere-phapar, Yapha, Tambong-kere etc.
Wheat (*Triticum aestivum*)	Gahu	Tho, Mashi, Si, Toksongsi, etc
Barley / cultivars	Jau	Jau, Uwa, Hoski, Tingshi
Yams (*Dioscorea* spp.) *Colocasia* sp. *Sechium* sp. *Ipomea* sp.	Tarul Bhyagur	Rato-ghartarul, Gittho, Seto-ghartarul, Ban-tarul, Patalley, Logo, Bhyagur, Rittho, Wakhey, Su, Suthani, Mithey-gittho etc. Pindalu, Lankey, Seto Karkalo, Maney, Kalo Karkalo, Kachhu etc. Iskushko Tarul, etc. Seto Sakarkhanda, Rato Sakarkhanda, etc.

		Simal Tarul, Phul Tarul, etc.
Pumpkin (*Cucurbita* sp.)	Pharsi	Lamchey thulo, Lamchey sano, Kalo Pharsi, Seto pharsi, Dalley pharsi, Auley pharsi, Panheley, Lekali pharsi, Maddhesey-paharsi pahadey pharsi, etc.
Mustard (*Brassica* spp.)	Tori/ Rayo	Kalo-tori, Seto-tori, Pahenlo-tori, Sarsewn, Chringla-rayo, Chilley-rayo, Phoppa-rayo, etc.
Soybean (*Glycine max*)	Bhatmas	Nepali Bhatmash, SetoBhatmash, Kalo Bhatmash, etc.
Pulses and Beans/ Legumes	Dal/Simbi /Bori	Ghew simbi, Singtamey simbi, Sadamey simbi, Harey simbi, Borungey simbi, Montulal simbi, Nepali simbi, Hiundey simbi, Bakuley simbi,Ghew bori, Khostey Bori, Soshta bori, Tuney bori, Kalo Bori, Kerau, Pahenli dal, Masyam dal, Rahari dal, Rajma, Khesari, Gahat, Arhar, Kauchhey, Dudhey matar, Hadey matar, etc.
Banana (*Musa* sp.)	Kera	Kabuli kera, Kadali, Dhushrey, Chinichampa, Ghew kera, Malbhog, Mungrey kera, Nangrey kera, Ban-kera, Jhapari, etc.
Chili (*Capsicum* spp.)		Sanhili-khorsani, Akabarey-khorsani, Dalley-khorshani, Lamchey-khordani, Bhindey-khorsani, Dhindey-khorsani, Jirey-khorsani etc.
Citrus (*Citrus* spp.)	Suntola/Jamir/Kagatey	Suntola, Kagati, Nimbu, Nibuwa, Bimirow, Bhogatey, Sunkhotro, Phoksey, Kali jyambir, Jyambir, Kamal, Naietey jyambir, Chaksi, Muntola, etc.
Large cardamom (*Amomum subulatum*)	Alainchi	Ramsai, Golsai, Madhusey, Bharlangey, Chibe, Seremna, Ramla, Sawney, Ramnang, Churumpho
Ginger (*Zingiber officinale*)	Aaduwa	Gorubathaney, Bhainsey, Majhauley, Jorethangey, Nangrey, etc.

(Compiled by Sharma G; personal communication)

Appendix- 6.1 Schemes on forest management by GOI and State Govt. in the KL, India

Schemes	**Objectives**
Centrally Sponsored Schemes – Forest Management	
Bamboo Plantation Scheme	Conservation, improvement and increase production of bamboo for providing regular income to the tribal and rural poor living in and around forests
Management Action Plan (MAP) for Conservation and Management of Khangchendzonga Biosphere Reserve –Sikkim	Improving and strengthening various actions for the improvement of conservation management in the KBR, including infrastructure improvement, community involvement and research
Integrated Forest Protection Scheme	Prevention and control of forest fire and improvement in the status of forest protection
River Valley Project- Teesta and Kangsabati	On watershed basis for management plan
Development of National Parks and Sanctuaries	Protection and development of wild life and bio-diversity in National Parks and Sanctuaries of North Bengal
Assistance to States for Development of Parks and sanctuaries- Khangchendzonga National park-Sikkim	Development of protected area for strong management and field support for monitoring and taking up the challenges
Forest Development Agency under National Afforestation and Eco-Development Board of National Afforestation Programme, Govt of India	Taking up the national objectives at Sikkim level

