THE SIKKIM STATE ACTION PLAN ON CLIMATE CHANGE

Report

सत्यमेव जयते
Government of India

Government of Sikkim

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Report

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MESSAGE

Sikkim due to its immensely rich flora and fauna is recognized as a "hotspot" of biodiversity. Sikkim represents more than 26% of the flowering plants of the country in only 0.2% of the geographical area of the country. The State has 28 mountain peaks, more than 80 glaciers, 227 high altitude lakes and wetlands and over 104 rivers and streams located within its boundary, which makes the ecosystem most complex and unstable. In the last few decades, the vulnerability of out fragile ecosystem has further increased owing to climate change, a matter of concern for everyone.

Sikkim is the first State in India, where unique climate change initiatives have been taken, such as "Ten Minutes to Earth" to nurture the environment by planting trees. In 2008, the State Government started the Glaciers and Climate Change Commission to study the impact of climate change on glaciers and river systems, the very first in the country.

As a pioneering step towards green, safe and healthy initiatives in the field of agriculture, the State initiated the State Organic Mission in 2003 with the objective of becoming a fully organic State by the end of 2015.

A State Climate Change Cell has been set up in the Department of Science and Technology in collaboration with Department of Science and Technology, Government of India, to work on the key environmental concerns like Glaciology, Climate Change, Glacier lake outbursts, floods (GLOFs) and act as a nodal centre in the State.

Climate change is a global phenomenon. To cope with the adverse effects of climate change, a National Action Plan on Climate change has been formulated by the Government of India. At the State level, the Department of Science and Technology and Climate change has compiled this important document. The State Action Plan on Climate Change (SAPCC) has been formulated to help communities adapt to changing climate and its consequences.

I commend the Department of Science and Technology for putting together a comprehensive Action Plan on Climate Change. I call upon every individual and organization to implement the suggested strategies to counter as well as adapt to the phenomenon of climate change.

With best wishes.

(PAWAN CHAMLING)

DEPARTMENT OF SCIENCE & TECHNOLOGY AND CLIMATE CHANGE
GOVERNMENT OF SIKKIM

MESSAGE

The state of Sikkim located in the Eastern Himalaya of Great Mountain range of Indian Himalaya is one of the biodiversity rich areas in India and the world. The state has a wide variety of flora and fauna, which makes the state unique and diverse. One of the main reason behind having these diversity and uniqueness is the physiography and its location. Despite its smallness the state has hot tropical weather in the South,cold alpine weather conditions in the North and pleasant weather in mid altitudes.

However, this rich biodiversity of the state is under threat. There is a threat of existence of our unique plants and animals and this ever increasing threat may also affect the livelihood of people of the state. This threat is universal and it effects all of us in the form of **'Climate Change'.** The threat of climate change is a fact accepted by scientists globally. Extreme fluctuation in temperature, abnormal behavior of plants and animals can be seen as effects of climate change.

Among the various causes, according to scientist the increase of carbon concentration in the atmosphere is considered as the foremost cause of climate change. According to them this has happened due to burning of huge volume of fossil fuels for generation of power since the beginning of industrial age right from the eighteenth century. Burning of fossil fuel produced so much of carbon that it acts as a thick blanket in the atmosphere causing global warming. It is said that the concentration of carbon is so high that it started affecting our nature and environment in which we live. Though we do not have many industrial units in Sikkim emitting large volumes of carbon into the atmosphere but we share a common atmosphere. Climate change is a global problem and each and every person in this world will be affected by the threat of climate change including us in Sikkim. Hence, it is the duty of every one of us living on this earth to minimise climate change.

The Government of Sikkim has undertaken a number of initiatives to address issues of climate change.Among which are the ban on cattle grazing in forests and on illicit hunting,reforestation programmes,ban on plastics,ban on use of chemical pesticides and fertilizers,etc. The result is in front of us; our forest area along with wildlife has increased tremendously. But these initiatives are not enough, a great deal is still to be done in order to reduce the impact of climate change.

I am pleased to learn that a **State Action Plan on Climate Change** for Sikkim has been prepared. I urge all the concerned departments to adopt the strategies contained in the State Action Plan on Climate Change.I am also pleased to learn that a Sikkim State Climate Change Cell has been established under Sikkim State Council of Science and Technology under National Mission on Sustaining Himalayan Ecosystem of National Action Plan on Climate Change program of Government of India.This Cell will provide the necessary technical support and guidance to various stakeholders.

With best wishes.

(Tshering Wangdi Lepcha)
Minister
Department of Science & Technology and Climate Change

DEPARTMENT OF SCIENCE & TECHNOLOGY AND CLIMATE CHANGE
GOVERNMENT OF SIKKIM

MESSAGE

The challenges of global climate change induced primarily by anthropogenically liberated greenhouse gas emissions resulted in the preparation of a strategic framework in 2008 called the **National Action Plan on Climate Change**.This National Action Plan required the States to frame similar strategic frameworks to address issues arising out of climate change.Accordingly,the **Sikkim State Action Plan on Climate Change** was prepared approved in late 2014.The Action Plan prepared has identified key areas of concern and suggested strategies to mitigate and adapt to the vulnerabilities of climate change to ensure the State's continued development while sustaining its unique and fragile environment.

The thematic priorities for addressing Climate Change are :-

1. Water.
2. Agriculture,horticulture and livestock.
3. Biodiversity,forests,wildlife and ecotourism.
4. Promotion of energy efficiency.
5. Urban and rural habitats and communities.

These priorities are likely to be the most vulnerable areas requiring supplementary programmes and policies in addition to existing ones.The State has identified these priorities with the understanding that climate change can be a detriment to growth but at the same time offer opportunities for development of new competencies.Considering that Sikkim is a global biodiversity hotspot and dependent considerably on ecotourism,adopting additional environmentally sensitive pathways is emperitive.Further,agriculture is the mainstay of 64% of the State's population and therefore the livelihoods of these farmers communities are inherently dependent on the vagaries of mountainous weather system.Adaptation to climate change will continue to be of eminent importance to decrease the vulnerability of these farming group.

The strategies so developed and presented in this publication are the result of many vigorous rounds of discussions,research and deliberations among concerned departments and has been facilitated by Inter Cooperation in Social Development and supported by GIZ India.It is hoped that the strategies identified will pave the way for development of concrete partnerships between various stakeholders and governmental agencies to collectively combat climate change in Sikkim.

(P.T.Euthenpa)IAS
Secretary

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Part 1

The Climate Change Context

Introduction to Sikkim

As per the 4th Assessment Report of the IPCC, warming of the climate system is unequivocal and is attributed mainly to anthropogenic activities (Box 1). In the past century, the Earth has warmed by 0.76°C on average and the rate of warming is increasing. In fact, according to WMO, 2010 was the warmest year on record. The global average temperature in 2010 was 0.53°C above the average compared against 1961-90 and is higher than the two previous warmest years-1998 and 2005 - in the last decade. The rise in sea level has almost doubled from 18 cm per century in 1961–2003 to 31 cm per century in 1993–2003. Similarly, extreme weather events have increased and regional climate patterns are changing. Climate change models, driven by a variety of socio economic scenarios project that on an average the global temperature may rise by 1.8 to 4.0°C by 2100.

In the case of India, the annual mean temperature of the country as whole for the period 1901-2009, has risen by 0.56°C (IMD, 2010) and by the 2050s the temperature may rise by 2-4°C (NATCOM, 2004). Further, a report by the Ministry of Environment and Forests the Government of India (MoEF GoI), focussing on four climate sensitive regions of India (INCCA, 2010) projects that by the 2030's the annual mean surface air temperature may rise by 1.7°C to 2°C with respect to the current climate baseline of 1960-1990.

Box 1: The IPCC on the climate system

During the course of the 21st century the resilience of many ecosystems (their ability to adapt naturally) is likely to be exceeded by an unprecedented combination of change in climate and change in other global change drivers (especially land use change and overexploitation) if greenhouse gas emissions and other changes continue at or above current rates. By 2100 ecosystems will be exposed to atmospheric CO2 levels substantially higher than in the past 650,000 years and global temperatures at least among the highest of those experienced in the past 740,000 years. This will alter the structure, reduce biodiversity and perturb functioning of most ecosystems, and compromise the services they currently provide.

Source: IPCC (2007a)

Climate change, as some of the studies suggest (NATCOM, 2004; INCCA, 2010), may alter the distribution and quality of India's natural resources and increase water insecurity, reduce agriculture productivity, enhance exposure to extreme weather events, and pose enhanced health risks thereby adversely affecting development of the economy closely linked to the natural resource base. The majority of India's population is dependent on climate sensitive livelihoods such as agriculture and forest products and are therefore subject to great risk due to exposure to the changing climate. In view of the requirements of a strategy to adapt to climate change, to enhance ecological sustainability and explore solutions towards more efficient technologies, the National Action Plan on Climate Change (NAPCC) was formulated and launched by the Prime Minister of India in June 2008. The

Damaged Patch *Pratylenchus*

NAPCC consists of eight missions that focus on enhancing energy efficiency; increasing the penetration of solar photo-voltaic and solar thermal technologies in the total energy mix; developing climate friendly sustainable habitats; a water mission for integrated water resources management; a mission on sustainable agriculture for making it more resilient to climate change; a green mission for enhancing ecosystem services of forests and for enhancing its carbon (C) sequestration capacity; a mission for sustaining and safeguarding the Himalayan glacier and mountain ecosystems; the last mission is aimed towards developing a strategic knowledge base to address the concerns of climate change.

For translating national policies into action, especially at local level, and decentralizing NAPCC objectives into local context, a territorial approach is necessary. Therefore the states should develop their own prioritised action plan vis a vis the State Action Plans on Climate Change (SAPCC) with the overarching objectives and missions of the National Action Plan on Climate Change. Through the SAPCC the State identifies the risks and opportunities posed by climate change. These strategies or initiatives identified in the SAPCC are used to mainstream climate change concerns into policy and development for the State by introducing low carbon, climate resilient developmental activities that can be adopted by the State and used to generate investments.

Approach to the Preparation of the Sikkim State Action Plan on Climate Change

The government of Sikkim has taken a systematic and proactive approach towards the formulation of the State Action Plan on Climate Change (SAPCC). A high level Coordination Committee was formulated with the Secretaries of different departments as members under the Chairmanship of the Secretary Department of Science and Technology who is also the focal person for climate change in the state of Sikkim (Box 2)

The Department of Science and Technology with the Department of Rural Development and Management of Sikkim, undertook a study in early 2010 to identify the vulnerability of the various rural communities due to climate change in four districts of the State. Results from the study indicate that there exist differential levels of vulnerabilities of the rural communities in these districts of Sikkim. These communities have various levels of adaptive capacities, with the southern districts being the most vulnerable having the least adaptive capacity to climate change. It concluded that massive support will be required to climate proof these communities to withstand the vagarities of climate change, especially the livelihoods of those that are climate dependent.

The study was presented and discussed in a two day workshop in Sikkim with participants from relevant stakeholders such as Sikkim Government Departments, Non Government Organizations (NGOs), research and educational institutions and the private sector. The discussions at the workshop identified key climate change concerns of the State of Sikkim and on how to take

Box 2: Composition of the high level Coordination Committee	
Secretary Department of Science & Technology	Chair
Secretary Rural Management & Development Department	Member
Secretary Forest Department	Member
Secretary Irrigation	Member
Secretary Power	Member
Secretary Urban Development	Member
Secretary Animal Husbandry and Fisheries	Member
Secretary Agriculture and Horticulture	Member
Secretary, Transport	Member

steps towards amelioration of the same. Based on these key issues, the Sikkim State Action plan on Climate Change has been formulated with strategies identified to addressing the challenges faced by the State into the future across the short, medium and long term. Also, the SAPCC would strengthen policies and programmes of the Sikkim Government undertaken over the past two decades to protect ecology and the environment of this Himalayan State towards sustainable and inclusive development.

The key areas of concern for Sikkim that were identified in the workshop were:

- Water
- Agriculture, Horticulture and Livestock
- Forests, Wildlife, and Eco-Tourism
- Promotion of Energy Efficiency
- Urban and Rural Habitats and Communities

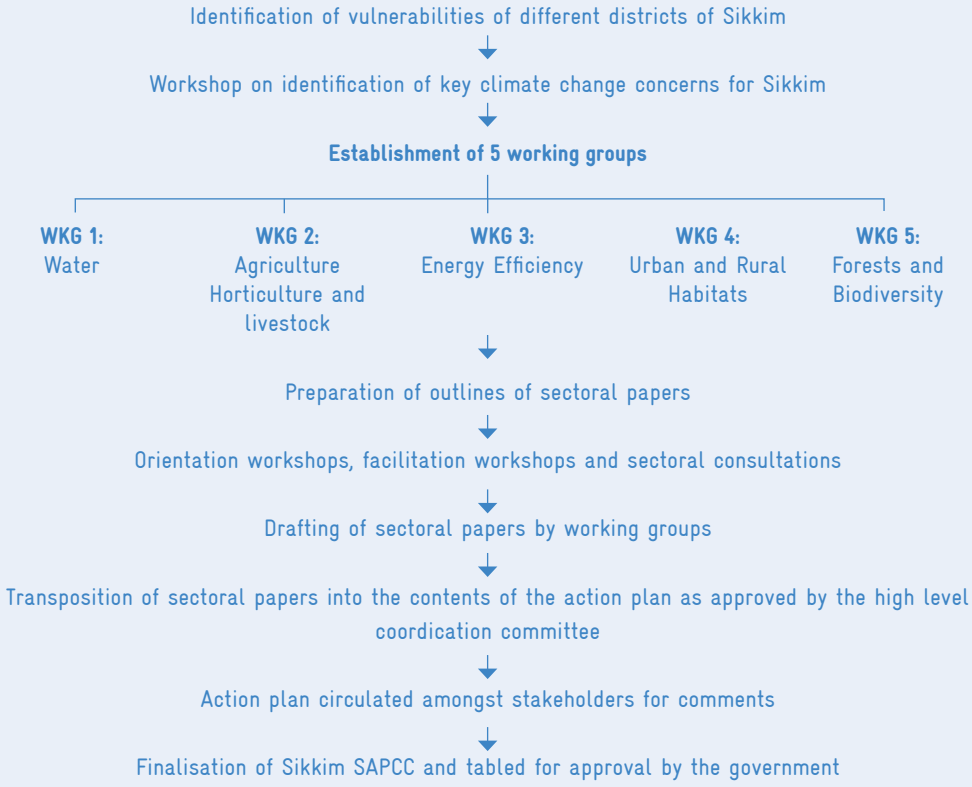
Under the Chairmanship of the respective high level Coordination Committee members, 5 Working Groups (WGs) for each sector was formulated. The members of the WG were drawn from related Government Departments, NGOs, educational institutions and the private sector. The support for the process of preparation of the SAPCCC was provided by the GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit).

As a first step in the drafting of the SAPCC, was to formulate the outlines of the sectoral papers in consultation with the WG members. A number of workshops were held where discussions focused on outlining the nature of orientation and facilitation for different WGs, the need to undertake in depth sectoral analysis, identification of key priorities and formulation of adaptation strategies. The resource persons in these workshops were nationally recognised sectoral experts who were also available for guidance for the prioritisation of strategies and development of the action plan.

Further, extensive consultations within the WG members and other stake holders were conducted. Based on the outcomes of such action, sectoral papers were drafted by members of the WGs forming the basis of the Sikkim SAPCC. These sectoral papers focussed on the identification of specific concerns in each sectoral caused due to climate change, the formulation of strategies for climate proofing vulnerable communities and landscapes, the concerns and prioritization of strategies, identification of actionable strategies needed to be implemented in the next 5, 10 and 15 years. The sectoral papers also made an assessment of the costs of implementation of actions based on strategies outlined. The contents of the sectoral papers were transposed in line with the framework of the SAPCC provided by the Ministry of Environment and Forests, Government of India. Following these steps, the draft SAPCC was circulated amongst all stakeholders for their comments. Upon inclusion of comments, the final revised Sikkim SAPCCC was approved by the High level Coordination committee and accepted by the Government of Sikkim, and the same was communicated to the Ministry of Environment and Forests March 31st, 2011 for its perusal and action.

The steps and time lines towards formulation of Sikkim SAPCC is shown in (Box 3.).

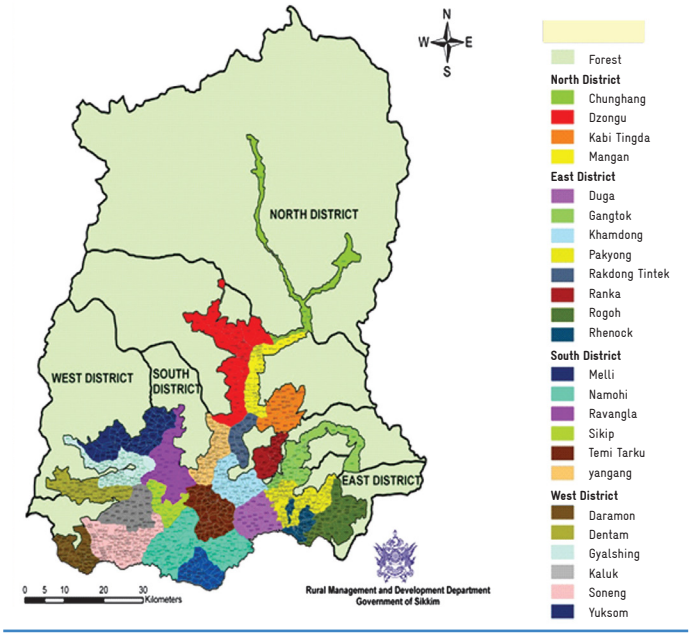
Box 3: Steps outlined to form the Sikkim SAPCC



The Sikkim Context

Sikkim is a north-eastern State in Indian lying between 27° 04' 46" S to 28° 07' 48" N latitudes and 88° 00' 58" W and 88° 55' 25" E longitudes. The total geographical area of the state is only 7,096 km2 and is strategically located sharing international borders with Bhutan, China and Nepal, and in the south, it is bordered by the state of West Bengal in India. It merged with India in the year 1975, prior to which it was ruled by a monarchy.

Figure 3.1: Development Block Map of Sikkim



3.1 SOCIO-ECONOMIC FEATURES

As per the Census of India (2001) the total population of Sikkim is 0.54 million (as per census 2011), accounting for barely 0.05% of the total population of the country. The rural population is approximately 70% in rural area (as per census 2011), with livelihoods linked to natural resources such as agriculture and forest products that are climate sensitive.

Culturally Sikkim is multiethnic, comprising of four districts – East, West, North and South with a total population of 5, 40,851 (see Figure 3.1). The literacy rate is one of the highest in India. The state GDP is Rs. 2,586 crores. Because of hilly terrain and lack of reliable transportation infrastructure, there are no large-scale industries. Breweries, distilleries, tanning and watch- making are the main industries. These are located in the southern reaches of the state, primarily in the towns of Melli and Jorethang. The state has an impressive growth rate of 8.3% (as per census 2011), which is the second highest in the coun-

Box 4: Sikkim socio-economic parameters*	
Area	7096 sq km
Recorded forest land with tree cover	5765.1 sq km
Per capita forest cover	0.61 ha
Per capita plants	0.7 per sq km
Green protection index	0.903
Urbanisation	11.1 % of total state area
Number of districts	4
Number of sub divisions	9
Number of towns	9
Total households	114223
Population	540851
Urban population	11.1% of total population
Density of population	76 per sq. km
Birth rate	18.4 per thousand
Death rate	5.2 per thousand
Infant mortality rate	33 per thousand
Sex ratio	920 females per '000 males
Population below poverty line	19.33%
Literacy rate	82%
Per capita outlay on health	Rs. 296 per capita
Doctor	1 doctor per 2504 persons
Per capita outlay on education	Rs. 1288
HDI	0.532
Total number of Govt. educational institutions	1545
Index of social & economic infrastructure	108.99
Plan expenditure in social sector	45.38%
Access to safe drinking water	
Per capita consumption of electricity	182 Kilo watt hour
Per capita income	Rs. 25257 per annum**
State GDP	Rs. 2586 crores
Main workers	39.31% of total population
Marginal workers	9.41% of total population
Non workers	51.28% of total population
Cultivators	49.91% of total workers
Agricultural labourers	6.43% of total workers
Cultivated area	109068 ha

Source: http://www.sikkim.gov.in/asp/Miscc/Sikkim% 20in%20Brief%202011.pdf
*** CSO 2008-2009, also submitted by the planning commission to the Lok Sabha*

try after Delhi. In recent years, the government of Sikkim has promoted tourism. Sikkim has a vast ecotourism potential and having tapped into this is contributing substantially to the State GDP. With the general improvement in infrastructure, tourism is slated to be the mainstay of Sikkim's economy.

Sikkim States vision for 2015 amongst others, is to achieve 100% literacy, produce 5,000 MW of power, make agriculture completely organic, and develop the state at par with some of the small developed countries.

3.2 GEOGRAPHIC FEATURES

Sikkim encompasses Lesser Himalaya, Central Himalaya, and the Tethys Himalaya. The area is like a stairway leading from the western border of the Tibetan plateau down to the plains of West Bengal, with a fall of about 8,298 metres in 240 kms from the upper reaches of the Himalayas to the Northern tip of West Bengal. It has also the steepest landscape in the country since the width of the Himalaya across its entire length is narrowest xhere (Schaller 1977). Slopes are on an average of 45° representing one of the steepest altitude gradients anywhere in the world. Sikkim has regions that extend from temperate, sub alpine to alpine and is one of the richest in biodiversity with diverse indigenous flora and fauna having high commercial value. The habitable areas exist only up to the altitude of 2,100 m constituting only 20% of the total area of the state.

Spanning Sikkim's western borders are the Khangchendzonga and the Singalila Range, a north- south spur of the Great Himalaya. The northern limits reaching out to the Tibetan Plateau is straddled by the Donkia Range while the eastern flank is bounded by the Chola Range. The major mountain peaks of Sikkim are; Khangchendzonga-8,846 m, Jonsang-7,444 m, Talung-7,351 m, Kabru-7,338 m, Siniolchu-6,887 m, Pandim-6,691 m, Rathong-6,680 m, Koktang-6,148 m, and Simvo-6,811 m.

Sikkim has two major rivers - the Teesta and the Rangeet. The turbulent Teesta, which has its source at the Chho Lhamu lake in the Tibetan Plateau is a little stream at first but gradually swells into a raging river as more tributaries converge into its path as it snakes through deep mountain valleys into the plains of Bengal. The gentler Rangeet has its source at the Rathong Glacier south of the Khangchendzonga massif. It meets with the Teesta at the valley dividing Sikkim and Bengal. Also, there are numerous perennial lakes in Sikkim such as Khechiperi, Gurudongmar, Chho Lhamu, Changu and Menmetsho.