Eco-Development around Protected Areas	Socio-economic development of the forest fringe population to reduce pressure on biodiversity in the protected areas
Grants-in-Aid under 12. Finance Commission	Maintenance of older plantations, purchase of patrolling vehicles, arms and ammunitions and also for afforestation
Singalila National Park	Management of biological resources of Singalila NP, which is located at highest Altitude Zone of the State, representing a number of rare endangered fauna
Gorumara National Park	Improvement and preservation of wildlife habitat in Gorumara NP, which is famous for one-horned Rhino and Bison
Neora Valley National Park	Management and improvement of bio-ecological resources of Neora valley NP which is unique for its rich diversity of flora and fauna spreading over altitudinal zone of 2000 to 3000 m
Medicinal Plants Conservation and Area Development Programme	Promote in situ and ex situ conservation of medicinal plants, through survey and inventory of medicinal species, development of better techniques for plantation and assisted natural regeneration of medicinal plants, documentation of medicinal plants in the state and extension activities
National Afforestation Programme	Regeneration and Eco-development of integrated forest and adjoining areas on a watershed basis, augmenting the availability of fuel wood, fodder and grass, securing peoples' participation in plantation and regeneration efforts, promotion of agro-forestry and development of government property and resources, conservation and improvement of NTFP, raising coastal shelter belt to mitigate the adverse impacts of cyclones, development of water resources thorough afforestation and water harvesting programme, extension of improved technology as the clonal propagation and use of root training, employment generation for the disadvantaged section of society, particularly women, SC/ST and landless rural labourers
State sponsored schemes: Afforestation and Forestry Development Schemes (WB)	
Protective Afforestation	Afforestation and soil conservation works in the vulnerable areas
Eco-Conservation of Sensitive Zones	Restore the ecological balance in highly erosion prone areas of Darjeeling. The nature of treatment under this scheme includes afforestation, gully plugging, construction of earthen dam, check dams, stream bank protection etc
Economic Plantation	The degraded forest areas of the Dooars and Terai have to be separated as per provisions of approved Working Plan. Some areas in alluvial zone also have been identified for raising plantations of mixed hard wood species. There is also take care of all younger plantations
Silvi-Pastoral	Weed infestation, inter-planting by grass, legumes and other fodder crops is taken up between plantation lines
Creation/improvement of Parks,Gardens, Urban Forestry and Greening of Rural areas	Aesthetic and recreational aspects of people is being increasingly felt in rural, semi-urban and urban areas
Decentralized Peoples' Nurseries	Kishan Nurseries under the programme to cover up the blank degraded areas outside the Forest areas
Strip Plantation	Plantations on roadsides canal banks and sides of the railway lines
Forest Resource Survey	Survey of forest resources using Geographical Information System, updated forest resource position continuously for future planning
Forest consolidation	Maintain the boundaries of forest areas through periodic survey and demarcation
Development of Forest communications	Improving communication in forest areas to improve the status of forest protection, quick transportation of harvested forest produces and better access to the remote forest fringe villages
Buildings	Forest personnel have to live in forest areas for forest protection and execution of developmental works. Construction of staff quarters, barracks, check posts, etc.
Forest Protection	Strengthen forest protection like providing mobility to field staff, procurement of arms and ammunitions, expansion and up gradation of R.T. Network, etc.

Working Plan	For working of forest areas, working plans need to be prepared and got approved by GOI. The Working Plan divisions are entrusted with the writing and revision of working plans. All activities connected with the exercise are funded from the scheme
Management Information System	Develop comprehensive and informative database in terms of the adopted policy of the State Govt., and linked all district offices to Headquarters of the Directorate
Research and Seed Propagation	Seed and tree improvement, establishment of seed stands and seed orchards, vegetative propagation trials, progeny trials, seed testing, grading and certification, species provenance and introduction, improvement of nursery practices, agroforestry, silvi-pastoral and ecological studies
Wildlife and Bio-diversity	Species conservation depends first and foremost on the habitat conservation, Bulks of the wildlife schemes are directed towards this end and have specific wildlife and bio-diversity focus i.e. protection of flagship, keystone, rare and endangered species in the protected areas
Allied Works Components	Survey and demarcation of external forest boundaries, improvement of forest roads, construction of small earthen dams and other water-bodies for ground water recharging, gully control and watershed management social amenities, income generation and employment for the sustenance JFM
Monitoring and Evaluation	Provided to monitor and evaluate the success of the plantations using scientific sampling methods
Training	Training of forest staff in wildlife, soil conservation, general forestry management, computer application, research, seed technology, social forestry and other sectors connected with fringe areas
Timber operation	One of the thrust areas is judicious harvesting of forest resource compatible with ecological, economic and environmental needs. As contractor system has been abolished in West Bengal, this operation is done wholly departmentally in North Bengal. Such harvesting of final and intermediate yield as per provisions of approved Working Plan not only creates substantial employment in rural areas but also generates revenue
Economic rehabilitation of fringe population	Participatory approach in management of forests in some agro-ecological zones implant scheme in the right frame. Such efforts need to be nurtured through appropriate JFM-support activities on adopted micro-plans continuously
Intensification of Management	Strengthening the infrastructure through acquisition of tools for management of data collection, storing and retrieval system in different spheres of activities
Amenities to forest staff and labour	Providing amenities to forest staff and forest villages
Publicity-cum-Extension	Generation of awareness about forests, wildlife and biodiversity conservation throughout the state
Development of Singalila National Park	Management of biological resources of Singalila National Park representing at the highest altitudinal zone and has representation of a number of rare and endangered fauna
Development of Neora Valley National Park	Management and improvement of bio-ecological resources of Neora Valley NP, the park is unique in having rich diversity of flora and fauna from 2000 to 3000 m
Lloyd Botanical Garden	Development of prestigious Lloyd Botanical Garden situated in Darjeeling and having potential of being developed as a model garden for the flora of montane and temperate areas
Forestry Research	Forestry research is an essential component of forest management and improving the quality of planting stock, selection of suitable species in different agro-climatic zones
Rural Infrastructure Development Fund(RIDF)	NABARD assisted programme towards improving economic standard of fringe dwellers through afforestation and other developmental works, i.e., construction and maintenances of roads, construction of irrigation channels, school buildings, community centres, ring wells, dug wells etc.