3.3 OBSERVED CLIMATE AND ITS CHANGING PATTERN

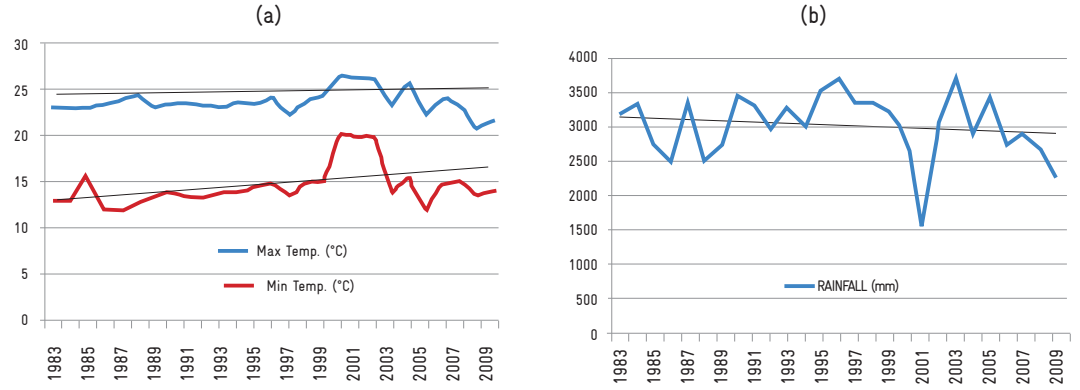
Altitude variation across Sikkim is the main factor controlling climate and weather conditions. Relief features such as high mountains act as barriers for the movement of the monsoon winds. Low temperature, high rainfall on windward slopes, comparatively dry on the leeward side and heavy precipitation in the form of snow at the mountain tops are the main features of the climate. Long term, reliable meteorological data is available only for two stations - Gangtok and Tadong (1957 to present). For rest of the 17 stations in Sikkim, rainfall data is available measured by rain gauges, but data series are not continuous and are unreliable for assessing the changing patterns of climate for a substantial period.[1]

Analysis of annual average maximum- minimum temperature and rainfall of the two stations indicates that though there is no change in the maximum temperature, but the minimum temperature has increased by almost by 2.5°C between the 1957 and 2009 (see figure 3.2 (a). Total rainfall has decreased by around 250 mm between the periods of 1983 to 2009. After the drought of 2001, the annual precipitation rose to a maximum of 3,700 mm but since then it has been continuously decreasing (Figure 3.2 (b)).

There however exists spatial variability. Monthly, seasonal and Annual analysis of data only

1 30 years is the minimum period of observation required to establish the signals of climate change

Figure 3.2: (a) Annual average maximum and minimum temperature trends and (b) annual rainfall trends in Sikkim



Source, ICAR station, Gangtok and Tadong

for Gangtok station for the periods of 1957 to 2005 indicates a trend towards warmer nights and cooler days, with increased rainfall except in winter (Seetharam, 2008). The temperature in Gangtok has been rising at the rate of 0.2-0.3°C per decade and the annual rainfall is increasing at the rate of nearly 50 mm per decade. Therefore, the temperature in Gangtok has risen by 1 to 1.5°C since 1957. Comparison of long term meteorological data available for Gangtok station (1957 to 2005) with the trend over the last few years (2006-09), shows an acceleration of these patterns, with winters becoming increasingly warmer and drier (see table 1). With climate change the winter rains are increasingly becoming scarce. During the year 2008 and 2009, the state witnessed one of the driest winters in living memory. According to Meteorological Department, Government of India, Sikkim Division, the year 2009 was the warmest year in the century for

Table 1: Percentage departures of average minimum temperature, average maximum temperature, and average rainfall of the period 2006-2009 with respect to long period average of 1957-2007 for Gangtok, Sikkim

Season	Long period Av. Max. Temp. (1957-2005)	Av. deviation in Max. Temp. between 2006-200 LPA Max. Temp. (%)	Long period Av. Max. Temp. in OC (1957-2005)	Av. deviation in Max. Temp. in OC between 2006-2009 LPA Max. Temp. (%)	Long period Av. rainfall in mm (1957-2005)	Av. deviation in rainfall in mm between 2006-2009 LPA rainfall (%)
January	12.8	-0.1	4.4	+2.1	32.6	-73
February	14.2	0.3	5.7	+2.0	62.6	-19
March	18.3	-0.3	8.9	+1.5	135.5	-25
April	21.0	-0.6	11.7	+1.4	270.3	7
May	21.7	0.1	13.8	+1.4	523.9	-26
June	22.2	-0.4	16.2	+0.9	630.9	-8
July	22.0	-0.2	16.8	+1.4	658.0	-10
August	22.4	-0.3	16.7	+1.0	578.9	0
Sept	21.5	-0.2	15.6	+1.0	464.6	2
October	20.9	-0.3	2.5	+1.5	175.6	-40
November	17.7	-1.0	8.8	+1.6	40.0	-24
December	14.6	-0.7	5.9	+2.1	21.2	-39

Source: 1. K Seetharaman, 2008. Climate Change scenario over Gangtok. Mausam, 59, 3, July 2008
2. IMD, Sikkim - climate parameters for 2006, 2007, 2008 and 2009

Sikkim. Also extreme climate events have become more frequent e.g. Cyclone Aliya in 2009.

The changes in climate over these long periods of observation indicate that the weather patterns have become unreliable. Further the autumn season has extended and winters have become dry and extreme climate events have become more frequent. Rainfall patterns have become erratic, monsoons are usually late and in general torrential rainfall has replaced the monsoon drizzle. This has increased the surface runoff and dry period during winters, resulting in a higher incidence of forest fires and drying up of springs i.e. discharge of springs has reduced and many of them have started becoming seasonal.

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3.4 BIODIVERSITY AND FORESTS

Sikkim is rich in biodiversity and is endowed with 26% of flowering plants found in the country i.e. approximately 4,500 species of which 424 are identified medicinal plants, 500 orchid varieties, 450 species of trees of which 11 species are oak, and 36 species of Rhododendron. Sikkim has 150 species of mammals, 550 species of birds, 650 species of butterflies and moths. Of these 19 species of mammals, 11 species of birds and 65 species of plants are threatened and endangered. Conservation of these species and their habitat warrants special attention in the State, especially in the context of climate change. About 72% of the Indian species of Rhododendrons are found here and hence Sikkim is called the cradle of Indian Rhododendrons.

Being rich in biodiversity, Sikkim also has cultivated cash crops, such as the medicinal plants which are indigenous to this region, exotic orchids, the Sikkim big cardamom, Sikkim mandarin, and livestock products such as milk and cheese. Changes in climate pose a threat to the production and productivity of these cash crops and livestock products, which are significant from the point of view of the livelihoods it provides to the people.

Exotic breed of cattle facing extinction

The recorded forest in SIkkim in 2009 was 3,377 km2 which is 47.59% of the total geographical area of Sikkim (http: //www.sikenvis.nic.in/15years1995-2010.htm, as on 5th March, 2011). Of the total forest area, 15% is dense forest cover, 64% has moderate dense cover and 21% is open forest. Forests are one of the richest natural resources of Sikkim. The composition ranges from tropical dry deciduous forests with Sal and its associates in the valleys of Teesta and Rangit to the alpine scrub and grasslands in high altitudes. During the last two decades the Forest Department has laid emphasis on growing fodder and fuel wood in the agriculture fallow lands of the villagers giving priority to plantation of broom grass for fodder and for the economic up liftment of the villages. Initiatives of the Government for afforestation have mass appeal with the Chief Minister leading the Green Mission in the State.

3.5 AGRICULTURE

More than 64% of the population of Sikkim depends on agriculture for their livelihoods, directly or indirectly cultivating 1,09,963 hectares which is only 15% of the total land area of Sikkim. The hill slopes have been converted into farmlands using terrace-farming techniques and is used for cultivation. Cardamom is the main cash crop in the district, which makes a premier part of economy (19% of the cropped area grows cardamom). Besides this other crops such as rice (13% of the land area), millet, corn etc. are also grown in limited quantity. Cabbage and potato are produced in large quantities in the Lachung Valley and are exported out of the State. Radish also is exported from this area. Other normal vegetables for daily consumption such as, peas, cauliflower, green leaves are found all over the district. A large quantities of apple is grown in the district in the Lachung Valley. Other fruits like peach, guava, orange, plum, phunsay grow in plenty. However, cultivation in Sikkim faces several problems which limits the scope of agriculture in Sikkim to a great extent. This is as, firstly, Sikkim is a small state and most of the regions are hilly and at high altitudes, unfit for cultivation. Out of the total, dry land and waste land constitute 58% and 10% of the total area respectively and whatever land is left for cultivation, it is besieged by variable agro-climatic conditions, difficult terrain, steep slope, acidic soil and prolonged dry spell. In a predominantly rural economy such as Sikkim, animal husbandry activities form an extremely important element in the effort to bring about substantial improvements in living standards. Livestock provide not only the much needed draught support to the rural families but also meets the demand of protein requirement through the supply of milk, egg, and meat. Adequate number of livestock like cattle, buffaloes, pigs, sheep's, goats, yaks and few others are reared in Sikkim. Yaks are reared in north eastern ranges bordering Tibet, Bhutan and western region bordering Nepal.

Farming on hills

3.6 WATER RESOURCES

Drinking water demand of the Sikkim populace living below 5,000 ft is mainly met through rainfall but an overwhelmingly high proportion of this rainfall occurs in the monsoon season only. Sikkim has high spatial and temporal variation from the north to the south and from the east to the west due to the highly variable terrain.

Water harvesting

To understand the spatial variability of rainfall in mountainous region of Sikkim it is necessary to have high resolution weather stations and also the availability of high resolution climate change projection models (~10km x 10km), this would adequately capture the high spatial and temporal variation of observed rainfall. Also the upper reaches of Sikkim have 84 glaciers covering an area of about 440 km2 with the total extent of permanent snow fields being 251 km2 (SAC 2001). This unique geomorphology has resulted in more than 315 glacial lakes located at an average altitude of 4,700 (+500) m (CISMHE 2005). The hilly Himalayan region has a paucity of water during the non-monsoon months which together with high rates of surface runoff cause heavy land degradation and erosion. Even though water is available in the valleys the constraints of the terrain forces overwhelmingly large proportions of the agricultural fields to be dependent upon the rains alone.

3.7 HYDROPOWER

S ikkim has a very high potential for electricity generation as it is endowed with a perennial water system with a large number of glaciers that feed the many water bodies in the state, giving the state. About 90% of Sikkim's electricity supply is from hydropower, generated from the Tista River making it one of the greenest State in India. The hydropower generation potentials from the Tista River in Sikkim alone has been estimated to be around 8,000 MW. Close to 45 million kWh of electricity is generated every year through state owned hydro power plants, with another 150 million kWh of electricity generated from hydro plants exploiting the potential of the river. This is managed by the National Hydro Power Corporation and other national power generators. Amongst other revenue generating sources, one of the key high revenue generating sectors for the state can be through the possible sale of electricity generated from its vast hydro electricity generation potential to the national grid.

3.8 URBAN HABITATS AND TRANSPORTATION

Rapid urbanisation in Sikkim in the last two decades has occurred due to the economic growth momentum and also due to the migration of the rural population to cities due to poverty. However, the urban population unlike other states is home to just 0.05% of the total state's area with just over 11% of the total state's population inhabiting the 9 urban centres of the state. The total urban population of Sikkim, as per the 2001 census was around 59,870 as against the total population of 5,40,851.

Given the terrain of Sikkim and in view that connectivity and accessibility are the key bottom lines, the growth of urban centres has been linear in nature, which means that the urban development of Sikkim has been taking place on main roads and on the arterial roads connecting the town and the state to West Bengal. This has also proved to be a major challenge for the state in addressing the issue of town development, due to the mixed land use patterns, where no area could possibly be earmarked for specific activities.

Sikkim's Vulnerability to Climate Change

4.1 PROJECTED CLIMATE CHANGE

Climate projections for 2030s for the North eastern part of India, including Sikkim is available from the recently published report of the MoEF (MoEF, 2010). It is derived from PRECIS, an atmospheric and land surface model developed by Hadley centre, UK. It projects at spatial resolution of 50km x 50km. The climate change scenarios are driven by the GHG emission projections constructed using the IPCC A1B socio-economic scenarios, that assumes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies, with development balanced across energy sources.

Three QUMP [2] runs of PRECIS, namely, QO, Q1, and Q14, using A1B scenario, indicates

2 To explore the modelling uncertainty, the Hadley Centre in 2009, generated ensembles of climate projections where each realisation differed from the other members by altering the approximations of the key climate processes within plausible bounds. These ensembles, together with output from other climate models, were used to understand and quantify uncertainties in climate projections on different space and time scales. Appropriate, statistical methods were used to combine generated ensembles with observations and climate projections from other international models to provide probabilistic climate projections of local climate on (multi)decadal time scales. Observations were used to weight each model variant according to its ability to simulate the observed changes. The probabilities measured the credibility of any given level of climate change. These realisations were named as Q0, Q1,..Planners can thus assess the risk of climate

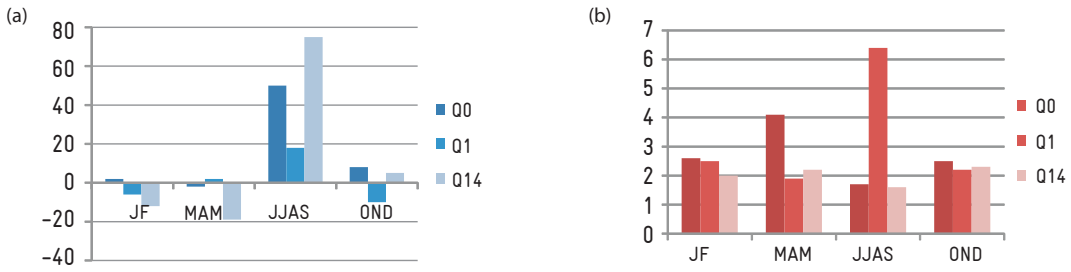
that the North Eastern region as a whole is likely to experience increase in average annual rainfall in 2030s with respect to 1970s by 3-56 mm with bulk of the contribution from the increase in rainfall during monsoon that is likely to range between 18-75 mm. Of the three QUMP runs, Q0 run is making the least projection in increase in rainfall in the monsoon period. In the winter period, especially in the January and February, there is a marked decrease in rainfall, decreasing upto 12 mms (see Figure 4.1a). This is in line with the long term observed decrease in rainfall during winter months in Sikkim. Further, it has been deduced that the northern western part of the North East region comprising of Sikkim show an overall reduction in precipitation by about 3% in 2030s with respect to the 1970s (Chapter 8, INCCA, 2010).

In 2030s, the average annual temperatures are likely to rise by 1.8 to 2.1°C in 2030s with respect to 1970s. On a seasonal basis, there is a significant rise in temperatures in the monsoon period in June, July, August and September. The temperature is this season is likely to rise between 1.6 to 6.4°C in 2030s with respect to 1970s. In March, April and May temperatures are also projected to increase, and the range of increase is likely to be between 1.9 to 4.1°C. Similarly, the winter temperatures, starting from October are also projected to increase by 2 to 2.6°C in 2030s with respect to 1970s (see Figure 4.1b)

Zeroing in on Sikkim, only one QUMP i.e. Q14, that simulates the observed climate the best, was analysed (Figure 4.2) indicating change in precipitation in 2050s and 2080s with reference to base line and (Figure 4.3) indicating change in temperature with reference to base line). In winters, i.e. Oct-Dec there might be increase in rainfall marginally, but in and Jan-Feb, the southern part of Sikkim is likely to experience a negative change i.e. the rainfall is likely to reduce with respect to base line by about 25% . Towards the end of the century, though summer rainfall is indicating a marked improvement, but the higher altitudes are likely to face lower precipitation with reference to base line. Similarly the Jan-Feb precipitation scenario improves in most parts of Sikkim, except in southern part, where the precipitation is likely to be still less by 15-20% with reference to base line.

As per the (Figure 4.3), the average maximum temperature in Sikkim is likely to increase by 1.8-2.6°C is 2050s, with temperature change gradually increasing from lower to the higher latitudes (also in this case higher altitude). Similarly, the minimum temperature is also varying within that range. It is to be noted that a smaller area in lower latitudes have change in minimum temperature which is of the order of 1.8°C as compared to a greater area having a change in maximum temperature by 1.8°C.

Figure 4.1: Projections of seasonal annual average (a) rainfall and (b) surface temperature for the North East including Sikkim in 2030s with respect to 1970s.



Source: INCCA 2010

change based on more than one probable scenario of climate change and use this information in deciding adaptation and mitigation strategies.

4.2 LIKELY IMPACTS AND VULNERABILITIES DUE TO CLIMATE CHANGE

4.2.1 WATER RESOURCES

Water is one of the most important sectors on which climate change (increase in temperatures, evapo- transpiration, spatial variation in rainfall, increase intensity of extreme rainfall and drought events) can have a profound impact, which in turn can have cascading impacts on other sectors. While a consensus

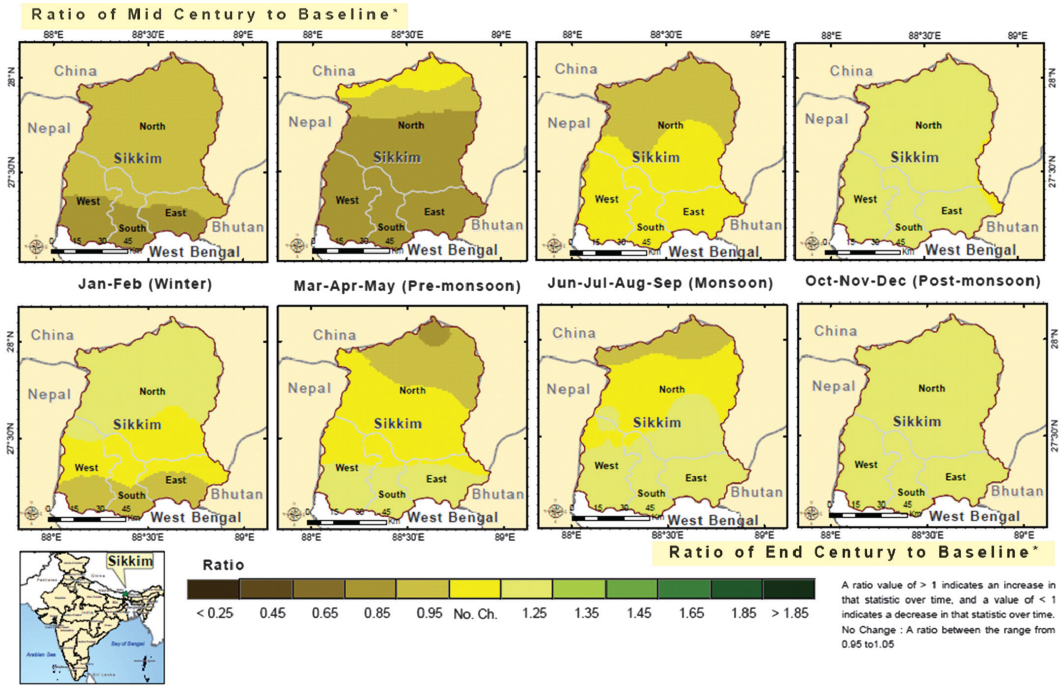
exists on the likely impacts of climate change on the water resources of the Himalayas, quantitative analyses of such changes are sparse due to the lack of baseline data essential for such analyses.

The National Water Mission, which is a part of the National Action Plan on Climate Change (NAPCC) (MoWR, 2010), identifies the threats to water resources due to climate change which are relevant to Sikkim are as follows:

- Drinking water dependent on rainfall likely to become more scarce as rainfall may increasingly get restricted to only monsoon period (as is the present situation) and there might be a reduced amount of rainfall as the number of rainy days decrease;
- Increase in intensity of rainfall will lead to high run off and less infiltration, and consequently adversely affecting spring recharge;
- Increased drought-like situations due to the overall decrease in the number of rainy days;
- Warming may lead to a decline in the glaciers and snowfields;

  Further, increased water temperature also may lead to
- Lower availability of dissolved oxygen,
- Altered ice-free period,
- Increased biological activity exhausting oxygen in water, and

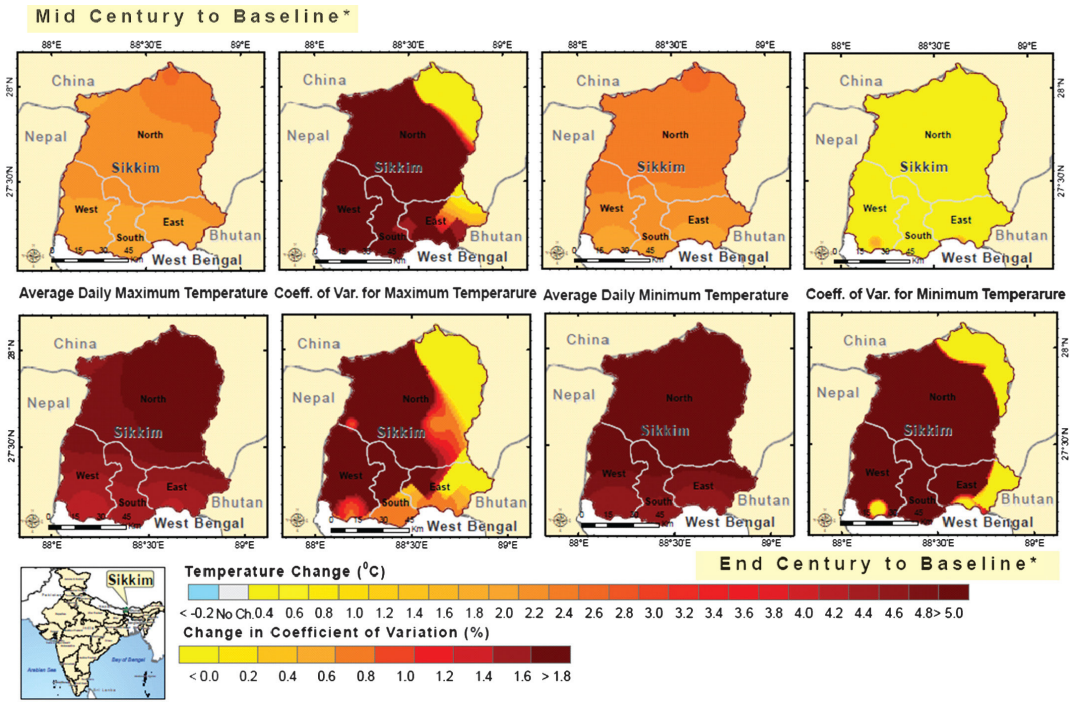
Figure 4.2: Change in average rainfall during winter, pre-monsoon, monsoon & post-monsoon seasons across Sikkim State in 2050s (top panel) and 2080s (bottom panel)



Source: PRECIS RCM daily weather datasets provided by the Indian Institute of Tropical Metereology, Pune

** IPCC SRES A1B Scenarios (Q14 QUMP ensemble) - Baseline (19611990), Mid Century (2012-2050) and End Century (2071-2098)*

Figure 4.3: Change in maximum and minimum temperatures in SIkkim in mid century (2050s) and at the end of the century (2080s)



Source: PRECIS RCM daily weather datasets provided by the Indian Institute of Tropical Metereology, Pune
** IPCC SRES A1B Scenarios (Q14 QUMP ensemble) - Baseline (19611990), Mid Century (2012-2050) and End Century (2071-2098)*

- Changed pattern of thermal mixing in water bodies to create anaerobic conditions leading to eutrophication.