(Source: State forest reports of both Sikkim and West Bengal)

Appendix- 6.2 Different schemes on wildlife management in the Khangchendzonga landscape, India

Schemes	Objectives
External and Centrally Sponsored Schemes- Wildlife management in KL-India	
Elephant Project	Development of elephant habitats, reduction of man-elephant conflicts, capacity building of elephant squads and also for economic uplift of the forest fringe people of the Eastern Dooars Elephant Reserve
Jaldapara Wildlife Sanctuary	Improvement and preservation of wildlife habitat in Jaldapara WS
Mahananda Wildlife Sanctuary	Management of Mahananda WS, which harbours a large number of rare and endangered species of wildlife
Chapramari Wildlife Santuary	Improvement and preservation of wildlife habitat in Chapramari WS in Jalpaiguri district
Khangchendzonga Biosphere Reserve and other sanctuaries in Sikkim	Multiple activities for the conservation management of wildlife, habitat improvement, infrastructure improvement, research, etc.
Sikkim Biodiversity Conservation and Forest Management Project (SBFP), sponsored by Japan International Cooperation Agency (JICA) since 2010-11.	To further strengthen, improve and create the existing policies, programmes and infrastructure development of the Department of Forest, Environment and Wildlife
Integrated Forest Management Scheme	Forest Fire control and Management, working plan, survey and demarcation, Strengthening of infrastructure for Forest Protection, Control and Eradication of Forests invasive Species Conservation and Restoration of the Unique Vegetation and Eco- Systems, and , Conservation and Restoration of Unique Vegetation and Eco Systems, etc.
State sponsored schemes: Afforestation and Forestry Development Schemes	
Development of Mahananda, Senchal and Gorumara Wildlife Sanctuaries	Management of Mahananda, Senchal and Gorumara WSs which have a large number of rare and endangered species
Wildlife and Biodiversity	Habitat conservation for flagship, keystone, rare and endangered species in the protected area
Nature Conservation- Protection and Improvement of Wildlife	Improvement of wildlife habitats in different forest areas of for improving the WSs and NPs
Tiger Reserves in Buxa	These are 50 % centrally sponsored scheme for overall development of Tiger Reserves and Eco-development works, and other developmental programmes
Jaldapara Wildlife Sanctuary	Improvement and preservation of wildlife habitats in Jaldapara sanctuary focusing Rhino habitat
Setting up a centre for Wildlife and Sustainable Forest Management	Wildlife and sustainable forest management and running courses on wildlife management and other related subjects jointly with IIT, Kharagpur
Control of Poaching	Control of poaching of rare and endangered animals viz. tiger, rhino, elephant etc. needs to be accorded highest priority
Integrated Development of wildlife habitats in Sikkim	Habitat development, conservation, anti-poaching, awareness, field staff strengthening and infrastructure strengthening, etc. under different wildlife protected areas and sanctuaries
Compensatory afforestation fund management and planning agency (CAMPA) schemes (Sikkim)	Compensatory afforestation , catchment area treatment planning, wildlife conservation and protection plan development and any other relevant work accomplishments

(Source: State forest reports of forest departments of West Bengal and Sikkim)

Appendix- 6.3 Some institutions working in the field of biodiversity conservation and management in Khangchendzonga landscape, India

Institution engaged in Biodiversity Conservation and management in KL, India	**Areas of expertise and experience**
a) Governmental organizations	
G. B. Pant Institute of Himalayan Environment and Development, Sikkim unit	Himalayan biodiversity conservation and management, Integrated watershed management, Ecosystem services, Herbals and RET plants conservation, Biotechnological interventions in saving rare plants, , Eco-tourism, Farm-based technology development, Training and awareness in capacity building, Glacial case studies, Natural spring sanctuary, etc.
Forest, Environment and Wildlife Management Department (FEWMD), Govt of Sikkim	Conservation and management of environment, Natural resources management, Forest and wildlife protection, Capacity building, Socio-economic approaches, etc.
Directorate of Forest, Govt of West Bengal	Conservation and management of environment and natural resources, Forest and wildlife protection, Capacity building, Socio-economic approaches, Natural resource management
Department of Science and Technology, Govt of Sikkim	Climate change, Remote sensing, Biodiversity Conservation, Science and technology, Wetland management
Institute of Environmental Studies and Wetland Management (IESWM)	Wetland management, Water resources, Climate change
North Bengal University (Himalayan Study Unit), Siliguri, North Bengal	Biodiversity, Water resource, Himalayan environment, Socio-economic development
Sikkim University, Sikkim	Natural resource management, Biodiversity, horticulture, Socio-economic development
Botanical Survey of India	Taxonomic and floristic studies on wild plant resources, Inventorization of the flora
Zoological Survey of India	Taxonomic study on animals from Protozoa to Mammalia, Inventorization of the faunal elements
b) Non-governmental organizations	
TMI, India	Himalayan biodiversity conservation and management, Water resource management, Agrobiodiversity management, Ecosystem services, Awareness, Wildlife management, etc.
Himalayan Nature and Adventure Foundation-Siliguri	Environmental movements, wildlife Conservation and Nature Education for children and youth, etc.
Ecotourism and Conservation Society of Sikkim (ECOSS)	Ecotourism, Conservation and development, Capacity building
Dooars jargon, Shantipara, Jalpaiguri	Eco-tourism, socio-economic, management, etc.
Khangchendzonga Conservation Committee (KCC)	Eco-tourism through home stay, Zero-waste management, Conservation of biodiversity, Conservation education and awareness programmes, etc.
ATREE, Sikkim/Darjeeling	Himalayan biodiversity conservation and management, Ecosystem management, Water resource management, Socio-economics, Awareness, etc.
PRERNA, Darjeeling	Himalayan biodiversity conservation and management, Water resource management, Socio-economics, Awareness, etc.
Center for Moutnain Dynamics, Kalimpong	Tourism, Cultural biodiversity awareness, livelihood options, etc.
WWF, Sikkim	Biodiversity monitoring, Environment and Wildlife Management, Environmental education viz-a-viz awareness

Sikkim Parayavaran Sanraksan Sangh (SPSS)	Agrodiversity and NTFPs promotion, Sustainable utilization of natural resources, Rehabilitation and afforestation activities, Water source conservation, Reducing forest and wildlife offences, Conservation Education: generating awareness, Appropriate technology intervention
Mutanchi Lom Aal Shezom (Community based NGO), Namprikdang, North Sikkim	Socio-economy, Health, traditional knowledge, sacred landscape, etc.
Green Circle	Capacity building on ecological ethics, Environmental protection, Environment education

Appendix 6.4 Milestones of environment and Wildlife Management in KL-India

Milestones	**Year**
• Forest Department set up. Reserve and Goucharan forests surveyed and demarcated; Forest Manual, a statute book for department adopted for operationalization; Sidkeong Tulku, the then Crown Prince of Sikkim pioneered the step ably aided by D.S. Ghale, the Bengal Forest Officer on deputation to Sikkim	1909
• Rai Sahab Bhim Bahadur Pradhan joins Forest Department and becomes Forest Manager after five years of service in Sikkim.	1919
• German scientist Ernst Schaefer expedition to Sikkim and identification of SHAPI or Himalayan Tahr at Phimphu, North Sikkim as distinct variety; advocacy for its total protection	1930
• Forests vested to the Darbar from under the ownership of landlords in different districts, a task ably implemented by Atal Singh Dewan, Range Officer in Sikkim.	1945-46
• First Cadastral survey to demarcate Revenue and Forest Lands in Sikkim	1952
• Indian Peafowl introduced into lowland Sal forests, South Sikkim	1972
• Extension of Indian Wildlife (Protection) Act 1972 to Sikkim	1976
• Khangchendzonga National Park (KNP) of area 850 km^2 declared	1977
• Kyongnosla Alpine Sanctuary and Fambong Lho Wildlife Sanctuary, East Sikkim; Shingba Rhododendron Sanctuary, North Sikkim declared	1984
• Jore Pokhari Salamander Sanctuary declared	1985
• Maenam Wildlife Sanctuary, South Sikkim, declared	1987
• Sikkim State formulates and adopts Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act, 1988	1988
• Forest Survey of India completes Forest Resource Survey of all districts in Sikkim • Modified resolution of West Bengal Protected Forest Rules 1956, No. 4461– for D/1S-16/88, where forest dwellers allowed to collect some NTFPs	1988-89
• Buxa Tiger Reserve declared in West Bengal	1990
• Singhalila National Park, Neora Valley National Park declared	1992
• Sikkim Democratic Front (SDF) Government announces and adopts "Harit Kranti Dashak" for greener Sikkim through people's participation • Cattle grazing in Reserve Forests, an age-old practice that had led to depletion of forest wealth, banned in Sikkim	1995
• Ban on use of non-biodegradable materials like plastics, poly bags etc. in Sikkim • KNP extended from 850 to 1784 sq. km. (25.10 % of total geographical area)	1997
• State award "Rajya Van Samrakshan Evam Paryavaran Puraskar" constituted • Barsey Rhododendron Sanctuary, West Sikkim declared • Participatory forest management introduced involving active peoples' participation through Joint Forest Management Committees (JFMCs) (26 June 1998) • Subsequent notification issued for Eco Development Committees (EDCs) in Sikkim • Five PAs (i.e. Senchal Wildlife Sanctuary, Mahananda Wildlife Sanctuary, Jaldapara National Park, Chapramari Wildlife Sanctuary, Gorumara National Park) declared in NWB	1998
• Dr. Pawan Chamling, Chief Minister of Sikkim adjudged Greenest Chief Minister of India by	1999

Delhi- based Centre for Science and Environment • Sikkim government adopted new nomenclature 'Forest, Environment and Wildlife Management Department' in tune with changing focus and shift in approach and objective • Smriti Van (Memorial Forests) concept by the Govt. of Sikkim at Bulbuley above Gangtok to take forestry programmes to people's level. All strata of people, individuals, institutions, clubs, societies and nongovernmental organizations participate by planting trees in memory of children, marriage, death etc. at a common venue and care, own and nurture trees to maturity. Smriti Vans now at each Panchayat Unit • Sikkim Government formulates, adopts State Forest, Environment and Land Use Policy in view of growing concern for protection of forests, environment and wildlife vis-a-vis increased developmental tempo	
• Khangchendzonga Biosphere Reserve with area 2619.92 Km^2 declared in Sikkim and total wildlife protected area 30.77 % of total geographical area which is the highest in the country • Eco Clubs and Green fund for Schools and Colleges in Sikkim	2000
• Sacred peaks, caves, rocks, lakes, 'chhortens' and hot springs notified in Sikkim. • Scaling of important peaks including the Mount Khangchendzonga banned. • JFMC/EDCs network and Watershed Development Committees (WDCs) created in Sikkim • State Biodiversity Park at Tendong, South Sikkim established.	2001
• Environmental Education introduced in Schools from Nursery to Class-8 in Sikkim • State Medicinal Plant Board (SMPB) set up • Herbal Gardens created in different Panchayats, care and management with technical inputs from the forest department of Sikkim • Sikkim to go organic; ban on chemical fertilizers/pesticides to save fields from scourge of pollution • Pangolakha Wildlife Sanctuary, East Sikkim declared	2002
• Eleven Important Bird Areas (IBAs) in Sikkim identified and recognized by government • Government of India, through its scientific wing, the Forest Survey of India records increase of forest cover in the state by 2 % between the period 1994-2003, the result of department's relentless regeneration efforts and the Government's intense policy focus in Sikkim	2003
• Green Indicators, 2004 a report developed by Noida –based group finds the Forest Protection Index of Sikkim to be the highest in the country (0.903) • First state in Himalayas to use Global Positioning System (GPS) to survey and demarcate Reserve Forest boundaries in Sikkim	2004
• Sikkim Ecology Fund and Environment Cess Act, 2005 framed. This Act provides for levy of cess on industries, traders and consumers for articles which pollute environment • Ban on killing of wildlife strengthened in Sikkim	2005
• Regulation of Trekking Rules, 2006 notified in Sikkim • Kitam Bird Sanctuary, South Sikkim declared • Sikkim State Green Mission, one of the most innovative policy articulations by State Government to realign people to the giant task of protecting, managing and regenerating the greenery in the state on their own with the Department guiding and supervising various operations • Constitution of State Biodiversity Board to oversee and manage the rich biodiversity of the Sikkim • Sikkim State Biodiversity Strategy and Action Plan (SBSAP) documented • Wetland Conservation Programme formulated and six wetland complexes included in National Wetland Conservation Programme in Sikkim	2006
• State Glacial Commission formulated • National Bamboo Mission launched in Sikkim and West Bengal	2007
• Eco-Tourism Directorate created (SK) • Hamro Van media venture on local cable TV launched for awareness • Chogyal Palden Thendup Namgyal Park, Gangtok, created • Sikkim Forests, Water Courses and Road Reserve (Preservation and Protection) Act 1988 got	2008