For Sikkim particularly, water yield which is a function of rainfall run off and evapo-transpiration is projected to decrease upto 12% in 2030s with respect to 1907s (MoEF, 2010). The consequences of these changes for food web interactions, community structure, nutrient dynamics, and water quality are likely to be critical for the ecological health of the wetlands and communities deriving benefits from them.

4.2.2 AGRICULTURE

The agricultural sector is highly dependent on the climate, and given the low productivity increase of the last few years compared to population growth, climate change is likely to have serious consequences for Sikkim's agriculture. Recent changes in climate indicating a warmer and dry winter has resulted in a decline in the production of the winter crops and increased incidences of forest fire which is showing an ascending trend into the temperate zone. Due to increased runoff and dry winters, springs have started drying up and their lean season discharge is reducing drastically. Annual mean rainfall showed high variation due to the geography, with the rain shadow areas in the lower part of South and West districts receiving only half the rainfall compared to East District.

With the dependency on agriculture, over 98% of all water in Sikkim is used for irrigation (2,135 cusecs use for irrigation out of 2,176 cusecs used for irrigation, urban and rural drinking water and industry in 2010, Source: Irrigation department, 2010), higher projected temperatures, increased evapo-transpiration and decreased winter precipitation may bring about more droughts in Sikkim. In addition, the Teesta and Rangit rivers may face highly variable flows with climate change.

Some of the key concerns in the agriculture sector due to climate change are as follows:

- Loss of production and quality (due to variable rainfall, temperature, etc.) Decreasing

water availability for crop production leading to crop yield instability.. Increased risk of extinction of threatened crop species including traditional crop varieties.

- Loss of soil fertility and soil nutrients due to the erosion and runoff of top soil. Loss of fields due to flash floods, landslides with rill and gully formation.
- Crop yield loss with flowers and fruit dropping due to hailstorms. Deteriorating produce quality in fruits and vegetables by untimely and incessant, heavy rains and hailstorms.
- Delayed sowing and late rainfall, damage to crops by sudden, early and late, spring frost in paddy and potato crops respectively, indicating a shifting of seasons.
- Outbreak of pests and diseases in the fields and during storage.
- Damages to road infrastructure, risking food security.

4.3 BIODIVERSITY, FORESTS, WILDLIFE, AND ECOTOURISM

Climate is one of the most important determinants of vegetation patterns globally having significant influence on the distribution, structure and ecology of forests and the overall biodiversity distribution. A recent study carried out by ICIMOD in 2010 on impacts of climate change on Eastern Himalayas (Tsering,2010), has concluded that diverse species are at risk due to climate change; where aquatic habitats are likely to have altered community structure and functioning; hydrology and nutrient inputs of wetlands are likely to be adversely affected; alpine ecosystems likely to be further reduced due to encroachment of vegetation types that grow at higher temperatures, the forest and grassland ecosystems may face wide spread fires; new invasive species or fast colonisation of invasive species may take place and long term ecosystem shifts may take place in protected ecosystems. The vulnerabilities of the biodiversity are further described below.

- Species at risk - Although there could be some benefits for at-risk species, in general, there is significant concern for species at risk that are already threatened by small population size, loss of unique habitats, and low reproduction/dispersal rates (among others). The potential for climate change to further exacerbate these existing causes could greatly increase the risk of extinction.
- Aquatic habitats - Extended summer low flow periods are expected in rain fed streams. This will further increase water temperature, favouring warm water species and altering community structure and functioning. Conversely, in snowmelt and glacier-fed streams, the magnitude and duration of summer floods is expected to increase. In either case, significant impacts on aquatic habitats are expected.
- Wetlands - Wetlands are particularly vulnerable to climate change. As physiographically limited systems, they are unable to migrate and, hence, are vulnerable to changes in hydrology, nutrient inputs etc..
- Alpine ecosystems -Given their restricted geographic area and narrow elevation range, alpine ecosystems are particularly vulnerable to climate change. Climate and vegetation change rapidly, with altitude over relatively short distances in mountainous terrain and as a result alpine ecosystems are particularly vulnerable to encroachment by lower elevation ecosystems.
- Forest and grassland ecosystems - A recent report (MoEF, 2010) using a dynamic global vegetation model showed that at the national level, in the north eastern region only about 8% of (or 6 out of 73) forested grids are projected to undergo change. Projections of NPP for this region are is likely to witness a 23% increase on an average. Thus the Government of India has formulated a National Greening India Mission in the context of climate change adaptation and mitigation and to sustain the ecosystem services of forests. Ongoing concerns include the increased potential for major widespread wildfires and the subsequent potential for transformations in disturbed ecosystems, such as the colonisation by

Flowers blooming in Sikkim

invasive species and resultant new species assemblages. Grassland ecosystems may expand in range, yet face threats in terms of lost species diversity.

- Invasive species - Climate change may expedite the colonisation of some areas by invasive species in both terrestrial and freshwater realms. Increased frequency and magnitude of forest disturbances will create openings vulnerable to colonisation by invasive plants.
- Protected Area (PA) ecosystems - Protected areas are widely acknowledged as one of the most important management instruments for biodiversity conservation. In the eastern Himalayas, protected area systems are some of the most intricate and complex, maintaining a delicate balance between conservation and sustainable use. The potential for major, long-term ecosystem shifts under a changing climate suggests a need to re-evaluate the protection of representative ecosystems with a stronger focus on the landscape approach as it is based on broad topographical features that do not shift with climate change.

4.4 IMPACTS ON HYDROPOWER GENERATION

There are three main impacts of climate changes on hydropower projects. First, the available discharge of a river may change, since hydrology is usually related to local weather conditions, such as temperature and precipitation in the catchment area. This will have a direct influence on economic and financial viability of a hydropower project. Moreover, hydropower operations may have to be reconsidered to the extent that hydrological periodicities or seasonality change. The reason is that, if the flow of water changes, different power generating operations, e.g., peak versus base load, would be possible using other designs for water use, such as reservoirs. Second, an expected increase in climate variability may trigger extreme climate events, by increasing the volume of water suddenly leading to floods or decrease in water leading to droughts. Finally, closely related to the above, changing hydrology and possible extreme events must of necessity impact sediment risks and measures. More sediment, along with other factors such as changed composition of water, could raise the probability that a hydropower project suffers greater exposure to turbine erosion. When destruction actually occurs, the cost of recovery would be enormous. An unexpected amount of sediment will also lower turbine and generator efficiency, resulting in a decline in energy generated.

4.5 IMPACTS ON HABITATS AND TRANSPORT

The types of changes that will affect urban areas can be due to changes in means, extremes and changes in the exposure to urban areas. With the continued expansion in urban habitats, with rural population shifting to urban areas, changes in means of climate parameters will intensify the stresses faced by poor urban residents on a daily basis impacting in a reduction or depletion of their stocks, assets and resources required to face occasional extreme events.

Additionally, with the increase in the intensity of these extreme events it is expected that this will have significant implications for the households, livelihoods and lives of such groups of people. Specifically in relation to urban areas, the IPCC states that "climate change is almost certain to affect human settlements, large and small, in a variety of significant ways" (Willbanks et al 2007: 371). Climate change is likely to exacerbate many of the risks faced by low-income urban residents – the IPCC also states that "poor communities can be especially vulnerable, particular those concentrated in relatively high-risk areas" (Willbanks et al 2007: 359). Urban areas in developing countries such as India already house a large percentage of people and economic activities that are most at risk from climate change, including extreme weather events. The summary of likely impacts of climate change on habitats, especially urban habitats in Sikkim is indicated (Table 2).

The transport sector is a major source of Greenhouse Gases (GHG) emission. Avoiding or reducing transport, shifting transport to less polluting modes and improving existing modes are the three major starting points. The relevant policy instruments include planning, regulatory, economic, information as well as technical instruments. Improved transportation planning, better roads, improved efficiency of energy use in transport and introduction of bio fuel mix in fossil fuel, and the increased use of Compressed Natural Gas (CNG) are some of the measures that can be introduced to reduce emissions from this sector in the Indian context including Sikkim.

Table 2: Likely impact of climate change on urban habitats

Changes in mean	
Temperature	Increase in energy demand for heating and cooling
	Worsening of air quality
	Impacts exaggerated by the urban heat island effect due to a higher density of habitats
Precipitation	Increased risk of flooding
	Increased risk of land slides
	Distress migration from rural areas
	Interruption in food supply
Changes in extremes	
Rainfall cyclones	More intense flooding
	Higher risk of land slides
	Disruption of livelihoods and urban economy
	Distress migration from rural areas
Heat or cold waves	Short term increase in energy demand
Abrupt climate change	Possible significant impacts from rapid changes in temperature or increase in frequency or intensity of temperatures
Changes in exposure	
Population movement	Movement from stressed rural areas
	Extended vector habitats
	Exposure to heat stress

Source: Willbanks et al., 2007

However, other than being the source of emissions, the road transport sector is also at risk due to climate change in Sikkim. This is as the roads may be exposed to increased incidences of landslides. Also increase in extreme precipitation may increase the number of accidents due to increased skidding on wet roads. Further melting of perma frost at higher altitudes may affect the high altitude roads that link the international borders. Therefore, a strong road network that is resilient to climate change is essential for the economy of the state as Sikkim is land-locked with goods and people travelling in and out of the state using the roads. Improved design of roads to make them climate proof is therefore essential.

Vulnerability Assessment of Rural Communities

5.1 INTRODUCTION

Long term climate observations in Sikkim, indicate that increasingly the winters are becoming warmer and dryer (see Section 3.3). Due to increased runoff and dry winters, springs have started drying up and their lean season discharge is reducing drastically. Annual mean rainfall show high variation due to the geography, with the rain shadow areas in the lower part of South and West districts receiving only half the rainfall compared to the East District. All this has resulted in a decline in the production of the winter crops and an increased incidence of forest fire which is now ascending into the temperate zone.

88.9% of the population are residing in the rural areas of Sikkim. Being dependent on agriculture, horticulture, livestock rearing and forest products are already at risk due to the current climate change and would be further vulnerable with the projected changes in climate in the future.

The state is administratively divided into four districts, namely North, East, South and West. Concerns due to climate change have indicated to a need for micro scale studies that would take into account the high variability in vulnerability that is typical of mountainous areas. Climate change related vulnerability studies

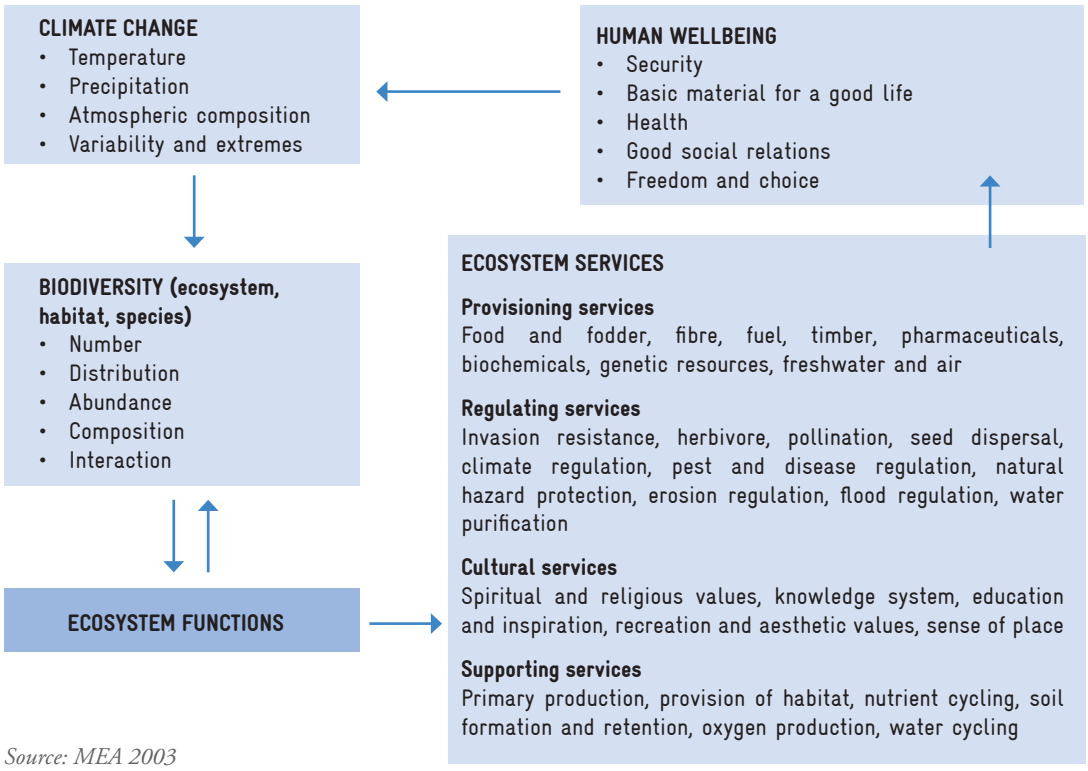
taken up in the state at the district level (macro scale), have found the South and West districts to be the most vulnerable (WWF-India 2010, IISc 2010). Inspite of being a small state, there is a high variation in exposure (temperature and rainfall), sensitivity (water, livelihoods and health) and adaptive capacity (poverty, literacy, environment and connectivity) indicators over short distances.

Further it is seen that, in spite of being a small state, there is a high variation over short spatial scales of exposure to temperature and rainfall; sensitivity of water resources, livelihoods and health; and adaptive capacity of the population defined by the level of poverty, literacy, environment and connectivity by roads and telecommunication indicators. It is therefore imperative that a strategy be put in place, where by the communities in villages dependent climate sensitive sectors can be made to adapt to the changing climate which is likely to see warmer temperatures and intense extreme events in the future with respect to what is being experienced now. In order to do so the first step is to ascertain the level of vulnerability of these communities. The task is further complicated by the steep mountainous topography of the state which is ranging from 300 to 8,598 meters within a narrow span creating micro climates which are highly variable at very small spatial scales.

5.2 LITERATURE REVIEW

Climate affects humans directly through the weather experienced (physically and psychologically) day to day and the impacts of weather on daily living conditions, and indirectly through its impacts on economic, social, and natural environments. The potential for climate change to impact on natural resources and hence biodiversity has long been noted by the IPCC, various other bodies (Feenstra et al. 1998), and research biologists (e.g., Peters and Lovejoy 1992). Climate change, including variability and extremes, continues to impact on mountain ecosystems, sometimes beneficially, but frequently with adverse effects on the structure and functioning of ecosystems leading to vulnerability of human well being and hence communities dependent on the same. Fortunately, the functioning of many ecosystems can be restored if appropriate action is taken in time.

Figure 5.1: Linkages between climate change, biodiversity, ecosystem services and human wellbeing



Source: MEA 2003

The linkage between climate and human wellbeing is complex and dynamic as shown in (Figure 5.1). Many studies have been carried out globally and in India which assesses vulnerability of ecosystems and biodiversity focussing only on climate change related drivers such as temperature, rainfall, extreme events, amongst others. The global studies have been reviewed extensively by the IPCC (IPCC, 2007b) and in India in its first national communication (NATCOM, 2004) and the latest study carried out by the MoEF, under its programme 'Indian Network on Climate Change

Assessment' (INCCA, 2010), 2010). However, second generation assessments are also being explored which adopt a multi-disciplinary integrated approach where socio economic drivers such as economic parameters, level of education, penetration of infrastructure etc. at a global level (Füssel and Klein 2006) as well as focussing on the eastern Himalayan region (Tse-Ring et al., 2010).

Sikkim is a part of the Eastern Himalaya global biodiversity hotspot with 47% forest cover (Mittermeier et al. 2004; FSI 2007). In terms of country-level vulnerability to climate change, India ranks very high globally (Moss et al., 2001). Within India, Sikkim state shows high resilience as compared to the other states (Brenkert and Malone 2005). The relative climate change vulnerability rank of Sikkim amongst the mountain ecosystems in the Eastern Himalayas was found to be 51 out of 89 (Tse-ring et al. 2010).

The state is administratively divided into four districts, namely North, East, South and West. Climate change related vulnerability studies taken up in the state at the district level have found the South and West districts to be the most vulnerable (WWF-India 2010, IISc 2010). The following sections, describe the methodology used to assess the vulnerability of rural communities in Sikkim, and further describes the results.

5.3 METHODOLOGY

The methodology aims at developing vulnerability indicators of the rural populace in Sikkim, which is an interplay of risk to exposure to climate change, sensitivity of the systems, and the adaptive capacity of the communities. It is important to have an integrated assessment as high levels of exposure and sensitivity of systems may get negated by high adaptive capacity thus resulting in lower vulnerability values. Developing countries owing to their comparatively lower adaptive capacity are considered to be inherently more vulnerable to climate change. Indicators for exposure, sensitivity, and adaptive capacity were derived from disaggregated attribute datasets.

There are a total of 163 Gram Panchayats (or villages) in the State, having an average population of 3,000 and an extent of 10 km2. The current study builds largely on secondary information in the form of reliable government sourced datasets and primary information collected from village consultations. A total of ten indicators available in a disaggregated manner at the village level were used to measure vulnerability. Ground truthing in the form of participatory approaches is also

integrated. The whole study was completed in six months from March to September 2010 incurring a field expenditure of less than USD 12,000.

Box 3: Exposure, sensitivity and adaptive capacity

Climate related vulnerability is defined as a function of climate change exposure, sensitivity, and adaptive capacity.

Exposure is defined by the magnitude, character and rate of climate change in a given geographical area.

Sensitivity to climate change is the degree to which a community is adversely or beneficially affected by climate related stimuli.

Adaptive capacity of a community is its ability to adjust to climate change, to moderate or cope with the impacts.

Source: IPCC, 2007b

5.3.1 DATA USED IN THE ASSESSMENT

Climate: Long term, reliable data is available only for one station - Gangtok. Climate change related studies based on the analysis of the data for this station month- wise, season wise and annually from 1957 to 2005 indicates a trend towards warmer nights and cooler days, with increased rainfall except in winter. The maximum temperature in Gangtok has been rising at the rate of 0.2 degree centigrade per decade and the annual rainfall is increasing at the rate of nearly 50 mm per decade (Seetharaman 2008; Ravindranath 2006; IISc 2010). Comparison of long term meteorological data available for Gangtok station (1957 to 2005) with the trend over the last few years (2006-09) shows an acceleration of these patterns (Table 1), with winters becoming increasingly warmer and drier now (Seetharaman 2010).

Exposure indicators: Long term, reliable meteorological data is available only for Gangtok station and was sourced from the Indian Meteorological Department, Gangtok office. Hence the disaggregated annual mean temperature data was obtained from the website www.worldclim.org However, the annual mean rainfall pattern indicated here was not found to be accurate and consequently this was sourced from the rainfall distribution map of National Bureau of Soil Survey and Land Use Planning (NBSSLUP) (2000).

Sensitivity indicators: Sensitivity component includes three sectors; water resources, livelihoods and human health. For each of this sector 1-2 indicators were selected to represent aspects of the sector that was quantitatively analyzed. The percentage of rain fed farming was used as a proxy indicator of the water resources availability. To represent the sensitivity of the livelihoods sector, two indicators were selected namely elevation and percentage of population mainly dependent on farming. Elevation was chosen since the crops in the subtropical belt (less than 1000m) have been impacted the most by pests, disease and weed. Elevation was obtained from the Shuttle Radar Topographic Mission (SRTM) produced by National Aeronautics and Space Administration (NASA) originally. The SRTM 90m DEM file (srtm_54_07.zip) was downloaded from the CGIAR-CSI GeoPortal (Jarvis et al. 2006). This file in Geotiff format was processed in Erdas Imagine software (version 8.5) to subset the study area from this image and exported to grid format. The percentage of population mainly dependent on farming was obtained from the Census (2001).

GPW: Gram Panchayat Ward

GPU: Gram Panschayat Unit

BDO: Block Development office

A: Total number of Households

B: Total no of Below Poverty line house holds

C: Total Population

D: No. of OBCs E: No. of MBCs F: No. of SCs

G: No, of STs

H: No of General population

Adaptive capacity indicators: The socio-economic conditions that bear on adaptive capacity component include economic capacity, human capacity, environmental capacity and physical connectivity. While poverty rate was used as a measure of economic capacity, the percentage of population passed class ten was used to represent human capacity. Population density was used as a proxy indicator of environmental capacity and the type of rural connectivity (paved road, mud road, and footpath) was used to represent physical connectivity of the village. These socio-economic data at village level was sourced from the Census of India (2001) and State Socio-economic Household Census (2005).

5.3.2 GROUND TRUTHING

Rapid assessments were carried out in the selected villages to ground truth the data that has been taken for the assessment. Six villages were selected from the 9 districts, which cover the entire altitudinal range of Sikkim, have a mix of disadvantaged population in terms of cast distribution; number of households that range from 0 family units under poverty line and families with maximum below poverty line etc. The list of the villages selected and their characteristics is summarised in (Table 4). Interviews with the villagers have thrown up their perception of what

Table 4: Rural villages chosen for rapid assessment of perception of climate change and impacts												
GPW	GPU	BDO	District	A	B	C	D	E	F	G	H	Altitude (ft)
Thasa	Singbel	Kamdong	East	55	34	–	0	21	0	273	0	3000-5000
Tsokha-Kyongtek	Yuksam	Yuksam	West	87	10	456	17	1	6	422	10	6000-8000
Lower Ribdi	Ribdi Bareng	Darimdin	West	88	14	429	24	73	5	327	0	7000-10000
Nerdang	Tashiding	Yuksam	West	131	32	660	50	74	124	371	41	3000-5000
Duwarey Gaon	Sumbuk Kartikey	Sumbuk	South	0	26	506	344	81	76	5	0	2000-4000

is happening to climate and how it is impacting their resources on which they are dependent. A summary of the weather parameters assessed and the impressions of their change and how they are impacting is provided in (Table 5).