assent from President of India (16 May 2008) • Campaign in forest area (North Bengal)- implementation of forest right act-2008	
• Awarded following appreciation from Centre for Development Finance, a prominent NGO (SK): ➢ First in Natural Resource Management ➢ First in performance in Land Use and setting up of State Council for Climate Change ➢ Second best ranking in Environmental Sustainability Index (SK) ➢ Sling Dong Tinkitam Fairrieanum Conservation Reserve, South Sikkim for the protection of orchid *Paphiopedilum fairrieanum* and its environment declared ➢ Working Plan under completion; Wildlife Management Plans under implementation ➢ Terms of Reference (TOR) signed between department and Japanese International Cooperation Agency (JICA) funded externally aided project with focus to promote ecotourism and natural resource conservation ➢ Forest Centenary 1909-2009 ➢ Ten minutes to Greenery	2009
• International Rhododendron Festival in Sikkim • State Action Plan for Climate Change (West Bengal)-scoping workshop on same topic	2010
• Sikkim Ecotourism Policy proposed and Sikkim Biodiversity Action Plan prepared • First people's summit on Environment in West Bengal • The West Bengal Fact Finding Commission on Environment inaugurated	2012

(Source: (i) Anonymous: Sikkim forestry a 100 years of service. Department of forest, environment and Wildlife Management, Government of Sikkim, Deorali, Gangtok 737102; (ii) Many reports and publications on North Bengal part of KL, India

Appendix 8.1 Major topics under Biodiversity Action Plan of Sikkim and its activities (S-short; M-medium and L-long)

Topics	Recommended Actions (Time duration)
Develop Biodiversity database	• Establish a state biodiversity information system (S) • Conduct biodiversity surveys and inventories (M) • Conduct regular surveys to monitor changes in species (L) • Update the list of endangered flora and fauna (S) • Assess populations and monitor species (L) • Develop a database on traditional knowledge (M) • Study and document microbial diversity (M) • Build the capacity of law enforcing officials (S)
In-*situ* biodiversity conservation	• Explore the scope for further expansion of the PA network (M) • Strengthen the capability of the DFEWM Directorate of Research (M) • Strengthen the DFEWM Directorate of Research to coordinate (M) • Evaluate the ongoing programs to address human animal conflict (S) • Initiate well-planned eco-development programmes (M) • Establish and notify permanent preservation plots (S) • Conduct research on species biology and ecosystem function (M) • Promote reintroduction and recovery of threatened plants and animals (L) • Strengthen the capability of DFEWM and other agencies (L) • Identify habitat for key wildlife species outside of PAs (M) • Strengthen forest fire-fighting program (L) • Conduct surveys of economically-important native bio-resources (M) • Develop strategies for conservation of unique wetlands (S) • Identify and recognize large and old trees, declare as heritage trees (S) • Link major butterfly habitats through strategic corridor development (M) • Develop approach to conserve identified Important Bird Areas (IBA) (S) • Complete proposal for inscription of KBR, KNP as World Heritage site (M)
Ex-situ biodiversity conservation	• Develop and standardize propagation and mass multiplication protocols (L) • Develop and standardize the conservation breeding protocols (M)

	• Conserve the genetic diversity of native land races (L) • Identify the seed viability and develop storage technologies (M) • Encourage propagation and cultivation of wild economic plants (M) • Create new botanical gardens and parks (M) • Improve labelling in existing and new gardens (M) • Develop new ex-*situ* conservation facilities (M)
Agro-biodiversity Conservation	• Register local varieties under the Farmers Rights Act (M) • Ensure direct access to market (M) • Preserve local germplasm of field and horticultural crops (L) • Identify hotspots of agro-biodiversity and cropping systems (M)
Impact of climate change	• Identify the vulnerability of different sectors of the state (L) • Identify priority habitats for species and ecosystems (S) • Use plant phenology as an indicator of climate change (L) • Undertake other multidisciplinary research (M) • Develop adaptive management approaches for relevant (M)
State Development Activities and Biodiversity Conservation	• Involve local agencies in impact assessments (EIA) (L) • Enforce the guidelines (L) • Monitor the preparation and implementation of EMPs (L) • Build capacity of the department to carry out Mid-term assessment (L) • Avoid the development projects affecting wetlands and other areas
Impact of pollution	• Conduct research to study the impacts of different types of pollution • Manage industrial effluents (L) • Promote the use of organic manures, bio-fertilizers, bio-insecticides (L)
Biodiversity conservation with use of technological interventions	• Use of conventional and biotechnological tools (M) • Encourage value added production from the local bio-resources (M)
Sustainable utilization of biodiversity resources	• Identify and document ethno-biological knowledge, (S) • Identify alternate income generating activities (M) • Promote the management of bamboos and canes and other NTFPs, (M) • Promote agroforestry on private lands (M) • Promote bee keeping improving pollination and livelihoods (M) • Document, disseminate and promote best practices (M) • Promote *ex-situ* cultivation of high value trade taxa (M) • Extend traditional sustainable land use practices (M)
Management of invasive species	• Conduct research on ecological assessment of invasive species (L) • Strengthen measures to contain and manage of invasive species (L) • Develop system for early warning (M) • Support capacity building particularly (S) • Support restoration of area affected by invasive species (M) • Establish procedures to ensure invasive species do not enter Sikkim (L)
Valuation of Biodiversity Resources	• Develop a system of natural resource accounting (M • Support studies to validate the valuation process (M)
Promotion of Awareness on Biodiversity	• Provide training to government and non-government agencies (M) • Make available literature based on research and documents (S) • Increase the awareness of law enforcement staff on biodiversity (S)
Policy, legislation and administrative measures	• Strengthen the capacity of state and local institutions (M) • Review the policies and laws for conservation and management (M) • Prepare Peoples Biodiversity Registers and strengthen mechanisms (S) • Include the evaluation of biodiversity (L)
Regional, national	• Establish contact with UN bodies (S)

and international coordination	• Seek the cooperation of other research institutions and universities (S) • Maintain a database of scientific and technical persons (S) • Annual brainstorming workshops (M) • Outsource research or establish joint ventures with research agencies(S)

(Source: Sikkim Biodiversity Action Plan 2012)

Appendix 9.1 Major issues and gaps under broad subject areas in Khangchendzonga landscape, India

Thematic area	Issue (s)	Gap areas
Physical parameters	Land use or land cover alteration	Insufficient information on land use and land cover changes
	Delineation of eco-climatic zones	limited information on weather parameters at spatial scale
	Degradation of wetlands	limited information available for KL-India, especially for plains of north-Bengal
	Shrinking natural water resources including springs; water crises at both Himalayan and terai part	Deficit information on detailed scientific assessments especially for north Bengal part
	Rapid urbanization- speedy expansion of settlements and towns	Policy gaps, assessments and studies are lacking, relatively
	Soil erosion and declining soil fertility	Widespread studies and assessments are insufficient
	Solid waste management-growing problem even in suburbs and road side village areas	Assessment of policy implementation, carrying capacity studies and management not up to the mark
	Mega development projects- a debated issue at local to global scale	Fewer case studies including policy implications and sustenance of resources
Climate change and environmental hazards	Climate change driven signatures visibility on various biological entities and ecosystems	Non-availability of an extended time-series climatic data for different ecological zones; Lack of climate change modeling at different eco-system levels of KL, India
	• *Distribution range shifting*- Snow Leopard, Blue Sheep, Him Tahr • Habitat alterations by climate change • Phenology shifts in various indicator species	Insufficient scientific data /information especially taking with case studies, Temporal and spatial level information lacking; photographic evidences are largely un-available, No long term scientific evidences; no periodical monitoring mechanisms like phenological stations/phenol-gardens, etc.
	Experiencing change in cropping pattern	Insufficient long-term scientific based extensive studies of climate sensitive crops
	Receding glaciers due to climate change	Limited modeling on prediction of temperature driven changes in glaciers' receding pattern
	Widely depleting natural resources due to climate change	Factors responsible to the depletion are not systematically/adequately worked out
	High frequencies of landsides	Assessment is lacking on weather-driven or anthropogenic; Suitable mitigation modeling not available
	Earthquakes– the KL, India is a sensitive zone	Appropriate policy framework is week towards on field implementation

	Tourism flow and carrying capacity are not sufficiently coinciding to climatic change driven hazards	Insufficient assessment on carrying capacity of places and sectors and lack of knowledge on climate change driven hazard predictions
Socio-economics	Diverse economic and social conditions amongst agro-climatic zones and societal sectors	Unequal opportunities, policy implications, systematic statistical inferences and modeling for possible road maps lacking
	Unemployment, drug addiction and suicides of youths in landscape	Sound assessments of reasons behind and behavioral analysis-based studies are lacking
	Long term sustainability issue of nature-based tourism	Lack of community-based tourism plan and programs, sustainable issues not worked out
	Availability of alternative livelihood options	Lack of practical approach- based modeling to strengthen self sufficiency of people, inadequate framework interlinking the human resource capacity with those of natural resources and infrastructure, Insufficient knowledge based on value addition in NTFPs
	Declining cash crop productivity and area under cultivation, especially the large cardamom	Lacking scientific based evaluation of crops and farming practices with changing scenario
	Gender equity and social inclusion	Studies lacking in insufficient presence of women in governance and policy making exercises
	Alternative energy sources	Alternative energy resource not properly ascertained, especially for the Jalpaiguri-Alipurduar area
	Unregulated tourism	Highly insufficient data available, studies and planning on resource linkages for the low-land and high-land tourism not available
	High population density of firewood users (especially in tea gardens), Huge cattle population and grazing problem especially in low land areas	Alternative fuel source lacking, limited provision for fodder. Unresolved conflict between wildlife and cattle, lack of extensive assessment over the issue
	Tea Industry health and economic condition of workers	Policy gaps and unresolved governance issues
Biodiversity	Poor representation of biodiversity database	Fragmented information on biodiversity components, patterns and processes
	Habitat degradation	Lack of scientific information on population dynamics, ecology, and human impacts
	Conservation status of tiger population in BTR	Insufficient population data and weak monitoring support
	Human-wildlife conflict (Elephant, Bison, Leopard, Wild Boar, Rhesus Monkeys)	Poor implementation of conservation action plan of endangered and scheduled species, insufficient assessment studies
	Threat to rhinoceros population	Inadequate support to implementation of conservation action plan, insufficient studies
	Growing pressure on rangeland biodiversity	Inadequate monitoring and assessment studies on flagship species
	Poaching/illegal trade of animals along the KL-India corridors	Not enough management resources, inadequate data sets
	Red Panda – high altitude movement between India and Nepal in Khangchendzonga-Singalila complex	Poor monitoring and data deficient