Table 5: The perceived changes in climate and impacts			
Sl.	Weather events	Change perceived (Generalized)	Some indicators
1	Snowfall	Reduced snowfall since last four years in temperate belt villages, less frost as well	Warm dry winter and less frost, most high altitude have become accessible during peak winter, new pest and diseases
2	Rainfall	Rainfall months have decreased but the intensity have increased. The spread of rainfall has declined from nine months in a year to 5 months to 7 months in a year. There is heavy down pour during monsoon, compared to constant low intensity rainfall in the past. The winter rainfall has decreased significantly over last 5 years especially in the lower belt	Frequent landslide, unreliable road connectivity, floods, longer dry period in winter
3	Hail storm	Are unpredictable and not frequent but the intensity have increased (the size of the hailstorm has increased); the hail storm this year was heavy compare to last 10 years.	Severe damage to tender maize crops, orange flowers, potato
4	Cold temperatures	Winters have become warmer, and duration has reduced from 6 months to 3-4 months with sub tropical zone being adversely impacted.	Increase in population of insects and vector borne diseases. Also water has stopped freezing in winter time.
5	High temperatures	The high temperatures persist for longer times from 5 months to 6-8 months with sub tropical zone being adversely impacted. Also the day temperature during peak monsoon has increased.	Villagers started using refrigerators and fans. Increase in outbreaks of pests, diseases and weeds in lower belt with decrease in yields of ginger, fruits, and tomatoes observed. Farmers in lower belts have started growing these crops
6	Dry season	Hardly any rainfall for continuous 6 months from Oct - Nov up till March with the environment dry and dusty	Frequent and ascending forest fires, drying spring water sources, decline in winter crops and vegetables

5.3.3 DATA ANALYSIS

There are three components namely exposure, adaptive capacity and sensitivity which are used to calculate the vulnerability. The indicators for a component are normalized so that the mean = 0 and range = 1. The Indicators In have been estimated using the following equation:

In = (I – Imin) / (Imax – Imin)

The value for each component is taken by taking the mean of all the indicators

C = Average (In)

Following this the climate-related vulnerability index (VI) is calculated as:

VI = (Exposure – Adaptive capacity) x Sensitivity

The VI is again normalized so that the mean = 0 and range = 1

Market place in Sikkim

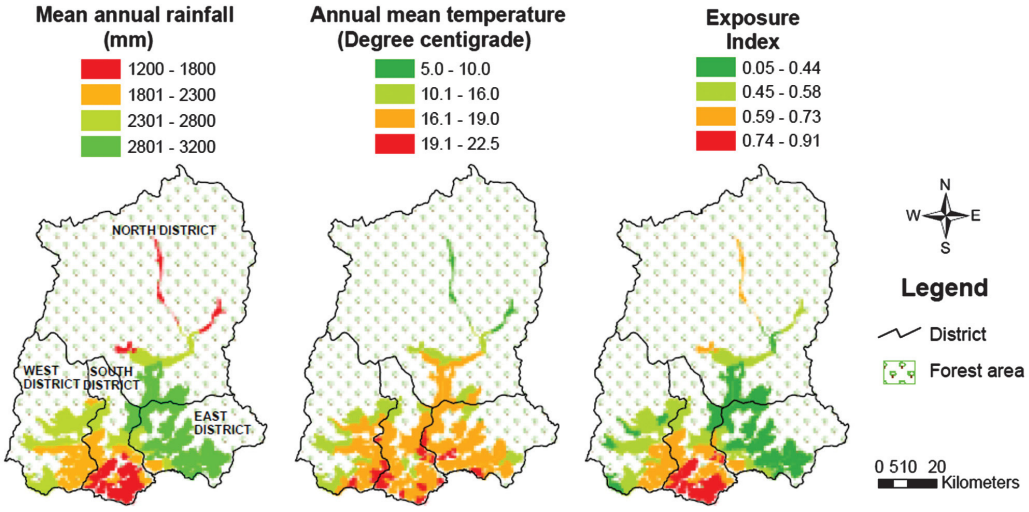
5.3.4 DATA INTEGRATION

The developmental units in the state comprise of 163 Gram Panchayat Units (GPU), 24 developmental blocks and 4 districts namely North, East, South and West. A village is defined as a GPU, and its administrative boundaries were marked on the Survey of India 1: 25000 scale topographical sheets. These boundaries for all the GPUs were then digitized and the village maps prepared. The census data was integrated on a Geographic Information System (GIS) platform. ArcGIS software (version 9) was used for integration of the various layers on a GIS platform.

5.4 RESULTS

Both temperature and rainfall showed large variations over short distances. While the annual mean temperature varied from 5°C to 22.5°C the annual mean rainfall varied from 1200 mm to 3200 mm (Figure 5.1). Climate exposure index was found to spatially vary from 0.05 to 0.91 with the mean being 0.53+0.16. The south central part of the state which has the lowest altitude is also drought prone, as it falls in the rain shadow of the Darjeeling Himalaya was found to have the highest exposure (Figure 5.1). The observations of the local community regarding the pattern of climate change and the associated impacts (Table 4 in section 5.3.2) are corrobo-

Figure 5.2: Exposure of the rural communities in Sikkim to climate



rated by the scientific studies of Seetharaman (2010) highlighted in (Table 1).

The sensitivity index estimated on the basis of (a) percentage of rain fed farming, (b) percentage of farmers, (c) elevation and (d) family size varied from 0.23 to 0.72 with the mean being 0.59+0.08 (Figure 5.3d). In the subtropical zone (less than 1000m) the production of important cash crops like ginger, orange and fruits has declined due to prolonged droughts and outbreak of pests, disease and weeds. Crops like maize, broom grass and turmeric were found to be the most resilient. This zone was earlier a very productive area with multiple cropping, now due to less winter rain only single cropping during the monsoons is possible. Storage and preservation of seeds is also becoming increasingly difficult due to pest, disease and dry winter. Communities in the middle and upper hills were found to be less vulnerable, as climate change provided opportunities for new crops, higher production and early ripening.

Adaptive capacity index estimated based on economic capacity (percentage of poverty), human capacity (in terms of number of persons having passed 10th class in school), environmental capacity population density) and physical connectivity (in terms of roads) varied from 0.24

Figure 5.3: (a), (b), (c) and (d) Distribution of parameters for measuring sensitivity of rural communities of Sikkim (e) Sensitivity index of rural communities in Sikkim

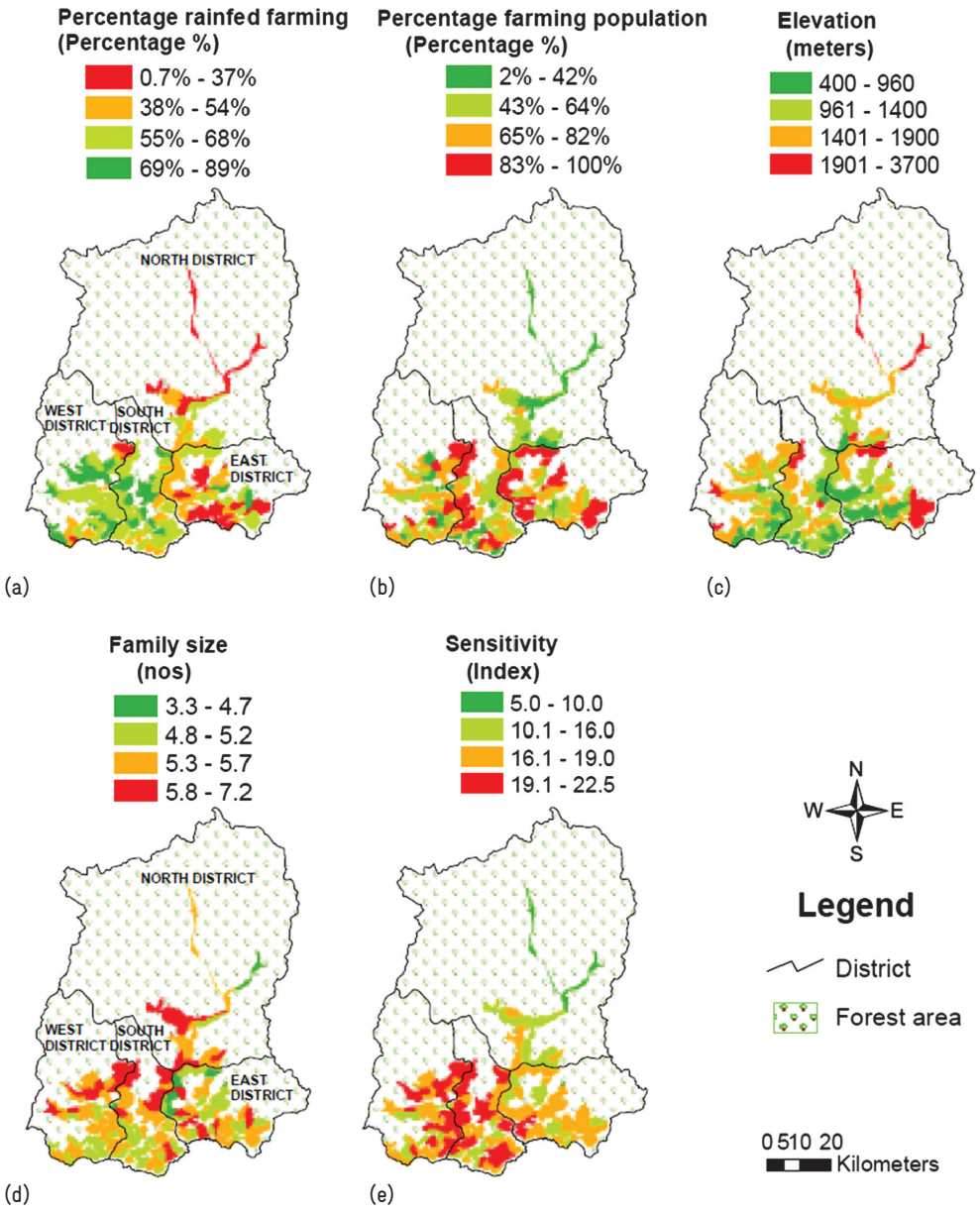
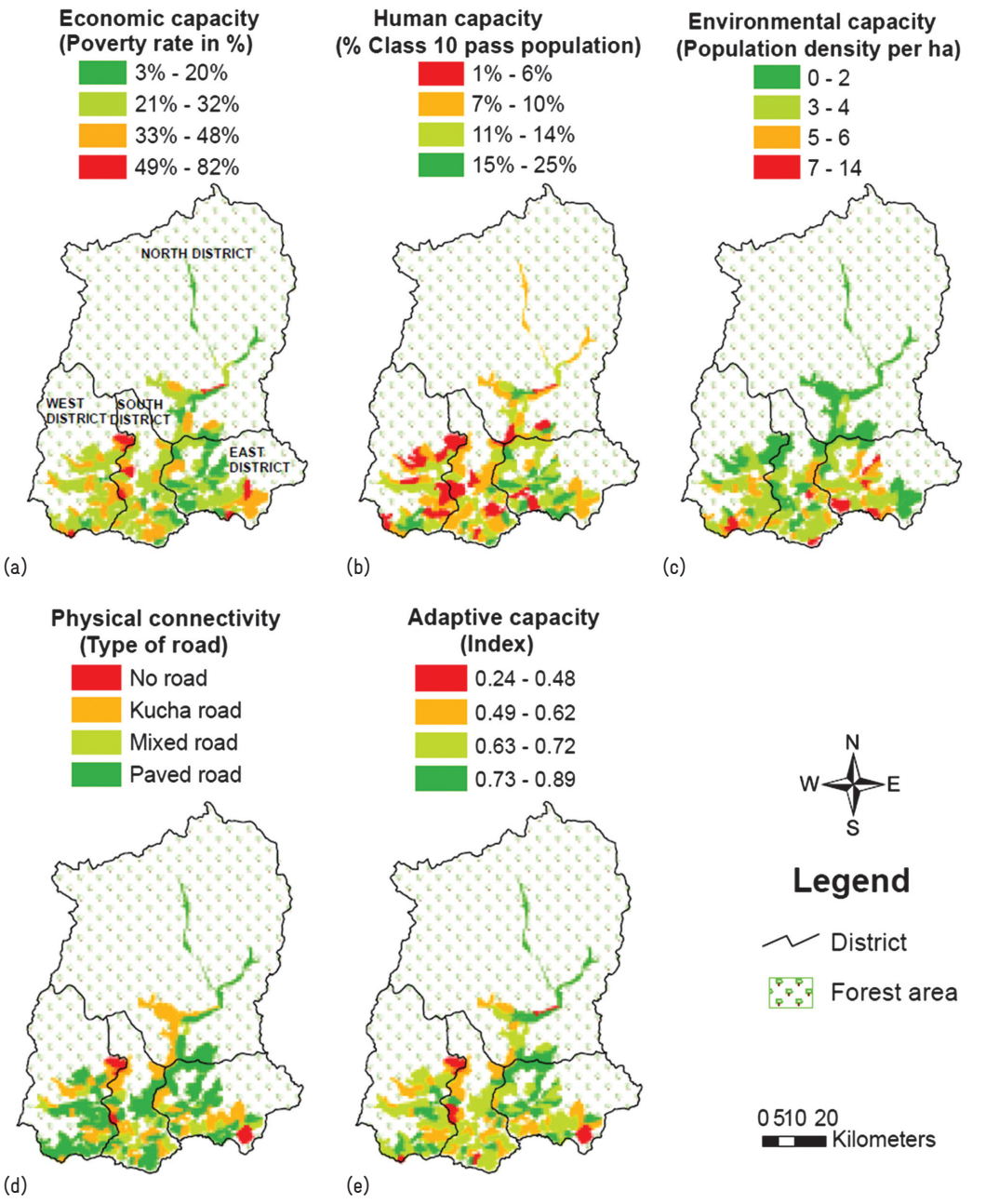


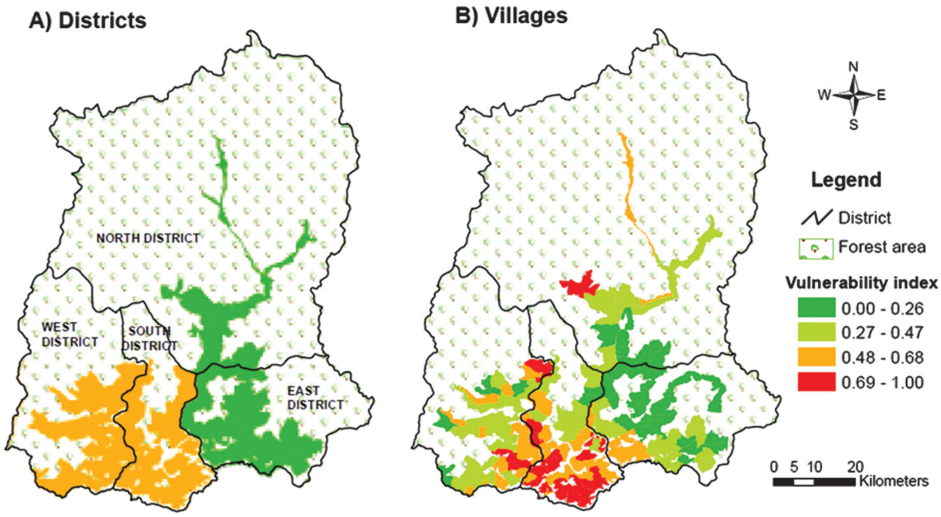
Figure 5.4: (a), (b), (c) and (d) Spread of indicators for adaptive capacity and (e) index of adaptive capacity amongst the rural communities in Sikkim



to 0.89 with the mean being 0.66+0.1 (Figure 5.4). Remote villages with lack of physical connectivity also showed high illiteracy and poverty resulting in weak adaptive capacity. Villages adjacent to urban centres with good connectivity and diverse opportunities displayed high adaptive capacity.

Finally, the vulnerability of the rural communities extending over 163 Gram Panchayats in Sikkim, estimated as a combination of exposure, sensitivity and adaptive capacity indices mentioned above, is found to vary between climate 0 to 1 with the mean being 0.43+0.22 (Figure 5.5). Exposure and adaptive capacity was found to determine the vulnerability to a large extent as sensitivity did not vary much. South district was found to be the most vulnerable followed by West. East and North districts were found to be relatively resilient to climate related change.

Figure 5.5: Vulnerability of rural communities in Sikkim



5.5 DISCUSSION

The rural communities have already started coping with the impacts of climate change using indigenous methods. The national flagship programme, Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) has become an important source of climate-proof cash income in the rural areas. Rural folk have started supplementing farming livelihoods with non-farm activities like MGNREGA, tourism, trade, non- farm labour and in extreme cases even migration. Ginger seed is now being protected from dry winter by storing it underground. Seeds of pulses, beans and soyabean are preserved by mixing with kerosene, ash, camphor etc. The seed bank has also been enlarged to account for replanting when young crops get damaged by hail. Fruit trees are protected from increased incidences of insect borers by applying kerosene, petrol and diesel in the tree holes. Springs are drying up specially during the dry winter months, and the local communities are coping by improving the water storage infrastructure, storing water overnight in tanks and containers and also pumping water from downstream. Crop residue is being stored for use as winter fodder for livestock.

A village by village analysis indicates that most of the vulnerable villages in terms of their exposure to climate lie in the drought prone subtropical zone of South and West districts (Figure 5.6a). Sensitivity of the Karzi- Mangnam village was found to be highest due to large family size (of seven) and largest population (100%) dependent on farming (Figure 5.6b). Comparative Rawtey-Rumtek village was found to be least sensitive owing to the smaller family size (of five), coupled with diversified livelihood opportunities available there and better irrigation facilities. Consequently the percentage of rain fed farming and population dependent on farming (61%) was much less here. In terms of a comparison of the adaptive capacity it was found that Karzi-Mangnam village had favourable environmental capacity which was offset by a high poverty rate (82%), low education levels (1% have passed class ten) and poor road connectivity resulting in the weakest adaptive capacity (Figure 5.6c). On the other extreme, Rawatey-Rumtek village had a low poverty rate (8%), high education level (25% have passed class ten) and is well connected resulting in a high adaptive capacity.

In spite of having moderate exposure, Karziangnam village showed high vulnerability due to high sensitivity and low adaptive capacity. Amongst all the villages,

Lungchok-Kamarey village had the highest vulnerability owing to a high exposure, high sensitivity and a low adaptive capacity. Similarly Rawatey-Rumtek village had the least vulnerability owing to the moderate exposure, low sen-

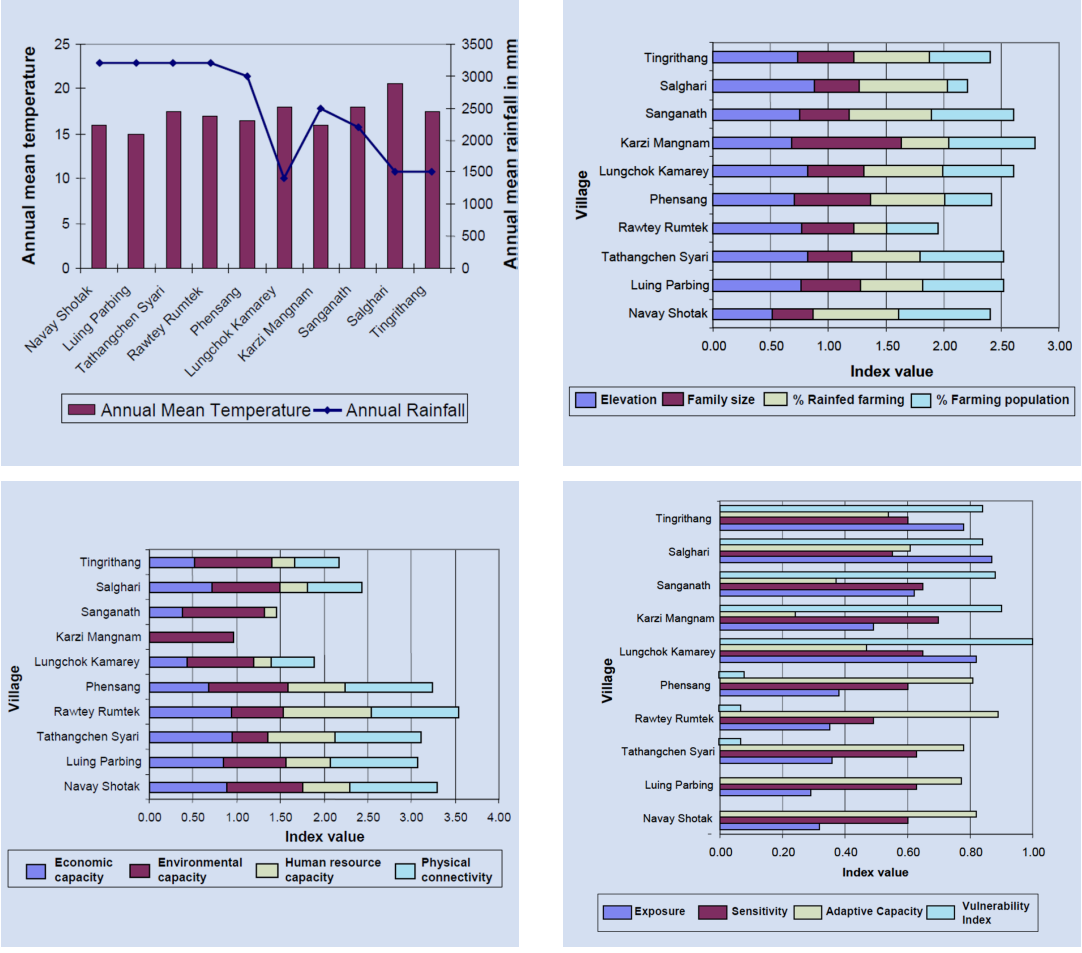
sitivity and high adaptive capacity (Figure 5.6d). Vulnerable villages like Sakyong-Pentong and Lachen (in North district) and Central-Pendam, West-Pendam and Singbel (in East district) were found to occur in less vulnerable districts. Also less vulnerable villages like Okhrey Ribdi and Yuksam (in West district) and Lingmo-Kolthang, and Paiyong (in South district) were found to occur in the vulnerable districts. From these results, it is concluded that the communities that practiced the most climate sensitive livelihoods, had least adaptive capacity and also faced high exposure. Communities practicing sensitive livelihoods of rain fed farming were found to have the least adaptive capacity (poverty, education, infrastructure etc) and also faced high exposure of climate-related change (drought, pests).

5.6 CONCLUSION

The farmers are already coping with the vagaries of climate, through the employment guarantee scheme Act (NGNREGA) which are in addition to the programmes and policies of the government to develop sustainably each sector such as the MGNREGA, and the indigenous practices of farmers such as preservation of seeds and tubers from extreme temperatures and exposure to high levels of moisture, forming seed banks and improving water storage capacities for irrigation in lean seasons.

To counter the exacerbated impacts of climate change, however, diverse development interventions are needed at village level itself, as significant variation in vulnerability was found within

Figure 5.6: Indicators for five least and most vulnerable villages in Sikkim
(a) Exposure indicators of annual mean temperature and annual mean rainfall; (b) Sensitivities; (c) Adaptive capacities and (d) Vulnerability Index



a district itself. For example while in Karjee-Mangnam interventions are needed in the sectors of education, health (family planning), incomes and roads, in others like Sanganath the priority sectors are education and roads. However, more indicators for each Gram Panchayat need to be included, to develop the vulnerability rankings, to ensure that errors of inclusion and exclusion are minimized and climate change adaptation funds are efficiently targeted especially in mountain areas.

To conclude, while not much can be done to reduce exposure which is an external driver of climate change, it is essential to:

- Undertake integrated multi-sectoral assessments that encompass the diverse sectors of education, health, environment, roads, irrigation, agriculture, water, poverty alleviation, skill development, non- farm employment etc. to determine to rank the villages in terms of their vulnerabilities functioning under existing programmes.
- Develop village specific adaptation packages to Improve the sensitivity and adaptive capacity of rural communities,
  - Through local interventions which are over and above the state and national policies.
  - Strengthening of the developmental programmes.
  - Diversifying livelihoods by promoting activities like village tourism, industries, animal husbandry etc.
  - Modifying farming practices by shifting to species and varieties that require less rain.
  - Improve water storage infrastructure and artificial recharge of ground water by rainwater harvesting.
  - Improve access to credit, savings and markets.
  - Quality education and skill development in different income generation activities.
  - Improve access to roads and telecommunication.