	Illegal collection of high altitude herbs	No assessment studies available on extraction impacts on natural habitats
	Impact of introduction of exotic species on local flora and fauna	Bleak information available
	Capturing/hunting of wildlife	Insufficient monitoring and assessment
	Unsustainable harvesting of plant resources	Assessment and monitoring lacking, relatively
	Increasing incidence of forest fires	Weak management infrastructures and inadequate warning system
Agrobiodiversity /Livestock	Depletion of genetic crop diversity for KL	Limited information on characterization of agrobiodiversity, introduction of HYVs
	Declining traditional farming systems	Lack of germplasm bank facilities at the regional level, lack of value addition
	Livestock and grazing issues	Very fragmented information, not sufficient to generalize even a region
	Migration of farming manpower to urban areas	Limited opportunities and recognition in rural sector
	Agro-forestry farming practices under threat	Eco-evaluation and awareness lacking, policy gaps
	Large cardamom crop under threat	No solution available for diseases, scientific studies not up to the mark, negligence in farming management and policy gaps
	Organic farming (in part in Darjeeling and relatively absent in Jalpaiguri-Alipurduar area)	Policy gaps, lack of knowledge and capacity building, assessment of gestation period lacking
	Cinchona plantations and socio-ecological susceptibility	Scientific assessment on long-term sustainability lacking
	Fragmentation of landscape due to tea gardens	Assessment of farming options for tea garden workers highly inadequate
	Extensive use of agrochemicals in farming system in north Bengal	Inadequate scientific assessment and poor knowledge dissemination mechanism
	Yak status	Long-term socio-ecological assessment lacking
	Status of livestock (increasing in the plains, decreasing in the hills)	Limited fodder resource in the hills, unmanaged grazing regime in the plains
Ecosystem functions and services	Underestimation of ecosystem functions and services	Highly insufficient scientific assessment, ecosystem dynamics poorly investigated
	Grassland expansion by removing forest trees in northern Bengal	Lack of policy implication and insufficient ground data
	Threat to conservation of sacred forests/groves	Incomplete status survey, lack of proper framework under local governance
	Dwindling wetland conditions	Ecological characterization and conservation prioritization lacking, incomplete inventory of wetland sites and biodiversity
	Decline in pollinators	Lack of assessment and promotional activities
	Degrading water resources (natural springs, marshlands, etc.)	Socio-economic evaluation lacking, largely unscientific developmental planning
Resource management	Poor trans-boundary cooperation and coordination	Inadequate approaches in understanding trans-boundary problems and future concerns, insufficient investigations
	Illegal trans-boundary trade	Inconsistency in management regimes of bordering countries, limited data availability

	Management of high altitude rangelands and pasture management	Inadequate institutional interactions, policy gaps, bleak local governance
	Lack in coordination, cooperation and capacity enhancement - Trade at traditional/old corridors - Eco-tourism between countries	Potential of trading corridors not fully explored, policy framework lacking for both issues, eco-tourism potential between countries not fully assessed
	Illegal trans-boundary movement of people and their impact	Strong policy not available among the parties, ground level assessment not available
	Trans-boundary movement of elephants	Unrevised elephant-friendly policies, mass-level awareness campaign inadequate, limited availability of comprehensive data
	Increasing human-wildlife conflicts	Inadequate improvisation of existing policies and newer management approaches, limited comprehensive studies
	Inadequtey in human resources and infrastructure for resource management	Inadequate financial support and manpower in view of proportionately large targeted areas
	Decline in traditional resource management institutions	Outmigration of youth, weakened knowledge transfer mechanism
Pollution	Dolomite extraction causing environmental hazards in Dooars' plains	Insufficient impact assessment, positive output of bilateral talks between parties inadequate
	Use of agro-chemicals and impounding health hazards	Comprehensive scientific assessment unavailable, ineffective policy implementation
	Water pollution	Inadequate assessment of decline in ground water quality, poor concern to the aquatic life
Long term conservation and monitoring	Various issues on Climate change and biodiversity: 1. Alteration of community composition 2. Changing habitats and growing threats on CR species 3. Shifting tree line 4. Shifting distribution range of species 5. Shifting timing of phenology events 6. Altering migration timings of animals 7. Altering avian habitats 8. Change in pollinator services 9. Changing sowing/harvesting timings of crops 10. Increasing susceptibility of crops	Difficulty in interpretation due to lack of comparable and consistent climatic data Data deficiency on lower groups of fauna and flora 1-8: lack of long-term temporal data 9-10: Insufficient long-term temporal data sets
	Receding glaciers	Inadequate information/data availability
	Changing Socio-economic scenario	Not enough baseline socio-economic data with indicators
	Eco-tourism environmental impact	Inadequate information for tourism monitoring
Policy and enabling environment	Landscape planning and management	Lack of cohesive elements in policies amongst regions
	Ineffectiveness of policies and schemes in certain places	Improvisation and revision of policies not sufficiently addressed
	Foraging boars and crop damages by animals	Gaps in pro-people policies