Part 2

Strategies and Actions to address Climate Change Concerns

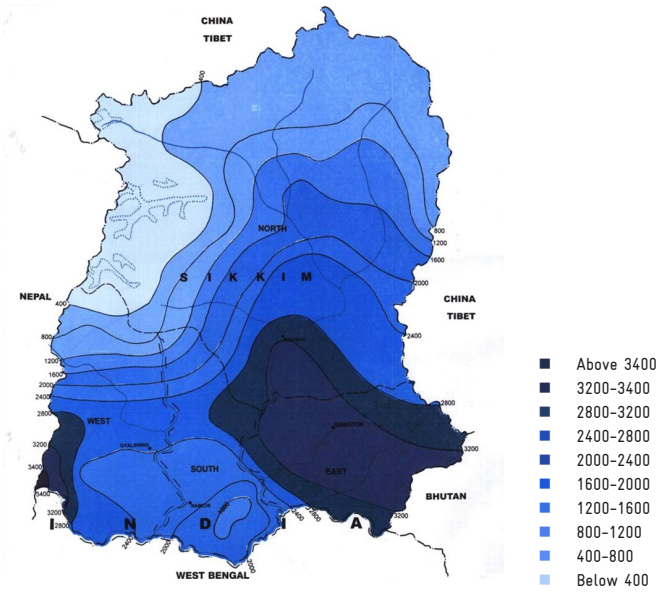
Water Security

Water harvesting

6.1 WATER RESOURCES IN SIKKIM AND CONCERNS OF WATER SECURITY

Nearly 60% of the geographical area of Sikkim lies above 3,000m and it harbors 10 peaks that rise above 7,000m. There are altogether 84 glaciers covering an area of about 440 km2 with the total extent of permanent snow fields being 251 km2 (SAC 2001). This unique geomorphology has resulted in more than 231 lakes as per Dept. of Science and Technology records located at an average altitude of 4,700 (+500) m (CISMHE 2005). The annual rainfall varies from less than 400 mm in the north to more than 3,400 mm in the south-eastern parts (see Figure 6.1), with

Rainfall contour map of Sikkim



Source: ICAR, SiIkkim

the river Teesta and its tributaries being the main drainage.

State of Sikkim solely depends upon "springs and streams" to meet its water demand. Water is available to the population of Sikkim though:

Water supply to Urban and rural marketing[3] centers is through:

Tapping of water sources located at higher ridges.

Transporting the same (raw water) under the influence of gravity from the source to the lower reaches, treatment to render it harmless and potable, storage and finally distribution to consumer points through Zonal Distribution Systems.

Springs flows from points where ground water intersects the surface. These springs get charged with rain water infiltration. Natural Charging takes place only if there is vegetation otherwise ground water recharge does not take place and the water flows away as surface runoff.

Surface water sources are very sensitive to pollution, degradation of environment, and climate. In the state at many places these sources are drying up. South and West districts of the state are comparatively dry areas.

Rural water

- Himalayan mountain springs (Mohaan, Kuaan and Dhara) provide the main source of water to the 80% of the rural population that thrives on this source of water (State socio economic census, 2006) for drinking as well as irrigation purposes. This is due to constraints of the terrain where piped water cannot be transported to the remote villages nor can canals be dug for water to reach every farming plot as in the plains. Of late the mountain people, who depend mostly on spring water, have started facing water scarcity with alarming frequency.
- Since water plays a vital role in the sustenance of this population, a wealth of traditional knowledge exists regarding their conservation and management. Water sources were preserved traditionally preserved as Devithan and kept free from biotic interferences. However, the religious approach towards protection of the spring and its catchment is slowly but surely losing its influence and spring sheds which earlier comprised of well-forested catchments are increasingly being reduced to a few trees or a bamboo clump.

It is noticed that during the lean period, discharge from the Bermeli stream for Namchi is gradually reducing (PHED, 2010, Annual Report, http: //www.sikkim- wsphed.gov.in/annual_report.htm, accessed on 8th March 2010). With late monsoons, rainfall over the seasons are erratic and coming in short bursts, extreme weather events are becoming more frequent, dry seasons are becoming longer, weather patterns becoming unreliable, e.g. autumn season has extended and winters have become dry. During the year 2008 and 2009, the state witnessed one of the driest winters in living memory. This has resulted in,

- Springs becoming seasonal.
- High volume of run offs down the hills during frequent extreme rainfall events leading to landslides and hence no retention for recharge of ground water due to reduced percolation of water underground.
- Lengthening of dry period during winters has resulted in a higher incidence of forest fires and hence denuding of forests and disturbing associated water sheds on the mountain tops.
- The lakes on the mountain tops have dried, as adequate recharge is not occurring.
- Degradation of vegetation leading to the inadequate recharging of water bodies charged through water collecting from catchment areas from the rains, which otherwise quickly flow down valleys and is lost.

3 Most of the Rural Marketing Centers which were a few years ago, small in terms of habitations are fast developing as small townships, such as Ranipul, Rhenok, Rongli, Pakyong, etc. These Centers are generally located in the proximity of clusters of villages as commercial and economic centers.

Box 6: Challenges towards ensuring water security in Sikkim in the context of climate change and other drivers

- Factoring in climate change in estimating future water demand by sector.
- For meeting water security the challenges would be
  - Recharging of dried springs
  - Recharging of natural lakes on hill tops
  - Maintenance of enough forest cover at the upper catchment areas for them to act as recharge zones
  - Enabling adequate artificial water harvesting to recharge ground water
  - Improving the base flow of critical streams specially in the lean season
  - Rejuvenation of stream-shed and harnessing the water from perennial streams in the lower belt of Sikkim
- Archiving and dissemination of traditional knowledge on water harvesting and conservation.
- Inadequate mapping of actual rainfall due to non availability of rainfall data at high spatial resolution.
- Non availability of high resolution climate change scenarios that can capture the micro climate variability of this mountainous region and make projections at short, medium and long term time lines.

Appropriate water pricing and regulation for judicious use of water under water scarcity conditions due to increase in droughts.

In this context the challenges and concerns facing Sikkim to make itself a water secure state would be to protect the springs and various recharge zones. Specific challenges are indicated in (Box 6.) Traditionally, water supply or harnessing schemes have received higher priority, but with the drying up of springs, these schemes are faltering, and there is felt need to revive the water sources through strategies which are ecologically sound, actively demonstrated and upscaled, and are cost effective. These can be new strategies, revival of old strategies of the government or revival of traditional strategies for conservation of water.

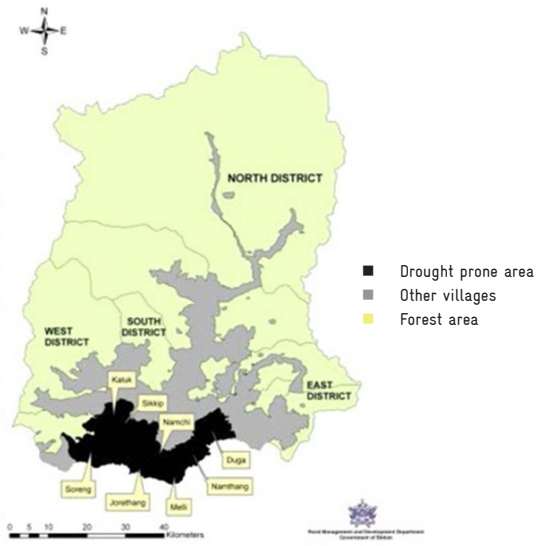
6.2 IDENTIFICATION OF REGIONS VULNERABLE TO WATER AVAILABILITY

Macro features related to geography, climate, watershed, land use and people's participation determine the strategy for water conservation. In mountainous regions, vulnerable areas which face drinking water scarcity during the lean season can be identified by having one or more of the following features:

- they are located on the ridge tops,
- they fall in the rain shadow area,
- they have little or no forest cover in the upper catchments,
- the prevalent land use is not amenable to water conservation.
- the general terrain is steep and rocky.

A study for developing strategies for enhancing rural water security, identifies 10 of the total 26 Blocks in the state as drought prone areas. These fall in the rain shadow of Darjeeling Himalayas, located in the gorge of the Teesta and Rangit rivers and having steep and rocky terrain, with little or no forest cover in the upper catchments.

Drought map of Sikkim



These drought prone areas lie in the lower belt of East, South and West District spanning across 10 Blocks of Duga, Rhenock and Khamdong in East, Namthang, Melli, Jorethang, Namchi, in South; Soreng and Kaluk in West; few parts of North district comprising of sal and middle hill forests (see Figure 6.2). Many of the watersheds especially in the South and West districts have forests along with river valley while the villages are in the upper catchments. Consequently surface runoff is high, ground water recharge is low and there is a need for rainwater harvesting to revive the ground water.

6.3 INSTITUTIONS MANAGING WATER IN SIKKIM

Irrigation and Flood Control Department: Its mandate includes Development of Water Resources, Construction of Minor Irrigation Channels, Maintenance of Irrigation Schemes, Water management and Water Conservation as a Nodal Department for clearance of schemes relating to river or reservoir works, Assessment of Irrigation and Irrigation Development, and Flood Control and Anti-Erosion Works, including Management and control of drainage and Jhora Training Works. Irrigation development in the State was initially looked after by the Rural Development Department till 1986 and Irrigation and Flood Control Department was created only in 1986 and since the department has been solely responsible for providing Minor Irrigation, River Training, Jhora Training etc.

Water Security and Public Health Engineering Department (WSPHED): The mission of the department vis a vis water is to provide safe and sufficient water for all the consumers, developing strategies to meet the increasing demand for water and sewerage system. Take into account suitable strategies and adopt suitable means to consider the environmental concerns thereby avoiding environmental degradation and pollution mainly while disposing the treated waste. Activities include construction and maintenance of water supply, sewerage and sanitation facilities in the urban towns, selected (semi-urban towns) bazaars and their peripheral rural areas; formulate and implement sewerage services and water supply tariff; and ensure conservation of water sheds, sources of water supply and environment.

Though WSPHED has been successfully supplying water to all its urban consumers, however, there still exists scope for improvements in the present system for which a forward planning and implementation policy based programs is essential to obviate any unforeseen future catastrophe of water shortage in the state.

Rural Management and Development Department (RMDD): The mandate of RMDD is to provide clean safe adequate drinking water to the rural habitation, improve the sanitation facilities, and ensure rural water security. The function of the RMDD includes assessment of actual ground position of water supply to rural communities in terms of numbers of habitations 'not covered, partially covered and fully covered'. It undertakes, on a regular basis the survey of water availability, i.e. survey of all the available water sources and upgrades water maps for the State. Undertakes monitoring and surveillance of water quality and intensification of water testing facilities e.g. establishment of water testing facilities in the Districts and Sub-Divisional Level. Completes the incomplete schemes; addresses the coverage of the newly emerged habitations/ reverse coverage habitations. Promotes appropriate alternate technology, viz., roof top collection, rain water harvesting etc. for dry pockets; works towards integrating Integration of rural water supply programme with other rural development activities and redefining appropriate unit for coverage area. Pilot projects have been taken up for spring shed development (namely Dhara vikas) which aims at artificial spring recharge using rain water harvesting techniques and is funded under MGNREGA. Resource mapping of springs is also underway by preparation of village spring atlas (www.sikkimsprings.org).

Department of Commerce and Industries: It covers the agro based industries, horticulture and floriculture, minor forest based industries, animal husbandry and dairy products, tourism related industries, information technology including knowledge based industries, precision

oriented high value low volume products, hydel power, tea industries, education and hospitality. All these industries use water and estimation of water requirement is essential for this department.

6.4 DEMAND AND PROJECTION OF WATER REQUIREMENT OF VARIOUS SECTORS

Almost every human and economic activity needs water as an essential requirement. Water may thus serve a variety of purposes, of which water use and demand for domestic and municipal water supply, irrigation for growing crops, generation of hydro-electric power, fisheries, recreational uses, and livestock requirement are more relevant for the state of Sikkim (CIMSHE, 2005). In most of the above uses like irrigation and domestic supply, water has to be abstracted and transported from its source while in others, it is used in its natural receptacle itself e.g. fish and plant growing, and recreational uses. Each of these uses can be categorised as non-consumptive or consumptive.

In case of hydro power generation, no water is consumed in the use as such, while in the case of industrial and urban water supply with planned waste water disposal system, 80% to 90% of abstracted water is returned back and thus may be again available for use. The return water may in most of the cases need some treatment and upgrading of its quality for the re-uses. Application of water by irrigation to agricultural crops also generates the return flow, although on a much reduced scale. However, the concept of return flow from irrigation and domestic uses has not been taken into consideration in this region because of hilly terrain.

Recently the Government of Sikkim, has brought a policy paper on consumptive sharing of Teesta water by different sectors. It has made projections of water requirements by sector for the years 2020, 2030, 2040 and 2050, and the table detailing the same is given below.

a. Irrigation demand: Like most states in India, agriculture is the main occupation and important land use in Sikkim too. Agricultural holdings are well spread over from an

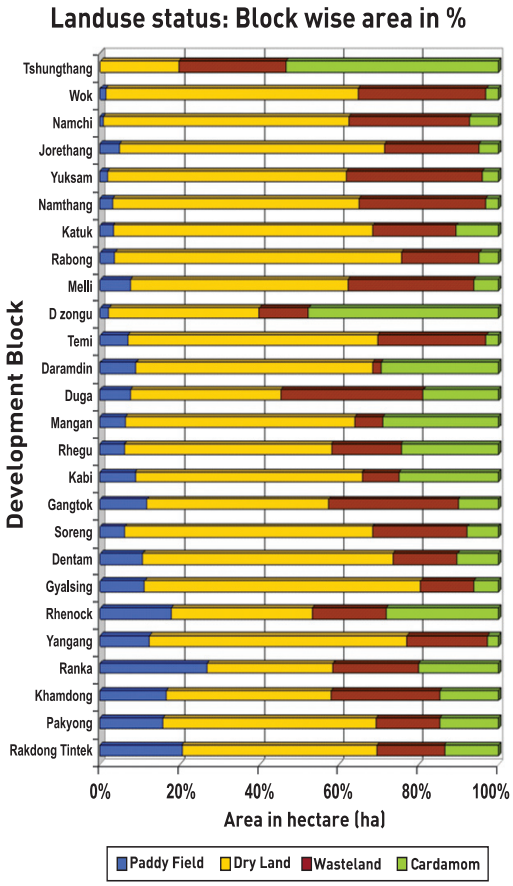
elevation of 300 to 3000 meters but most of the cultivable lands are terraced and farmers have settled on these holdings with established regular cropping system. Marginal holdings and small holdings club together comprises about 50% of all operational holdings but occupy 41% of the total area. The average size of land holding is 1.3 ha. Of the total 109963.0 ha of land available for cultivation, 14.76% is in North Sikkim, 28.96% in East Sikkim, 26.95% in South Sik-

Table 6: Projections of water utilisation by sector in Sikkim

Sector	Year wise tentative projections				
	2010	2020	2030	2040	2050
Irrigation use					
a. Kharif	1764.00	2058.00	2352.00	2499.00	2646.00
b. Rabi	371.00	464.28	557.05	649.89	742.74
Urban Suburban Areas (PHED)	23.70	42.51	55.27	71.86	93.41
Rural areas (RMDD)	17.00	20.72	25.26	30.79	37.53
Industries (Department of Commerce & Industries)	0.42	0.53	0.66	0.83	1.03
Maximum requirement of water for Kharif season (IA+II+III+IV)	1805.12	2121.76	2433.19	2602.48	2777.97
Minimum requirement of water during Rabu season (IB+II+III+IV)	412.12	528.04	638.24	753.37	874.71

Source: Irrigation Department

Figure 6.3: Block wise land use status in Sikkim



kim and 29.34% in West Sikkim. Of the total cultivated area, 14,680.6 ha is under paddy cultivation, 21,761.7 under cardamom, 11,743.4 is waste land and 64,739.8 is dry land. The distribution of land by crop is given in (Figure 6.3.)

Using cropping area of different crops, net irrigation requirement, efficiency of utilisation by crops the gross irrigation requirement is represented as a sample estimate of irrigation water requirement (presented in (Box 7) for paddy and wheat). Using the same procedure, the gross irrigation requirements of Kharif and Rabi Crops have been is presented in (Table 6.2). These however do not take into consideration the increase in water demand due to increase in temperatures in the future due to climate change.

b. Drinking water demand: Both urban and suburban requirements need to be estimated on a regular basis for meeting the water demand of the ever increasing population, especially in the urban areas where the rural population migrates for employment opportunities. The water demand in rural, urban and sub urban areas has been worked out for 2020, 2030, 2040 and 2050 on the basis of population projections (see Table 6). Availability of water in the context of climate may be highly variable seasonally, with water in monsoon season and no water in the ever drying winter months, and water available through extreme precipitation. Appropriate planning needs to be carried out to address this concern in the future especially to trap the water flow during extreme precipitation events.

c. Industrial demand: Industry requires water of good quality for its use, and for this it uses cleaner upstream water. However, the water it discharges is always of lower quality than the feed water and this wastewater is discharged downstream. At best the wastewater discharged represents a quality that can be recycled for lower grade of industrial use and at worst represents water quality which is unsuitable for every use other than navigational purposes. In other words, this water is unfit for usage, is seldom used by the industries and usually used for certain agricultural purposes or by villagers to meet their daily needs. Planning the growth of industry in Sikkim has to be in consonance with water availability in future in the climate change context and reutilisation of waste water.

Box 7: Sample estimates of gross irrigation requirement for paddy and wheat for the state of Sikkim

Crop	Area under irrigation (th ha)	Net requirement (mm)	Irrigation (Mcm)	Efficiency (%)	Gross irrigation requirement (Mcm)
Paddy	15	489	73.35	73	100.5
Wheat	10	38	3.8	56	6.8

Source: CISEM, 2005; accessed from http: //www.sikenvis.nic.in/ccstbs.html accessed on 8th of March 2011

6.5 ENSURING WATER SECURITY - CURRENT POLICIES AND PROGRAMMES OF THE CENTRAL AND THE STATE TO ADDRESS THESE CONCERNS

a. Rural water

National Rural Drinking Water Program (NRDWP): With a view to provide clean and safe drinking water to one and all the Accelerated Rural Water Supply Programme was introduced in 1972-73 by Government of India to assist the States and Union Territories to accelerate the pace of coverage of drinking water supply. The programme has since then been re-named as Rajiv Gandhi National Drinking Water Mission and recently as the National Rural Drinking Water Program (NRDWP). Rural Management and Development Department being the nodal Department for the implementation of the rural water supply programme in the State has been operating water supply schemes for the rural areas. The programme has been conceptualized keeping in mind community participation from planning to implementation, operation and maintenance of the water supply schemes. As per the revised survey on 2003, of the total 2,498 habitations, 2,021 are fully covered, 477 partially covered and there are no uncovered habitations till Dec 2010. The State Government is giving due importance to this sector so as to provide potable drinking water to all the people in the villages of Sikkim. For ensuring safe drinking water, new initiatives like Electro- Chlorinators and Terra-filters have been taken up recently. Jalmani programme has been launched to provide safe drinking water in the schools.

Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) - In order to enhance rural water security a new spring shed development programme has been initiated jointly with WWF-India and People's Science Institute, Dehradun under the banner of "Dhara Vikas". Outcomes include preparation of a "Village Spring Atlas" and increase in the discharge of the springs. Pilot spring shed development works are already underway in Duga, Sumbuk, Kaluk and Namthang. At the state level a website www.sikkimsprings.org is also being developed. Also, storage tanks are being provided emphasis by creation of household water storage tanks in the drought prone areas.

b. Irrigation

Flood Control and River Training, Irrigation and Flood Control Department is also undertaking construction of Minor Irrigation Channels (MICs) from Centrally Sponsor Schemes as well as State Funding Resources. Thus, the periodical survey for MICs is being carried out at the interval if every five (5) years. However, as per the records available, the number of Minor Irrigation Channels (MICs) constructed before 1982-83 are 327 and up to 1986-87, the total is 510 numbers. This was the first ever census of MICs taken up with the reference year up to 1986-87. The second census of MICs with reference year 1995-96 was taken up for which the purview of details were enhanced wherein the total number of channels constructed were 854 in numbers with the total Gross Potential Creation 20,009 hectares. Thereafter, the third

Table 7: Gross potential and actual potential of land use under irrigation upto Dec 31, 2010

Year	Completed Schemes (Nos.)	Net requirement (mm)	Irrigation (Mcm)	Efficiency (%)	Gross irrigation requirement (Mcm)
Paddy	15	489	73.35	73	100.5
Wheat	10	38	3.8	56	6.8

Source: CISEM, 2005; accessed from http: //www.sikenvis.nic.in/ccstbs.html accessed on 8th of March 2011

census was taken up with the reference year up to 2000-2005, show that total number of MICs constructed were 1,076, with the total potential created as 23, 1501.90 hectares till the reference year. The report of fourth census with the reference year up to 2006-07 shows that 1,485 numbers of MICs have been constructed up to the reference year with the potential creation of 27,998 hectares. The total gross potential created up to the financial year ending December 2010 -2011 stands at 29,233.84 hectares. (Table 7) below shows the gross potential and actual utilisation of area for irrigation.

Further proposal of 225 numbers of MICs which has now been submitted to the Ministry of Water Resources under Additional Central Assistance would create an additional potential of 8,244 hectares with completion period of three years and the total creation of potential after its completion would stand at 37,477.84 hectares against the target of potential created of 50,000 hectares which was fixed during early nineties and may be needed to be revised after the fifth census which would be conducted in the year 2012-13 i.e. in the beginning of the Twelfth Five Year Plan. The irrigation department proposes to provide with sufficient number of MICs to ensure adequate water for irrigation to the entire cultivable area of 102,000 hectares at least by 2020-2025.

6.6 STRATEGIES TO ADDRESS CLIMATE CHANGE CONCERNS TO ENSURE WATER SECURITY

Some of the strategies to ensure water security in Sikkim that can be implemented in phases through next 5 years, next 10 years and next 20 years are listed below.

a. Artificial recharge to revive springs by harvesting rainwater: Building local capacity with skills in geo- hydrology, social mobilization and taking up rain water harvesting works is the biggest challenge to undertake artificial recharge to revive springs by harvesting rainwater. And over the last 3 years, more than 20 such trainings have been organized and 7 master trainers have been now developed. A village spring atlas is under preparation and currently stores information on 600 springs. Spring shed development work is ongoing in 15 springs. The outcomes of this program are made available in the web portal – www.sikkimsprings.org.