	Isolated approaches in Ecotourism amongst parts in KL-India	Short of legal master plan for in North Bengal
	Weak Trans-boundary and regional cooperation	Comprehensive regional trans-boundary and regional cooperation framework yet to be formulated
	No free flow movement under transboundary ecotourism amongst friendly countries	No existing common policies
	Poor exposition of multi-stakeholder for landscape development and coordination mechanism	Limited coordination amongst stakeholders
	Isolated and underutilized capacities of various institutions to implement landscape conservation plans/programmes	Inadequate coordination mechanism and support in place
	Lack of Knowledge management	Lacking knowledge network establishment still

Appendix 11.1 Assessment of location specific interventions and actions in the KL, India

Thematic Areas	Interventions and actions	Target Areas
Land-use, climate change and environment hazards		
Land cover land use	• Developing extensive land use database and monitoring land use change on long term basis • Monitoring wastages and tourism capacity	• KL-India • North Bengal
Climatic and physical database ecosystem pliability	• Establishing weather stations at different ecological zones and developing long-term data at spatial and temporal scale on climate change • Monitoring glaciers at temporal basis • Research for long term phenology based data generation • Promoting and strengthening of natural springs and ensuring spring recharge. • Studies on long term sustainability and associated biodiversity by big development projects	• KL-India • Sikkim • KL-India (along altitudinal transect) • Sikkim & Darjeeling • KL- India
Pollution	• Impact assessment study on dolomite mining pollution on biotic and abiotic elements • Research studies on adverse affects of pesticides and chemical uses in the tea gardens on human health and farming	• Dooars region (north Bengal) • North Bengal
Socio-economic and livelihood options		
Livelihood options	• Ensuring technology transfer to farming • Strengthening and promoting community based ecotourism • Promoting value addition in important cash crops and NTFPs and medicinal plants • Promoting traditional farming with value addition • Promoting gender equity culture	• KL-India • KL-India • KL-India • KL-India • KL-India
Socioeconomic infrastructure and services	• Assessing economic and socio-cultural structural performance • Promoting suitable alternative livelihoods options • Promotion of alternative energy sources • Establishing knowledge network	• KL-India • KL-India • KL-India • KL-India

Biodiversity and Ecosystem services		
Biodiversity assessment	• Biodiversity inventory at different ecosystems level, in gap areas, and updating for all the protected area in KL, India	• KL-India
	• Assessing biodiversity patterns and processes	• KL-India
	• Comprehensive population and habitat assessment, and long term monitoring studies on flagship and threatened species	• Along altitudes, KL-India
	• Study for corridors' identification amongst PAs and placing provisions for PA management plans	• KL- India, with particular reference to Sikkim
	• Biodiversity response assessment in temperate and high altitude zones by establishing permanent monitoring stations	• Sikkim and Darjeeling
Conservation	• Strengthen conservation management of priority PAs and corridors/connectivity	• KL- India
	• Assessing and identifying IPAs and newer IBAs, and their conservation	• KL, India
	• Monitoring wildlife activities and dynamism	• KL-India
	• Developing and implementing conservation strategies and action plan for prioritized endangered taxa	• KL- India (prioritized areas)
	• Promoting conservation practices in sensitive PAs and around wildlife habitats	• KL- India
Ecosystem services	• Monitoring trans-boundary movement of wildlife	• KL- India
	• Assessing high altitude pasture lands, wetlands and scared forests	• KL-India
	• Assessing ecosystem services and role of NTFPs	• KL-India
	• Assessing pollinators' services and its impact	• KL-India
	• Economic valuation of ecosystem services in representative biomes	• Identified biomes in KL, India
	• Updating knowledge /documentation on traditional knowledge and its services	• KL- India
Invasive alien species	• Assessing their impacts on flora and fauna and monitoring and controlling mechanisms planned	• KL-India
Agrobiodiversity	• Establishing germplasm bank facilities for crops and livestock	• KL-India
	• Promoting conservation of traditional farming systems	• KL-India
	• Promoting organic farming practices	• North Bengal
Resource management		
Trans-boundary cooperation	• Initiating and strengthening trans-boundary cooperation and coordination	• KL-partners
	• Assessing trans-boundary movements and pressure	• KL-India
Management of pastures	• Strengthening local governance and enriching knowledge base	• KL-India
	• Empowering human resource, community, and stakeholders	• KL-India
Natural resource management	• Capacity building of community for sustainable use and assessment on local governance	• KL-India
	• Establishing forum to ensuring active involvement of various stakeholders	• KL-India
Traditions and culture	• Strengthening local management systems	• KL- India
	• Historical place and cultural monuments' assessment and restoration in hills	• Prioritized in KL-India
Long time conservation and monitoring		

Biodiversity	• Strengthening biodiversity database temporal and spatial scale and periodic assessment	• KL-India: represented biomes
Climatic change	• Developing climate change models at different eco-climatic zones • Phenology monitoring on indicator species • Community based traditional knowledge documentation and validation, in cases	• KL-India • KL- India: along transects • KL, India
Socio-economic monitoring	• Monitoring socioeconomic status changes	• KL-India
Glaciers study	• Monitoring glaciers at temporal basis	• KL-India
Tourism	• Assessing ecotourism flow	• KL-India
Monitoring Trans-boundary	• Monitoring along transboundary routes/sites • Strengthen regional cooperation	• KL partner countries • KL-India
People's participation and orientation	• Enriching the knowledge bases among community, youngsters, etc.	• KL-India
Policy and enabling environment		
Policy and legislations	• Legal and policy provisions for improved landscape conservation management • Synchronization of national policies and laws amongst transboundary country	• National intervention and regional willingness
Knowledge dissemination	• Developing information and data centre on conservation and development • Encourage diversified stakeholders' participation through consultations and joint ventures	• KL-India • National and regional level