The novelty of the idea lies in rain water harvesting specially in the recharge zone, to increase the percolation of rain water and thus result in the recharge of ground water. This can be achieved through digging up of staggered trenches with hedge row (see Figure 6.6a). These measures will help in ensuring that the surface runoff of rain water in the spring shed is reduced, and more water percolates down to recharge the spring. The earlier practice in the state was to construct a stone masonry boundary wall around the water source and take up plantations at the source itself. These activities would no doubt have helped in protecting the source, but would not have assisted in recharging and increasing the discharge. This paradigm shift in water source development works will entail rejuvenating the spring shed (also called Mohan ko seer), while not disturbing the water source and will help in ensuring long term water security for the villages of Sikkim. The cost of this artificial recharge comes to about INR 3 lakh per spring.

b. Reviving dried up hill top lakes: Wherever existing, natural lakes and ponds have sufficient catchment area. The approximate capacity of the hill top lakes is about 2-5 crore liter. These need to be developed to increase the percolation of stored water. The geo-hydrology of the lake needs to be understood to identify the recharge and catchment zone. Reviving of natural lakes is the most cost effective way of recharging ground water. In some places where lakes have dried up due to breaches in the embankments, these can be repaired and restored to increase the storage and percolation capacity. In certain dried up lakes, especially those on ridge tops, which have limited catchment area, one may also consider artificial recharge using spring water harvesting techniques. Water is piped into the dried up lake from perennial spring sources. (see Figure 6.6 b) picture of a dried up natural lake on a hill top in Sikkim.

Figure 6.6 a: Staggered trenching with hedge row
b: A dried up natural lake on a hill top in Sikkim

Natural lakes have traditionally played a vital role in rural water security by acting as natural reservoirs helping in recharging the groundwater, aquifers and downstream springs. Quite a few of these lakes have dried up either due to change in land use, engineering works, or catchment degradation among other reasons. Nagi lake of Namthang, Tamley Chaur in Mungrang, Budhang Pokhri in Garhi, Poison lake in Kaluk are all such lakes, located on hill tops, having 2-5 lakh litre capacity.

c. Increasing base flow of critical streams by rain water harvesting: There are a few critical streams which are harnessed for drinking water purposes like Bermelli stream in South District which feeds whole of Namchi town, Ravangla town and adjacent rural areas. Similarly the Ratey chu stream feeds the whole of Gangtok Municipal Corporation.

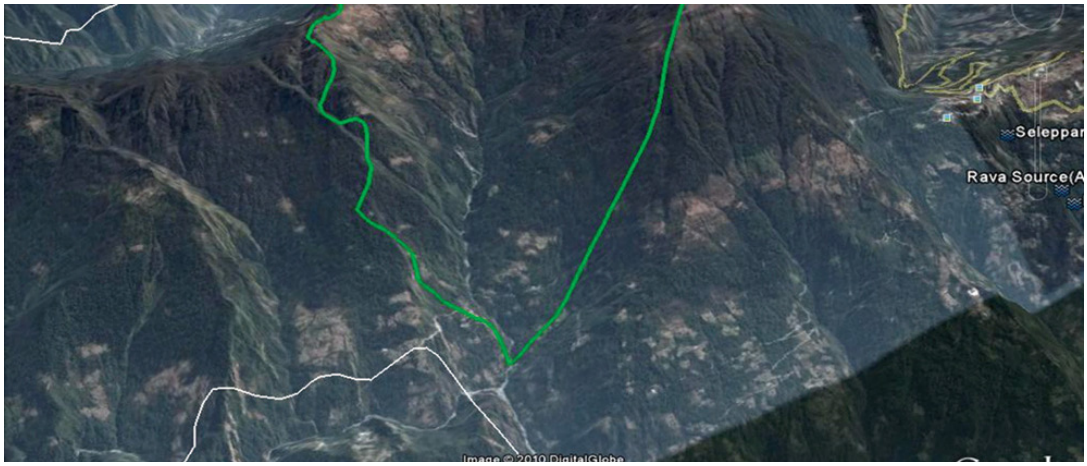
The town of Namchi, South district of Sikkim water supply system solely depends upon "Surface Water Source" from Bermelli stream. See figure 6.6c showing the catchment of Bermelli stream in Borong, Sikkim. The basic water supply system consists of:

- Tapping of water sources located at higher reaches of Bermelli khola
- Transporting the raw water through gravity from this source to the lower reaches finally distributed to consumer points through zonal distribution system.

The concept revolves around the idea of increasing the base flow of Bermelli stream specially in the lean season which is winter (Dec. to April) so as to be able to tap this water and supply it to the Namchi township through the existing water storage and distribution network of the Public Health Engineering (PHE) Department. The left bank of stream and the adjacent areas forms the recharge zone and rain water harvesting structures like pits, trenches etc need to be created to supplement the natural rain water recharge.

d. Exploring possibility of harnessing stream water for meeting household and irrigation needs: The drought prone lower belt of Sikkim is infact blessed with perennial streams like Khani, Seti, Rabi, Rolu, Manpur, Barhi, Raphu, Rohtak, Reshi etc to name a few and a few perennial waterfalls like Omchu falls in Sikkim. The water of these streams has not been traditionally utilized since they flow through gorges and lift irrigation systems are absent in the State. While spring shed development programs can assist in ensuring water for drinking and domestic use, rejuvenation of stream-shed and harnessing the water from these perennial streams provides the possibility of meeting not only the household needs but also the irrigation needs and has the potential to transform the entire rural economy of the villages. The discharge of these streams decreases upstream and an assessment of the volume of discharge with elevation during the lean season is needed to figure out whether there is sufficient water at an elevation from where it can

Figure 6.6 c: Catchment of Bermelli stream in Borong, Sikkim



be tapped by gravity flow. This then provides the possibility of installing village and community level reservoirs to provide water for the lean season.

e. Increasing water storage capacity by building household, community and village level reservoirs: In villages which are located on the top of hills, there is perennial water shortage and one of the strategies is to construct roof top rain water harvesting tanks. In mountainous areas, most rural houses have sloping roofs of galvanized cast iron (GCI) making rooftop water harvesting feasible, however, the scattered houses make it difficult to have a collective approach to rainwater harvesting which is more cost effective. The cost to construct a 34,000 liter capacity Reinforced Cement Concrete (RCC) tank comes to Rs. 1.5 lakh.

Detailed planning for water storage tanks for Gangtok city along with the tentative locations has been prepared and an overview of the locations of the tank is as given in (Figure 6.6e). A similar plan for other urban centres is also underway.

Most of the villages located in the middle hills, have access to piped drinking water which is sourced from perennial springs. This continuously flowing water goes waste during night time, since it is not used by the household. Household level tanks can be constructed to store this perennial spring water overnight, and this stored water can be used during the day for household as well as minor irrigation works. The cost to construct a 10,000 litre capacity RCC tank comes to RS 1 lakh.

f. Formation of Water Users Associations (WUAs): Gangtok receives water supply from four major sources, namely,

1. Treated and piped water supply by the PHED; access coverage ranges between 70-85%,
2. Untreated and piped water supply by RDD; 21%,
3. Private piped, untreated water supply from springs,
4. Manually collected supply from springs.

Since the sources of water supply is varied and often with problems such as leakage, it is recommended to form water users association which would help in monitoring water supply and also can be used as a platform to help in regulating the use of water, conserving water and also help in identifying some key issues regarding supply such as leakage which can be rectified immediately.

g. Pricing and regulation: Lack of metering is an issue in Sikkim. This also leads to a lot of leakage of water going undetected. Further, the lack of pricing and regulation of water is also contributing to overuse of water resources. It is therefore proposed that water for household, industries, irrigation and be properly priced by water regulators. In order for this to happen it is also proposed that the State Government set up water regulators with defined powers.

Figure 6.6 d: Over view of the locations of the tanks

Source: CDP, Gangtok

h. Periodical census of all the minor irrigation schemes after every four years: This was the first ever census of MICs taken up with the reference year up to 1986-87. The second census of MICs with reference year 1995-96 was taken up for which the purview of details were enhanced wherein the total number of channels constructed were 854 in numbers with the total Gross Potential Creation 20,009 hectares. Thereafter, the third census was taken up with the reference year up to 2000-200, show that total number of MICs constructed were 1,076 with the total potential created as 231,501.90 hectares till the reference year. The report of fourth census with the reference year up to 2006-07 shows that 1,485 numbers of MICs have been constructed up to the reference year with the potential creation of 27,998 hectares.

i. Adoption of innovative techniques viz. Drip and Sprinkler irrigation: In addition to adopting innovative techniques such as drip and sprinkler irrigation, the government also proposes to stress on multiple- cropping pattern, introduction of macro-irrigation, macro-management of agriculture and initiation of conjunctive use of water resources.

j. Proposal for enforcement of Irrigation Water Tax: The Government is actively exploring the possibility of enforcing Irrigation Water Tax, to ensure the sustainable use of water for irrigation and also to reduce wastage of the water resources.

The action plan to achieve the strategies discussed through A to E above is given in (Table 8) with the actions needed to be undertaken at short, medium and long term. The total cost of the actions is estimated to be Rs. 580 cr (only Rural Water) at current prices.

The action plan to achieve the strategies F to J above is also given in the table and separate budgetary statement is given below the strategy table. The list of strategies, discussed through A to J above are given below along with the actions needed to be undertaken at short, medium and long term.

Table 8: The action plan for water sector

S. No	Strategy	Activities	Responsible agency	Unit cost	Units	Financial requirement	Actions to be taken in next 5 years	Actions to be taken in next 10 years.	Actions to be taken in next 20 years
1	Archiving and disseminating traditional water management practices	• Assimilating information on traditional water resource managements • Disseminating the same through developing brochures in local language • Providing demonstration of traditional practices	• RMDD	• Rs. 200 per brochure • Rs. 5000 for demonstration cost • Research student for assimilation of traditional knowledge (Rs. 1,80,000 per annum for one year)	• 5000 brochures • At least one demonstration session for each village • One student	Rs. 20 lakhs	Year 1: Assimilation of traditional knowledge Year 2: Publication of brochure Year 3-5: Cover 100% of villages for demonstration Rs. 20 lakh	-	-
2		• Introduction of low cost rainwater infiltration methods	• RMDD	• Rs. 2000/- per site	• 5000 sites • Rs. 1 Cr. per year	Rs. 5 Cr.	Rs. 5 Cr.		
3	Artificial recharge to revive springs by harvesting rainwater	Geohydrology assessment to identify the recharge zone, Spring shed development to artificially recharge ground water	• RMDD • Irrigation department	Rs. 3 lakh per spring	500 springs	Rs. 15 Cr.	Complete assessment of geohydrology in next five years Rs. 3 Cr.	Attempt to cover 25% of the springs in next five years Rs. 4 Cr.	Cover 75% of the springs in next 10 years Rs. 8 Cr.
4	Reviving dried up hill top lakes	Geohydrology assessment to identify the recharge zone, incase insufficient catchment then harvesting of spring water strategy to fill up the lake during the monsoons		Rs. 200 lakh per lake	5 lakes	Rs. 10 Cr.	Complete assessment of geohydrology to identify recharge zones of all 5 lakes Rs. 3 Cr.	Devise strategies for spring water harvesting in 1st 2 years Implement the strategies in 2 lakes in next 3 years Rs. 3.5 Cr.	Implement the recharge strategies to rest of the 3 lakes in next 10 years Rs. 3.5 Cr.

S. No	Strategy	Activities	Responsible agency	Unit cost	Units	Financial requirement	Actions to be taken in next 5 years	Actions to be taken in next 10 years.	Actions to be taken in next 20 years
5	Increasing base flow of critical streams by rain water harvesting	Geohydrology assessment to identify the recharge zone, arti----ficial recharge by rain water harvesting measures in upper catchment and adjacent areas	• RMDD • Irrigation department • WSPHD	Rs. 200 lakh per stream	10 streams	Rs. 20 Cr.	Undertake geohydrology assessment to identify recharge zones of 3 streams and identify strategies for rain water harvesting to increase base flow of these streams Rs. 6 Cr.	Implement strategies for rainwater harvesting in the 1st 3 streams Undertake geohydromorp hology of next 3 streams Rs. 7 Cr.	Implement rainwater harvesting measures of the 3 streams for which geo- morphology studies were undertaken in the 2nd plan Undertake the studies for the next 4 streams and complete implementation of rainwater harvesting to increase base flow of all streams
6	Exploring possibility of harnessing stream water for meeting household and irrigation needs	Assessment of feasibility, Creation of MIC and water harnessing measures	• WSPHD • RMDD	Rs. 200 lakh per stream	5 streams	Rs. 10 Cr.	Assess the feasibility and create MIC for 5 streams selected	Implement water harnessing measures for 2 streams	Rs. 7 Cr. Implement water harnessing measures for 3 more streams
7	Increasing water storage capacity by building household, community and village level reservoirs	Water harvesting tanks at • Household level (30,000 litre) • Community level (5 lakh litre) • Village level (25 lakh litre)	• RMDD • WSPHD	Rs. 1.5 lakh Rs. 20 lakh Rs. 75 lakh	1000 nos 100 nos 100 nos	Rs. 15 Cr. Rs. 20 Cr. Rs. 75 Cr.	Cover 30% of household level Cover 30% at community levelCover 30% at village level	Cover next 30% of household level Cover next 30% a community level Cover next 30% village level	Cover rest of household level Cover rest of community level Cover rest of 30% village level
8	IEC		• RMDD • WSPHD • Irrigation department			Rs. 10.60 Cr.			
9	ICT and Project Management		• RMDD • WSPHD • Irrigation department			Rs. 10.60 Cr.			

S. No	Strategy	Activities	Responsible agency	Unit cost	Units	Financial requirement	Actions to be taken in next 5 years	Actions to be taken in next 10 years.	Actions to be taken in next 20 years
10	Enhancing the understanding of hydrology pattern in Sikkim	i. High resolution rainfall mapping and dissemination real time information and 7 day forecasting to farmers - Installation of automatic weather stations at every gram panchayat - Developing capacity in a university in Sikkim to synthesise, analyse and develop forecasting capacities - Tie up with telecommunication vendors for real time messaging of information 2 times a day and 7 day forecast once a day	• DST • RMDD • Irrigation Department • WSPHD	i. Rs. 1,50,000 per weather station (AWS) Rs. 10,00,000 per annum for personnel hired Rs. 1 per message Rs. 30 lakh per mobile tower	i. 163 AWS 2 persons- one senior, one student Rs. 54,000 per day (60% of 90,000 rural households) Extending towers in remote areas	i.Rs. 24.45 Cr. Rs. 100 Cr. Rs. 54000 per day= Rs. 1.97 Cr. per year = Rs. 9.9 Cr. In most vulnerab le areas where connectivity is not there	i. Installing 50 stations in 1st five years Hiring personnel Pilot real time dissemination in 50 villages May reduce to 1/2 the present cost = Rs. 5 Cr. due to decrease in message cost Adhoc budgeting: Rs. 30 Cr. in 5 years (depends on the number of towers needed considering the undulating topography)	i. Installing 50 stations in 2nd five years Hiring personnel Pilot real time dissemination in 50 villages Rs. 5 Cr.	i. Installing AWS in rest of the stations in next 10 years Hiring personnel Pilot real time dissemination in rest of the villages
		ii Take short term studies to understand the geohydrology of springs, streams and lakes		ii. Rs. 25 lakhs for each study	ii. 20 studies	ii. Rs. 5 Cr.	ii.Rs. 2.5 Cr. (Undertake 10 studies in first five years)	ii. Rs. 2.5 Cr. (Undertake next 10 studies)	
		iii. Undertake studies to understand the geo- hydrology and infiltration rates in drought prone area.		iii. Rs. 25 lakhs per study	iii.20 studies	iii. Rs. 5 Cr.	iii. Rs. 2.5Cr (10 studies)	iii. Rs. 2.5 Cr. (10 studies)	
		iv. Build capacity to undertake surface run off modelling		iv. Rs. 2 Cr.	iv. One programme (one project scientist, 2 researchers, access to models, computers, data)	iv. Rs. 1 Cr. per year	iv. Rs. 1 Cr.		

S. No	Strategy	Activities	Responsible agency	Unit cost	Units	Financial requirement	Actions to be taken in next 5 years	Actions to be taken in next 10 years.	Actions to be taken in next 20 years
		v. Undertake studies to analyse the impact of various projects/ programmes of the government on water security and biodiversity		v. Rs. 1 Cr. per study	v.a. impact of MGNREGA v.b. impacts of IWMP v.c. impact of NRDWP v.d. Other projects on recharge of springs and water shed management	Rs. 50 lakh Rs. 50 lakh Rs. 50 lakh Rs. 50 lakh	Rs. 50 lakh Rs. 50 lakh Rs. 50 lakh Rs. 50 lakh		
11	Develop water regulation policies in the context of climate change	• Develop consensus policies for water regulation	• Irrigation department • WSPHD Department of commerce and industry				• Set up water users association • Zoning of Gangtok and the four district headquarter to put in place and ensure rationalization of water distribution • Streamlining and strengthening asset registers with a detailed but evolving asset management plan	Ensure full compliance of all systems to regulate and monitor sustainable water use in all urban areas Zoning of all towns in Sikkim to put in place and ensure rationalization of water distribution. (The focus to be shifted from Supply Driven to Demand Management)	Monitoring the supply of water for irrigation but ensuring optimal and sustainable use of water for irrigation Ensure full compliance of all systems to regulate and monitor sustainable water use all over Sikkim Zoning of all towns in Sikkim (including the new towns), to put in place and ensure rationalization of water distribution.
12	Reutilisation of waste water from industries	• Identify barriers to reutilisation of waste water • Review available technologies • Upgrade existing technologies and • Install technologies to clean waste water	Department of commerce and industry	Rs. 10 Cr. per unit cost	20 units	Rs. 200 Cr.		• Upgrade existing technologies and • Install technologies to clean waste water In 50% of the plants	• Upgrade existing technologies and • Install technologies to clean waste water In rest of the 50% plants

S. No	Strategy	Activities	Responsible agency	Unit cost	Units	Financial requirement	Actions to be taken in next 5 years	Actions to be taken in next 10 years.	Actions to be taken in next 20 years
13	Accelerated Irrigation Benefit Programme	• Increase the coverage of cultivable crops under irrigation to 37,477.84 hectares to cover the full potential of cultivable land	Department for Irrigation and Flood Control Department			Rs. 1000 Cr. for Short, medium and long term		• Increase the coverage of cultivable crops under irrigation from 37,477.84 hectares to 75,000 Hectares	• Increase the coverage of cultivable crops under irrigation to full estimated cultivation potential of 102,000 hectares
14	Flood Management Programme (Includes Jhoras Training, river training, anti-erosion etc)	Map out the main Jhoras in and around Gangtok and start Jhora training.	Department for Irrigation and Flood Control Department			Rs. 6000 Cr. for short medium and long term	Take up Jhora training and flood control in Gangtok	• Take up Jhora training and flood control in all Urban Centres	• Take up Jhora training and flood control in entire Sikkim

The budgetary requirement for short, medium and long term for two of the key programmes of the Irrigation and Flood Control Department and for water management systems to be implemented by the concerned department is as follows:

Table 9: Budgetary requirement

	Short term (2010-2020)	Medium term (2020-2030)	Long term (2030-2040)
Awareness generation programme	Rs. 3 Cr.	Rs. 5 Cr.	
Accelerated irrigation benefit programme	Rs. 400 Cr.	Rs. 500 Cr.	Rs. 700 Cr.
Water body conservation and restoration and flood management programme (includes jhoras training, river training, anti-erosion programmes etc)	Rs. 1,500 Cr.	Rs. 2,000 Cr.	Rs. 2,500 Cr.
Monitoring and streamlining water supply (Integrated water management and policy frame work)	Rs. 300 Cr.	Rs. 400 Cr.	Rs. 500 Cr.
Total	Rs. 2,203 Cr.	Rs. 2,905 Cr.	Rs. 3,700 Cr.

Agriculture Sector

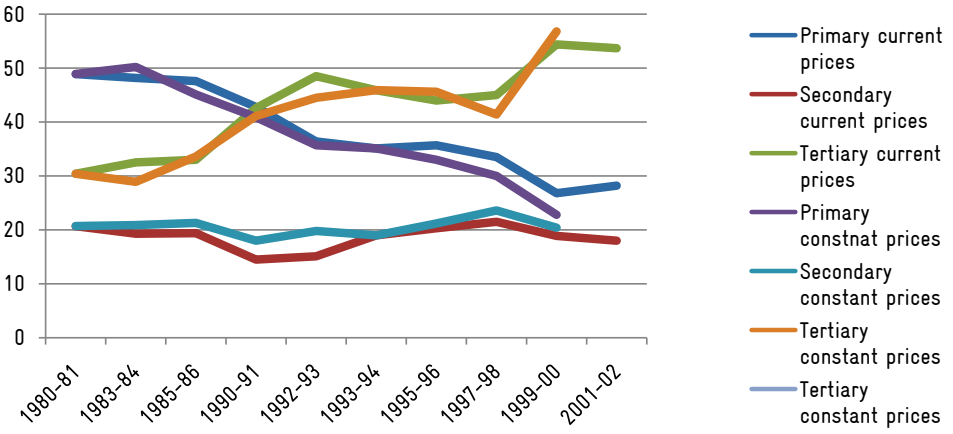
7.1 AGRICULTURE SECTORAL OVERVIEW

Context

Agriculture is the mainstay for more than 64% population of the State and this sector accounts for 17% State GDP with agriculture being the second highest contributor to the state income and the single largest employer.

In Sikkim 69% of the work force is employed in agriculture directly or indirectly. Kharif is the main season for agriculture crops in the state and about 80% crops are cultivated during this season. Main agriculture crops grown in the kharif season are cereals (rice, maize, finger millet), pulses (urd and other pulses) and oil seeds (soybean). In the rabi season wheat, barley, buck wheat and mustard crops are cultivated. Crops are grown in Sikkim due to the diversity of climatic variations caused by a broad range of altitudes. The mixed farming systems of agriculture, horticulture and livestock rearing practices are common in Sikkim. In general, maize ginger intercropping or maize-urd are common practices in low and mid elevation dry-fields; paddy/ maize/ wheat/tori/potato crop rotation at lower elevations; orange-legumes/ginger at mid elevation, cardamom at mid and higher elevation, seed-potato-maize or maize- soybean or seed potato pea/ soybean/ temperate fruits at high elevation are common crop rotations.

Figure 7.1: GSDP sectoral shares



The cropping patterns of the state have undergone metamorphic changes since Sikkim's merger with India in 1975. These changes are significant indicators of the ongoing process of agricultural transformation from cereal-dominated subsistence agriculture to high-value, cash crop dominated commercial horticulture. The precise changes in cropping patterns in terms of area under different agricultural and horticultural crops from 1975-76 to 2004-05 indicate a definite shift in cultivation towards horticultural crops. The overall increasing trend in cropped area of major cereal crops during last 35 years is observed. However, the cropped area of 3 crops started declining from 1995. The productivity of maize and rice is increasing while wheat the productivity is declining.

Horticulture crop coverage in the State is 57% of the total cultivated area and about 70% horticulture farmers are marginal and small.

The main horticulture crops of Sikkim are: mandarin, orange, pear, and tropical and sub tropical fruits such as litchi, guava, banana, etc; vegetables such as beans, garden peas, chayote, leaf mustard, radish, cabbage, cauliflower, tomato and gourds; root and tuber crops like potato; spices crops like large cardamom, ginger, turmeric and cherry pepper; flowers like cymbidium orchids, rose, liliums, gladioli, anthurium, gerbera, alstroemeria, zantedeschia, etc. Floriculture has lately emerged as an important income generating sector for Sikkim farmers. The state has 23,400 ha land for both vegetables and root crops, 23,360 ha for spices (cardamom, ginger and turmeric) and 12,190 ha under fruits at the end of 2009-10. Farmers follow mixed cropping system and most areas are overlapping.

7.1.1 KEY ISSUES COVERING THE SECTOR

Arable land is limited, agriculture is practiced on slopes, where soils are acidic and productivity is low. More than 70% of the farmers are small and marginal with fragmented holdings (average<0.4

Figure 7.1: GSDP sectoral shares

Table 10: Change in land holding pattern								
	1976-77				1990-91			
Category	No %	%	Area %	%	No %	%	Area %	%
Marginal	34.3	59.53	6.84	21	49.56	70.7	10.3	28
Small	25.23	–	14.17	–	21.19	–	17.7	–
Semi medium	23.92	40.47	26.44	79	17.19	29.24	23.68	72
Medium	13.79	–	31.66	–	9.68	–	28.11	–
Large	2.75	–	20.9	–	2.37	–	20.2	–

ha) and the per capita land availability is too small to sustain livelihood through cultivation alone.

Recurrent hailstorms cause heavy damage to oranges, temperate fruits, vegetables, large cardamom, etc. Heavy rainfall and flood during monsoon wash away roads and bridges impacting transportation of agricultural products for marketing. Many times the horticultural crops like off-season vegetables grown in the interior areas cannot be marketed, resulting in heavy loss to poor farmers during May to August months and 7% from October to January (Rabi season) resulting in prolonged dry spell. The climate is conducive for orange production. However due to die-back problems during the past, the yield of many of the old orchards has declined. The agriculture production is dispersed, low volumes insufficient to cover consumption needs of people and does not allow farmers to realize economies of scale in marketing. Higher dependence of farmers on external sources for improved seeds, planting materials and inputs make the production cost high.

Production of large cardamom and ginger has declined due to pest and disease infestation. This phenomenon of decline is common to neighbouring countries of Nepal and Bhutan as per recent statistics. Adequate research support is lacking to tackle these problems. Other challenges to the agriculture sector include a lack of efficient information system on markets driving the farmers to sell products in local markets at relatively low price. Further, the farmers produce highly perishable products but due to lack of proper post harvest management, value addition and marketing system, post harvest losses are high and value realisation is poor. Additionally, farm mechanisation is low due to hilly topography.

7.1.2 CURRENT POLICIES AND PROGRAMME GOVERNING THE SECTOR AND ITS LINKAGE TO NATIONAL POLICIES

The State policy on agriculture is to become a fully organic state. To promote organic farming, the department conducts demonstrations on the proper use of organic fertilizers, biofertilizers and soil conditioners. Popularization of 'effective microorganism' technology for production of organic manure, plant extracts and their use is an important programme to promote organic culture. Organic certification is another critical requirement for achieving the necessary organic status. The department has taken up mass campaign for organic certification.

Centrally sponsored programme for agriculture was launched in the State in 2000-01 to improve livelihood opportunities and to bring prosperity. The Mission is based on the "End-to-End Approach" taking into account the entire gamut of agriculture development, giving due importance to soil conservation, and the River Valley Project and scheme is resilient enough to include any innovative activities in a holistic manner. The objective of the scheme is to improve the production and productivity of agricultural crops by harnessing the potential of the region.

Technology Mission for Integrated Development of Horticulture was launched in eight North Eastern States in 2001-02, to improve livelihood opportunities and to bring prosperity. The

mission is also based on the "End- to-End Approach" taking into account the entire gamut of horticulture development, with all backward and forward linkages, in a holistic manner. The objective of the scheme is to improve the production and productivity of horticultural crops by harnessing the potential of the region. Special emphasis is to be given to "low volume, high value, and less perishable horticulture crops".

The Rashtriya Krishi Vikas Yojna (RKVY) was launched in the state in the year 2007-08 with an aim of achieving 4% annual growth in the agriculture sector during XI plan period by encouraging holistic development of Agriculture and allied sector.

7.1.3 ADMINISTRATIVE AND INSTITUTIONAL STRUCTURE GOVERNING AGRICULTURE SECTOR

The Ministers lead the sectoral departments for policy development, implementation, monitoring, etc. of Five- Year Plans in the State. The Secretaries head the sectoral development departments and the Chief Secretary heads the Secretaries. The issues related to policy development and implementation of the respective sectors are brought to the notice of the Legislative Assembly, discussed, passed and published in State Gazette Notification for enforcement. The sectoral planning and development of State Five-Year Plans are brought to the main actor of the State –the Planning and Development Department - for onward submission to the National Planning Commission for consideration. The State Planning and Development Department closely monitors the sectoral policies and processes and the results are submitted to the National Planning Commission for monitoring at the national level. At the district level, the Zilla Panchayat Institutions coordinate and implement the State policy programmes while at the grassroots Gram Panchayats function as policy and programme implementation

7.1.4 DEMOGRAPHIC PROFILE AND OVERVIEW OF THE AGRICULTURE SECTOR

The per capita availability of different types of land utilization has declined rapidly over time because of the increasing population pressure. Per capita availability of net cultivated area has declined from 0.31 hectare in 1976-77 to 0.12 hectare in 2001 (61.29 %) in a period of 25 years. There is an increase in the number of landholdings from 31,091 in 1976-77 to 52,697 in 1990-91. In 1990-91, the lowest strata of landholders, the marginal holders, representing about 50% of the population held 10.3% of the total operational land area. In contrast, farmers with large holdings (more than 10 hectares) accounted for 2.3% of the landholdings, but owned 20.2% of the operational area. Percentage of people below the poverty line is continued to be lower than the national average, except in 1993-94.

7.1.5 TYPES OF CROPS GROWN AND TRENDS

All kinds of seasonal, off-season and perennial crops are grown in Sikkim due to the diversity of climatic variations caused by a broad range of altitudes. The mixed farming system of agriculture, horticulture and livestock rearing is common practice in Sikkim. In general, maize-ginger or maize-soybean, beans inter- cropping are common practices in low and mid elevation dry-fields. The cropping pattern followed at low and mid altitudes is paddy-maize/wheat/ mustard/potato/ vegetables. Orange-legumes/ ginger mixed farming system is common at mid elevation. Seed potato-maize or maize-peas, offseason vegetables or seed potato- pea/ medicinal crops/temperate fruits are grown in temperate region. Large cardamom is grown at mid and higher elevation under semi-shade conditions, mostly forest cover.

There is a great shift in the cropping patterns from cereal-dominated subsistence agriculture to high-value, cash crop dominated commercial

Table 11: Per capita availability of food grains, pulses, oils horticulture products				
Item	1975-76	1980-81	1990-91	2000-01
Population (000)	262	316	406	540
Cereals	110	163	229	169
Pulses	7.32	26	36	26
Edible oils	1.2	6	6	6
Fruits	49	59	70	50
Vegetables	21	29	101	164
Roots and tubers	53	59	125	136
Spices	45	58	126	151

Source: Project for Sustainable Agriculture and Rural Development in Mountain Regions (SARD-M): 2006

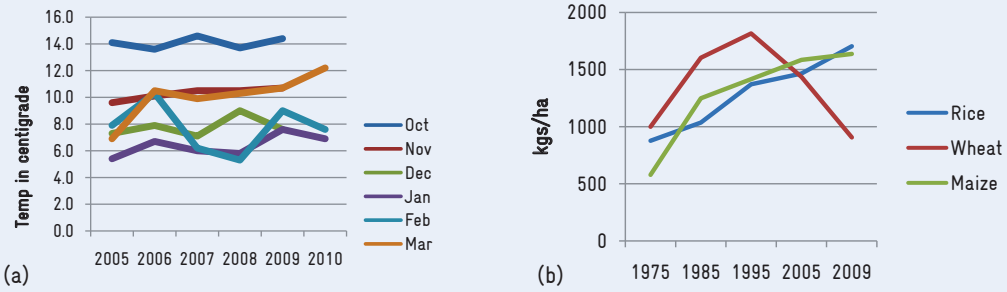
horticulture (Table 11). The cropping pattern is determined by altitude range and slope.

7.2 KEY CONCERNS DUE TO CLIMATE CHANGE

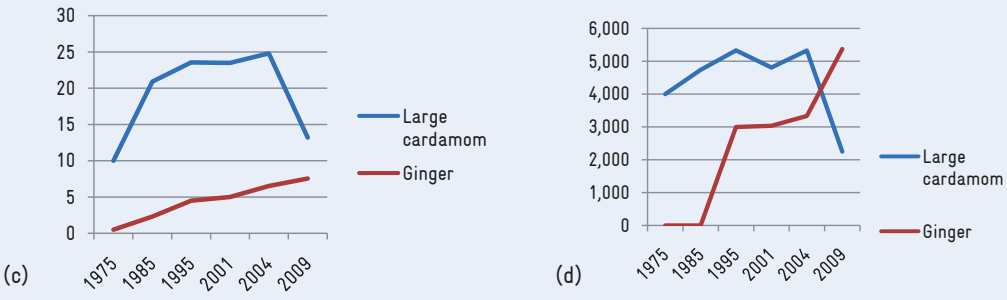
In Sikkim, change in climate is observed in the form of temperature rise (0.2°C every year) and annual rainfall decrease (50 millimetres every 10 years). Further, high runoff results in low absorption of moisture by soil and loss of nutrients impacting crop productivity. Additionally, with change in climate the monsoon rains are becoming shorter and the winters are becoming longer and drier. The rise in minimum temperatures and moisture stress during winter season has caused sharp decline in wheat production. Our analysis indicates fall in wheat productivity with rise in winter temperatures (2005-2010) (Figure 7.2a and 7.2b).

High surface runoff leads to less absorption of moisture into the soil and loss of nutrients that are required for crops impacting crop productivity. Sub tropical region is likely to face more droughts affecting productivity of

Figure 7.2 (a) Winter temperatures recorded at Gangtok (b) Productivity of Crops (c) Trends in cropped area (d) Trends on productivity of principal horticulture crops



Source: Department of Food Security and Agriculture Development Department (DFSADD) annual report



Source: Annual report HCCDD and Project for Sustainable Agriculture and Rural Development in Mountain Regions (SARD-M): 2006

important crops. Orange orchards are expected to face problems of more diseases and pests. There will be a total shift in cropping pattern. With winters becoming drier, there will be a shift from two crops to a single monsoon crop. Lack of water and moisture stress is likely to encourage more land fallowing. There is a greater likelihood of decline in production of cash crops like ginger, large cardamom and orange due to prolonged droughts and outbreak of pests and disease (Figure 7.2c and 7.2d). Communities in the middle and upper hills will be less vulnerable, as climate change provides opportunities for new crops, higher production and early ripening.

Villages lying in sub tropical zones will be most vulnerable as these villages will face higher impacts of climate change added to higher sensitivity and low adaptive capacity. South district is found to be the most vulnerable. The projected demand of per capita availability of different crops such as grains, pulses and horticulture products is shown in following table. Although productivity of some crops is increasing with growing population there will be a serious threat for food security (Figure 7.2e and 7.2f).

It is every likely that crops grown in different altitudes may be effected and cropping patterns may have to be modified to suit the changes. As the length of the dry spell increases, natural springs which are the main source of water get dry partially causing decline in ground water recharge. Due to high degradation of forests on hill tops of South and West districts, these districts receive low precipitation resulting in longer dry spells.

Soils in some pockets are gritty, light textured, stony with less water holding capacity. As the terrain is sloppy rain water runoff is fast resulting low soil moisture. The soils turn more acidic due to washing away of salts from rain water due to leaching effect. Further, with change in climate the monsoon rains are becoming shorter and the winters are becoming longer and drier impacting productivity.

Change in climate effects mountain environment, biodiversity, hydrological cycle and socio-economic conditions. These changes may affect precipitation patterns leading to changes in river runoff and ultimately affecting hydrology and nutrient cycles along the river basins, including agricultural productivity and human wellbeing.

7.3 LIVESTOCK SECTORAL OVERVIEW

Context

Livestock farming is an integral part of the farming system of the state. Over 80% of rural households in the state own livestock and earn supplementary income from them. Livestock production in Sikkim is predominantly the endeavour of the small producers. Small and marginal farmers own nearly 85% of all species of livestock and poultry, even though they own or operate less than 55% of the farmland and

Figure 7.2 e: Healthy ginger crop

Figure 7.2 f: Inspection of seed for multiplication

practice mixed crop-livestock farming system. Poultry holding (almost back yard poultry) by marginal and small farmers is 90% with 3-14 birds per house hold. Some 80% sheep population of the state is found in North and West Sikkim. Sheep are kept for meat and wool. Goat is kept exclusively for meat purpose and the local people prefer goat meat (chevon) over mutton. Pigs are kept mostly by tribal and its meat is favoured by local population.

7.3.1 KEY ISSUES OF THE SECTOR

- High Incidence of parasitic diseases especially in large ruminants.
- High incidence of digestive disorders due to consumption of poor quality green fodder (practically weeds).
- Increase in number of haematuria due to feeding of poor quality forages.
- Reproductive disorders like retention of placenta and infertility due to mineral deficiency with keeping cattle becoming uneconomical due to longer intercalving period.
- High incidence of mastitis especially in crossbreds due to poor quality of cattle sheds and keeping cattle in unhygienic conditions.
- Low productivity despite having good germplasm due to lack of awareness on good practices.
- Low priority of farmers to cultivate fodder and animals depend mostly on low quality roughages.
- The agriculture operations in Sikkim mainly depend on draught power and the decline in male animal populations it is becoming difficult to manage agriculture.

7.3.2 KEY CONCERNS OF CLIMATE CHANGE

The crop production in Sikkim is entirely dependent on work animals for farm power. Cultivation of crops in narrow terraces on steep, sloppy terrain needs the special, small, compact resilient and climate change resistant bull such as indigenous Siri cattle. The breed is currently under extinction.

Most of the exotic breeds (see figure (7.3 a) and (7.3 b) below) are completely climate sensitive and increase in temperature will quickly impact their productivity and health.

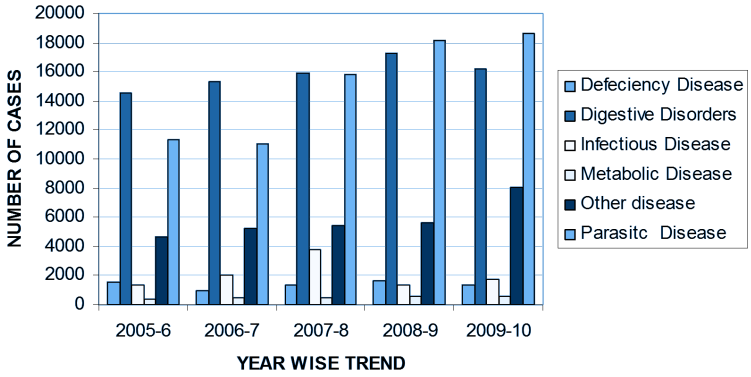
Warmer and wetter weather (particularly warmer winters) will increase the risk and occurrence of animal diseases, as certain species who serve as disease vectors, such as biting flies and ticks, are more likely to survive year-round. Certain existing parasitic diseases may also become more prevalent,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

Conditions inherent in industrial animal agriculture facilities can increase the emergence of diseases that affect humans and animals alike. Outbreaks of diseases such as Foot and Mouth Disease or Avian Influenza affect very large

Figure 7.3 a: Exotic breed under extinction

Figure 7.3 b: *Siri* cattle breed

Figure 7.3 c: Disease profile of the state



Source: AH, LF, VS Annual Report 2009

numbers of animals and contribute to further degradation of the environment and surrounding communities' health and livelihood.

The disease investigation cell had observed an increasing trend in reproductive disorders like retention of placenta and higher infertility cases, parasitic diseases and vector borne diseases (Figure 7.3c). The infertility cases are reported mainly due to mineral deficiency possibly due to high soil erosion trace minerals leach out.

Animal diseases constitute a major constraint to livestock production and the safe utilization of animal products. For the poor, the impact of livestock disease on lives and livelihoods is particularly severe. Indeed, an outbreak of disease can mean the difference between sufficient food stocks and food insecurity, between having a secure income to the loss of key household assets.

The milk union procures milk from villages daily and markets it in form of liquid milk and milk products in potential locations in the state. The milk collection in union show increased trend (Figure 7.3d). Further, more farmers join union as the milk market is at the village and it is also source of regular income for the all class of people. Milk being the very nutritious medium to almost all kind of microorganism, it gets spoiled very quickly when it is exposed to outside environment with variation in the temperature. In summer time, temperatures are getting very high as compared to earlier years and such an upward trend is felt year after year. This increase in temperature in the summers poses a challenge to the collection of good quality milk.

The curdled milk received by the Sikkim Milk Union is increasing year after year inspite of taking all controlling measures (Table 12). This is mainly due to the rise in temperature. The state is also known for its torrential rains which have increased in the recent years due to climate change. As a result of unexpected torrential and erratic rains, there are frequent

Figure 7.3 d: Milk procurement and number of suppliers

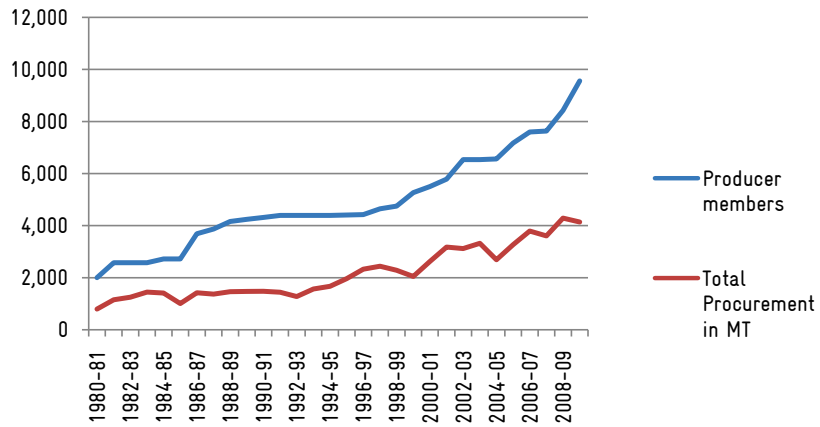


Table 12: Year wise milk spoilages at SMU					
Month	Quantity curdled	Month	Quantity curdled	Month	Quantity curdled
	(in kg)		(in kg)		(in kg)
April '07'	3779	April '08	3975.5	April '09	5322.0
May '07'	8686	May '08	4276.0	May '09	5414.0
June '07'	8236	June '08	12914.0	June '09	15517.0
July '07'	10293	July '08	14147.0	July '09	17663.0
Aug '07'	5031	Aug '08	10146.0	Aug '09	10968.0
Sep '07'	1441	Sep '08	6588.0	Sep '09	7120.0
Oct '07'	1985	Oct '08	2158.0	Oct '09	3961.0
Nov '07'	832	Nov '08	438.0	Nov '09	1391.0
Dec '07'	78	Dec '08	355.0	Dec '09	109.0
Jan '08'	0	Jan '09	223.0	Jan '10	221.0
Feb '08'	113	Feb '09	526.0	Feb '10	1587.0
March '08'	4808	Mar ' 09	539.0	Mar '10	3750.0
Total	40,474	Total	56,285.5	Total	73,023.0

Source: Sikkim Milk Union Annual report (2010)

landslides and consequently the roads are closed making it extremely difficult for the collection vans to reach designated collection centres. This leads to milk being retained in unsuitable places resulting in rapid multiplication of bacteria in high temperature resulting in increasing acidity and spoilage of milk. In case of landslides, the milk either needs to be quickly trans-shifted or transported with the help of suitable vehicles to chilling centres. Therefore, there is a need to add 12 chilling units and provide 7 trans-shipment vans at strategic points throughout the State.

Rise in temperature increases lignifications of plant tissues which in turn reduce the digestibility thus impacting the productivity of animals. Local fodder crops rich in energy like pakpa, phultarul, tapioca, yam are gradually under extinction.

7.4 STRATEGIES

The following adaptation strategies are identified to cope up with the climate change in Sikkim.

a. Agriculture

1. Introducing new varieties

To ensure livelihood security of the poor relying on agriculture, focus should be on optimizing productivity with maximum profits. Research and development will play a vital role in identification of new cultivars resilient to higher temperatures, water stress and high concentration of CO2. In context to rice which is a staple food of the Sikkimese people, concrete research work is to be done in finding most suitable high yielding variety (HYV) cultivar of Rice which is best suited to the Eastern Himalayan foothill further can sustain in a low light intensity and in water stress condition. System of Rice Intensification (SRI) is such a technology which helps to grow paddy in minimum water requirement and present situations call for more research work in upland paddy.

Maximum area cultivated falls under the maize crop in Sikkim. However, still some good hybrid cultivars are required for more crop production whose yield must be uniform and fetches more income to marginal farmers. Rise in temperature is beneficial for the maize crop; therefore adaptive trails need to be conducted in value added maize cultivar such as popcorn, baby corn and sweet corn in relation to different ecological zones for systematic planning. Suitable cultivar of Rape and mustard crops, improved varieties of buckwheat like Himpriya for high hills , VL-7 and PBR-1 for low hills and lentil as pulses especially in lower belt for the rabi season should be introduced in drier belts of Sikkim as the area under wheat is gradually shrinking. Rape and mustard can be a good alternative for the poor farmers in sustaining their livelihood.

Multilocational adaptive research works have to be formulated giving priority to these areas. The Indian Council for Agricultural Research (ICAR) stationed in Sikkim Krishi Vigyan Kendra and supporting Departments have to play a key role.

2. Popularization of indigenous varieties

An exercise of mapping existing traditional varieties cultivated by local farmers in different regions should be conducted and characterized. Sikkim has a fleet of landraces of all types of crops which need to be identified. Futuristic DNA mapping, systematic preservation and notification of varieties for crop production and collection of information about their morphological triads and nature of adaptability are few grounds where active research works are essential. The local landraces have a good capacity to fight against invasions and threats. The preservation of the gene bank of these landrace would be an excellent effort to cope with future threats and climate change. The local cultivar of buckwheat, maize, paddy, soybean, rajma, rice bean, urd are the underrated, endangered species which can be multiplied in Government farms as well as in farmers fields towards its popularization in coming decades. Their cultivation practices are to be improvised through the introduction of newer technologies and setting up of fixed packages and practices of these landraces for their crop production.

3. Crop diversification

Initiate crop diversification programmes to shift in practices of farmers from growing crops which are sensitive to climate change. Crop diversification should continue with due emphasis on the following:

- Revamping and systematic technological packages should be provided to the production pockets based on their level of development i.e., whether the pocket is a basic pocket, or a commercializing pocket or a commercial pocket and their levels are to be estimated.
- High value commodities should be identified for each of the districts and production cost should be reduced by giving minimum support price, so the farmers could gain maximum profit from his produce.
- In cereal food grains, beside HYV varieties relatively prime focus should be on priority commodities such as soybean, buckwheat, baby corn, sweet corn, popcorn, etc which can have good markets (both domestic and external as processed food package).
- The identification of production pocket area and farmers cluster approach which has been initiated in the State should be strengthened and, in order to make it sustainable, the following activities should be conducted regularly: Regular interaction and Workshops to support the development of pocket area activities; Orientation towards cooperative groups; Promotion of mass communications; To raise such issues in Gram Sabha for farmers awareness; NGOs to be activated in facilitating the group formation process.
- Women must be identified as core member in the group or farm organization. This will enhance their self-confidence and social status and can be effective in introducing a large number of women to decision making processes which is vital in crop diversification.

Efforts of line departments and resource centres should concentrate on the production pockets, so that they become stronger and more effective.

A forum among procurement centres, producers and extension agents should be established. This approach will help farmers to have direct exposure in marketing aspects.

Regular training to these identified prolific area farmers on production technologies particularly on selected commodities and their marketing aspects including processing, packaging, grading, etc., should be taught in detail to eradicate any misconception and error.

4. Integrated Pest Management (IPM)

As the policy direction of the state is for 100% organic farming, all farmers are required to adopt

organic pest and disease control management systems. The chemical control of diseases and pest is to be replaced by physical and biological means. The IPM laboratory at Gangtok is to be strengthened to provide support in identification of suitable bio control agents and their production and application in the field for their efficacy.

5. Seed production and certification

The state will have to be self reliant in organic seed production by 2015. For quality seed production, the state needs to develop infrastructures for storage and seed testing in every district. The farmers should be encouraged to take certified seed production to produce own quality seeds so the dependency on outside source can be minimize.

6. Water management system

Prolong conditions of water stress in plants is one of the vital issues for low production of crops and finding scientific ways and means to use water efficiently providing water in critical moisture stress conditions for crop health is the prime goal of the water management system. Ongoing programmes such as drip irrigation, construction of rain water harvesting structures, installation of community tanks and bench terraces are to be strengthened to increase crop productivity with less usage of water and simultaneously conserving the rapidly diminishing water resources.

Through the repair of damaged channels, creating micro irrigation systems and construction of water harvest structures will allow fallow lands after the paddy crop to be brought under cultivation (Figure 7.4b). Newer technologies in water conservation and their efficient utilization during the dry period are to augmented the lack of water.

7. Soil conservation measures

Land which is cultivated without any soil conservation treatments will be brought under treatments. Bench terracing followed by reclamation of soil to conserve soil and soil moisture is to be taken up. For improving health of the soil, regular soil testing will be high on the agenda, and based on these test reports, soil amendment programmes will be undertaken.

Figure 7.4 a: Sprinklers being used

8. Reduce weather related risks

Weather stations are required in all 9 subdivisions to monitor the change in weather and therefore draw a contingency plan. By 2025, the entire block should have one small weather

Figure 7.4 b: Water wastage and improved management systems

station each in the locality for data collection and interpretation of these data to fight back any risk and adverse climate. Establish high resolution weather stations for weather data collection at micro- level covering entire state and disseminate the information regularly to improve consciousness among farming community on weather related risks, help farmers in making critical farming decisions and efficient crop management practices. Studying weather trends in regular intervals can allow one to take some preventive measures as required minimizing crop loss to a greater extent.

9. Institutional strengthening

Capacities within the agricultural department are required to be further developed to gain knowledge on climate change and advice farmers on the correct adaptation practices. Training centres are required to be strengthened and facilities upgraded to train farmers and field staff. In the present scenario, the institutional training and capacity building for farmers and field staffs are being handled by State run State Agriculture Management and Extension Training Institute (SAMETI) led by Director SAMETI, supported by the Deputy.Project Director at the state level and an Agricultural Technology Management Agency (ATMA) in each district under the control of the Project Director assisted by a Deputy Project Director. These institutes need to be more empowered and prioritised in order to run these institutes more efficiently, further, every district has State run one Krishi Vigyan Kendra (KVK) headed by a Programme Coordinator and a Subject Matter Specialists in their specialized field for the dissemination and transfer of technology and research intervention. Except in the East District,, the KVK is managed by ICAR,GOI. These institutes have to be brought under one focal point to strengthen forward and backward linkage with scientist and extensionist and the farmers interface.

10. Monitoring of climate change programmes

Information systems within departments to be strengthened focusing on collection of baseline data and measure changes periodically with climate change impacts. All the developmental works of the department related to climate change should be closely monitored hence forth. Outcomes and evaluations to be studied minutely to slow down the process of climate change by efficient implementation of the programmes undertaken. A separate cell for Planning, Monitoring and Evaluation (PME Cell) is to be strengthened and empowered within the department for surveying climate change with pinpoint agendas. All planning of strategies to be done with the help of GIS and advance techniques in meteorology.

11. Risk management

Wide publicity is being given to encourage farmers to take crop insurance which is readily available through the Kisan credit card and to also apply for crop loans so their crops will be automatically insured. Additionally the Kisan credit card enables farmers to grow new crops with money in hand thereby avoiding the farmers falling prey to victimization by moneylenders and other financial middle men. These facilities are announced in every gram sabha. The rabi crop are being affected by moisture stress condition, therefore there is a need to draw out contingency plans to ensure good crop production. A viable volume of quality seeds has to be maintained as buffer stock in store which can be used in the contingency plan.

12. Prospect of farm mechanization

Sikkim as a state has favourable conditions for raising almost all types of agricultural and horticultural crops due to its widely varied micro-agro climatic regions. However, farm mechanization in the state is very low in mechanical power, efficient implements, land reclamation, water management, renewable energy and post harvest activities. Mechanization is restricted by stepped, small and irregular fields, undulating topography, lack of adequate hill technology, poor facilities of repair, maintenance and manufacture of implements and high cost of gadgets. The immediate attention of the state government and other funding agencies is required to strengthen the agricultural engineering to handle farm mechanization problems more efficiently.

Despite various limitations and constraints, there is a great scope to increase productivity of land and farmers economy by creating small water resources for increasing irrigated areas, land development, use of efficient farm power and implements, harnessing more rainwater, disseminating renewable energy gadgets and introducing small scale agro based industries employing post harvest engineering principles.

As the state is gearing to tackle the challenges of climate change, farm mechanization has become more of a challenging task where every measure and step need to be taken with greater care and thought considering the dimension of climate change. The micro size power tillers with better efficiency to manover in small sized terraces with zero tillage operation, weeding capacity, seed drill and easy intercultural operation have become essential to this landscape. The new agri-engineering college for Post Harvest Technology, Ranipool can work closely with the Government Department in the formulation of agri–engineering activities and implementation of appropriate tools and machinery to resist climate change in the state.

b. Horticulture

1. Introducing new varieties

To ensure livelihood security of the poor relying on agriculture, focus should be on optimizing productivity with maximum profits. Research and development will play a vital role in identification of new cultivars resilient to higher temperatures, water stress and high concentration of CO2. For this, the support of research institutes like the ICAR, NRCO and Spices Board need to be called for.

2. Popularization of indigenous varieties

Mapping of existing traditional varieties practised by farmers in different regions are to be conducted and characterized. Fruit crops such as local varieties of mango, yams, colocasia, etc having high resilience and need to be identified and promoted.

3. Crop diversification

Continue and intensify crop diversification programmes to include more crops which have wider adaptability and the improvement of existing practices of growing and cultivating crops which are climate resilient crops need to be promoted.

4. Rejuvenation of large cardamom

Undertake the large cardamom rejuvenation programme through control of disease and pests. Involve ICAR, Spices Board etc with a special focus on identification of emerging diseases, production of quality plant material including tissue culture. Building systems in horticulture department to provide advisory services for improved management practices including shade trees.

Figure 7.4 c: Flower cultivation in greenhouse

Figure 7.4 d: Flower cultivation in greenhouse e: Fodder collection system

5. Ginger disease management programme

Continue programmes developed to control pests and diseases through biological and organic interventions.

6. Rejuvenation of Sikkim mandarin oranges

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

7. Improve floriculture programmes

Climate change will definitely impact production of flowers. Promotion of protected cultivation of high value commercial flowers should be the focus.

8. Production of off-season vegetables

Off-season vegetables have very high scope for improvement of rural economy.

9. Integrated Pest Management (IPM)

As the policy of the state is to become 100% organic, all farmers are required to adopt Integrated Pest Management System. Steps have been already initiated to replace chemical control of diseases and pests by bio-pesticides, bio-control agents and other organic methods. These programmes need to be intensified to expedite the process to organic conversion. The IPM laboratory at Gangtok needs to be strengthened to provide support in identification of bio control agents and their production and distribution to the fields.

10. Water management system

Undertake water management programmes to use efficiently water and provide critical moisture for crop health. Ongoing programmes such as drip irrigation, construction of rain water harvesting structures, community tanks are to be strengthened to increase productivity with limited water and simultaneously conserve rapidly diminishing water resources. Through efficient system of water management, fallow land can be targeted for use after the paddy crop for cultivation of vegetables, potato and other horticultural crops during the rabi season.

11. Reduce weather related risks

Establish high resolution weather stations for weather data collection at village level and sensitise the farming community on weather related risks. This system should also focus on helping farmers to make critical farming decisions for efficient crop management practices.

12. Monitoring of climate change programmes

Information system within the department needs to be strengthened with focus on collection of baseline data and a system to measure

changes periodically with climate change impacts.

13. Risk management

The Kisan credit card for crop insurance is being widely publicized to encourage the farmers to acquire it.

c. Animal husbandry

1. Strengthen disease investigation system

Research studies need to be conducted to study the causes of haematuria and other emerging diseases and develop control measures by involving livestock research institutions.

2. Preventive health measures

To control and contain the existing epidemic diseases, the department needs to prepare a long term strategies where by the 100% population of the livestock get regularly vaccinated. Beside this, animal health camps need to be set up in order to make people aware of adopting different control measures.

3. Improve cattle sheds

Improved management practices at the farmers' level help them in developing improved cattle shed so as to maintain better hygienic conditions and avoid unnecessary waste of cow dung and urine thereby reducing the level of emission of unwanted gasses to the atmosphere.

4. Breeding practices

Undertake programmes to conserve threatened breeds and create infrastructure for establishing embryo transfer technology.

5. Feed and fodder development

Production of leguminous fodder crops that require less management systems are to be promoted as mixed crop system.

To combat winter fodder shortage farmer centred fodder banks are required to be established. Undertake mineral mapping in different regions to assess mineral status and accordingly supply specific mineral mixtures to the farmers.

6. Dairy development

Improvement in quality of milk will be undertaken by establishing milk cooling facilities at strategic locations. As total quality management improves facilities at Jorethang and Gangtok dairy plants for conducting bacteriological tests.

7. Livestock based diversified livelihood activities

i. Poultry farming:

Production of poultry and poultry products are to be promoted to sustain the income of the farmer by developing mixed farming systems.

ii. Piggery farming:

A large population in the state consume pork and the demand for it is increasing. Pig rearing in a sustainable manner is to be promoted to augment incomes of the poor.

iii. Institutional strengthening:

Capacities within the department required to be developed to gain knowledge on climate change and advice farmers on the right adaptation practices. Training centres are required to be strengthened with all facilities to train farmers and field staff updated.

iv. Risk management:

The state is encouraging farmers to acquire Kisan Credit Card in order to insure all farmers crops and is being announced in every gram sabha.

Table 13: Actions for the Agriculture sector									
Strategies	Current programmes/ projects	Fund available	Implemented through (institution/ programme/ project)	Actions in next 5 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices
a. Crop based adaptation									
Introducing new plant types in crops like paddy, maize, mustard, buckwheat that absorb less light, can with stand high temp. water stress and higher concentration of CO2.Lentil to be introduced in lower belt	–	–	Field crop section of FS and ADD, schemes of RKVY	Research and developmentto identify cultivate with the help of ICAR and KVK.	Rs. 5 Cr.	Field research to identify cultivate and their implemen- tationin field	Rs. 5 Cr.	Popularization of the cultivate amongst farmers and their full adoption.	Rs. 10 Cr.
Segregation and popularization of indigenous varieties, land races of buckwheat , rice-bean beans, soybean rajma, and horse gram etc.	RKVY –	Rs. 0.97 Cr. –	FS and ADD/ ICAR –	Mapping of all landraces and characterization of varieties and documentation. Study of morphological characters for State Government notification. –	Rs. 5 Cr.	Field research on identified landraces and their improvisation with ICAR support Field testing in various altitudes.Gene banks development, multiplication, preservation of seeds.	Rs. 4 Cr. Rs. 2 Cr.	In situ preservation. Full adoption and popularization in the farmers fields	Rs. 1 Cr. Rs. 5 Cr.
Crop diversification, development and improve- ment in prolific sector for more commercialization. of cereals grains.	Macro manage- ment/ INM	Rs. 8.90 Cr.	FS and ADD	Conduct studies on performance of existing crops with soil health management, nutrient management under climate change context.	Rs. 20.02 Cr.	Conduct studies on performance of existing crops with nutrient management under climate change context	Rs. 14 Cr.	Crop adaptation, application on crop diversification	Rs. 8 Cr.

	Pulses and oilseed	Rs. 0.52 Cr.	FS and ADD with ICAR support.	Adoption of new cultivar and their transfer of technology	Rs. 2 Cr.	Research and development works on their productivity, improvement and scope for adaptability in drier areas.	Rs. 4 Cr.	Adoption of crops and popularization of technology	Rs. 1 Cr.
Seed production and certification.	ICDP, HYV production under Macro- management- ment	Rs. 1.99 Cr.	Field crop under FS and ADD	Develop certification systems. Initiate the process of certification. In depth training on certification of quality seeds.	Rs. 3 Cr.	In continuation develop certification systems. Initiate the process of certification. In depth training on certification of quality seeds.	Rs. 5 Cr.	Infrastructure development for seed certification	Rs. 1 Cr.
b. Water based adaptation									
Water management system	Rain water harvesting, stream water conservation	Rs. 0.40 Cr.	Directorate of Natural Resource Management.	Construction of water harvesting structure and related activities	Rs. 6.25 Cr.	Construction of water harvesting structure and related activities	Rs. 12.5 Cr.	Construction of water harvesting structure and related activities.	Rs. 25 Cr.
c. Soil based adaptation									
Soil conservation measures	Bench terracing	Rs. 0.35 Cr.	Directorate of Natural Resource Management	Mechanical soil conservation measures	Rs. 7.5 Cr.	Mechanical soil conservation measures	Rs. 15 Cr.	Mechanical soil conservation measures	Rs. 30 Cr.
	Reclamation of acidic soil	Rs. 0.80 Cr.	Directorate of Natural Resource Management	Application of lime and soil amenders organically.	Rs. 2.8 Cr.	Application of lime and soil amenders organically.	Rs. 5.6 Cr.	Application of lime and soil amenders organically.	Rs. 11.2 Cr.

				Establishment of soil testing system with the facility of analyzing micronutrient.	Rs. 1 Cr.	–	–	–	
	–	–	–	Soil mapping and develop plants for soil amendment programme.	Rs. 2.5 Cr.	Soil mapping and develop plants for soil amendment programme. -in continuation	Rs. 2.5 Cr.	Application on climate change.	–
d. Mapping of crops according to suitability of various region	–	–	FS and ADD with the help of Science and Technology	Crop mapping through GIS and DNA finger printing: and awareness among field staffs.	Rs. 2 Cr.	Crops mapping through GIS and DNA finger printing and awareness among educated rural youth.	Rs. 2 Cr.	Crop mapping through GIS and DNA finger printing and popularization.	Rs. 1 Cr.
e. Land use based adoption.									
f. Real time Crop monitoring									
Reduce weather related risks.	PME and weather watch		FS and ADD with the support of Meteorology (GOI) and GIS station.	Establishment of weather station on pilot basis in all 9 sub divisions. And training of staffs	Rs. 5 Cr.	Establish small weather station on pilot basis in all the blocks subdivisions. Data collection and dissemination. Village awareness.	Rs. 25 Cr.	Feeds back, records, seasonal weather interferences. Interpretation. of data.	Rs. 2 Cr.

Pest and diseases management and integrated pest management	Macro man- age- ment in agriculture	Rs. 0.42 Cr.	FS and ADDIPM Lab/Organic farming	Release of bio control agents in farmers field and their mass production.Bio pesticides pro- duction.	Rs. 1.5 Cr.	Identification of more bio control agents and their population. Contingency planning to safeguard crops loss.	Rs. 3 Cr.	Popularization of IPM models, their full package adoption etc.	Rs. 4 Cr.
Risk management through risk sharing insurance micro finances others.	Agri insurance under ERAS	–	FS and ADD with support of NABARD and lead bank	Populariza- tion of Kisan credit cards and contingency plan to meet the crop loan	Rs. 1 Cr.	Insurance policy to entire farmers in spe- cific crop loans and contingency plan to meet the crop loan	Rs. 2 Cr.	Benfit from Kisan card and crop insurance policy.	Rs. 0.10 Cr.
Institutional strengthening	Extension reform, KVK interventions	Rs. 5 Cr.	FS and ADD/ ICAR	Gender sensiti- zation, capac- ity building for officers and field staffs, backward and forward linkage.	Rs. 10 Cr.	Infrastructure de- velopment, capacity building for officers and field staffs, backward and forward linkage.	Rs. 15 Cr.	Sensitization, dissemination of information and capacity building for productive activities.	Rs. 20 Cr.
Farm mechanization	Macro man- age- ment in Agri	Rs. 0.44 Cr.	FS&ADD/ Agri- engineering with College of Agi engineer- ing and Post harvest Technol- ogy, Ranipool	Development of hill friendly tools and equipments. Development of hill technology in Farm mechaniza- tion	Rs. 10 Cr.	Development of hill technology in Farm mechanization and their implementation.	Rs. 15 Cr.	Popularization and adoption of these hi- tech tools and tillers by farmers and their uses.	Rs. 20 Cr.

Table 14: Actions in the Horticulture sector									
Strategies	Current programmes/ projects	Fund available	Implemented through (institution/ programme/ project)	Actions in next 5 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices
a. Crop based adaptation									
Introducing new plant types that absorb less light, can withstand high temperatures, water stress and higher concentrations of CO2	Sourcing of high quality planting materials of fruits, vegetables, flowers, etc from Research Stations / import from other countries	Rs. 40 Cr.	HCCD Deptt.	Research and development to identify cultivars with the support of ICAR, NRCO and other institutes	Rs. 50 Cr.	Field research	Rs. 100 Cr.	Popularization (in 2000 ha)	Rs. 100 Cr.
Popularization of indigenous varieties	Area expansion using indigenous crops (most of the horticultural crops are indigenous in origin – Sikkim mandarin, large cardamom, ginger, cherry pepper, turmeric, pea, bean)	Rs. 500 Cr.	HCCD department	Mapping of all varieties and carry characterization of varieties and documentation cultivars with the support of ICAR, NRCO and other institutes.	Rs.20 Cr.	Conservation of the gene pool	Rs. 100 Cr	Popularisation	Rs. 200 Cr.
				Covering large areas under these crops	Rs. 2500 Cr.	Continue area expansion programme	Rs. 5000 Cr.	Covering large areas under these crops	Rs. 10000 Cr.
						Field testing in different altitudes Contribute to gene bank		Popularization in the field	

Crop diversification	Fruits	Rs. 200 Cr.		Conduct studies on performance of existing crops under climate change context	Rs. 200 Cr.	Field trials involving farmers	Rs. 50 Cr.	Popularization	Rs. 100 Cr.
	Off-season vegetables			Up scaling plantation of sub tropical fruit plants (e.g. litchi, guava) 2000 ha	Rs. 400 Cr.	Continue with the alternate fruit plantation, off-season vegetables (2500ha)	Rs. 800 Cr.	Continue with the alternate fruit plantation, off-season vegetables (2500ha)	Rs. 1500 Cr.
Large cardamom programme	Control of pests and diseases Replantation (area expansion)	Rs. 500 Cr.	HCCD department	Research studies for resilient varieties in collaboration with the Spices Board	Rs. 20 Cr.	Field trials with new varieties	Rs. 30 Cr.	Multiplication and popularisation of these new varieties	Rs. 1000 Cr.
				Production of quality planting materials through nurseries and tissue culture	Rs. 50 Cr.	Production of quality planting materials through nurseries and tissue culture	Rs. 1000 Cr.		
				Replantation for area expansion	Rs. 2500 Cr.	Replantation for area expansion	Rs. 5000 Cr	Replantation for area expansion	Rs. 10000 Cr.
Ginger disease management programme	Area expansion	Rs. 1000 Cr.	HCCD Deptt.	Study the scope new areas for ginger production	Rs. 60 Cr.				
				Identification of bio control agents & conduct Field trails	Rs. 25 Cr.	Continue control of disease and pests through bio control agents	Rs. 100 Cr.	Continue control of disease and pests through bio control agents	Rs. 250 Cr.
				Control disease and pests through bio control agents	Rs. 50 Cr.	Area expansion			
				Area expansion	Rs. 300 Cr.		Rs. 600 Cr.	Area expansion	Rs. 1200 Cr.

Rejuvenation of Sikkim mandarin oranges	All kinds of rejuvenation activities	Rs. 2000 Cr.	HCCD department	Cleaning, pruning, etc Supply budded plants to select farmers on pilot basis.	Rs. 5000 Cr.	Popularization of budded plants in larger area	Rs. 1500 Cr.	Popularization in the field	Rs. 4000 Cr.
				Improve irrigation system		Improve irrigation system		Improve irrigation system	
				Assured irrigation for 25 % cropped area during lean period (Oct-April) Expand areas of production (2000 ha)		Assured irrigation for 25 % cropped area during lean period (Oct-April) Expand areas of production (2500 ha)		Assured irrigation for 50 % cropped area during lean period (Oct-April) Expand areas of production (5500 ha)	
Vegetable cultivation	Area expansion on summer vegetables and offseason vegetables in open as well as protected	Rs. 240 Cr.	HCCD Department	Continue promotion of off-season vegetables and summer vegetables (1500 ha)	Rs. 600 Cr	Continue promotion of off-season vegetables and summer vegetables (3500 ha)	Rs. 1400 Cr.	Continue promotion of off-season vegetables and summer vegetables (6000 ha)	Rs. 2400 Cr.
Improve floriculture activities	Area Expansion-bringing more areas under different kinds of flowers. Capacity building through training, sensitisation and exposure programmes Infrastructure development including production, post harvest and consolidation centres	Rs.5 Cr. Rs.100 Cr.		Explore new varieties and crops having wider adaptability & start sourcing for pilot testing (50 ha area) explore modern and scientific technology for production and post harvest management Asses participation of SHGs / Associations/ NGOs	Rs. 500 Cr. Rs. 50 Cr. Rs. 10 Cr.	Discard unsuccessful programmes and retain only effective ones Source new varieties and crops and initiate popularization programmes (to cover 200 ha)Pilot testing of new technologies (to cover 20)	Rs. 2000 Cr.	Popularize and expand to 500 ha Popularize and expand to 200 ha	Rs. 5000
							Rs. 200 Cr.	Build more infrastructures Continue involvement of SHGs/ NGOs (100 nos)	Rs. 2000 Cr.
						Asses the utility of infrastructures developed	Rs. 10 Cr.		Rs. 500 Cr.
						Promote more NGOs/ SHGs (50 numbers)	Rs. 25 Cr.		Rs. 30 Cr.

Seed Production and Certification				Develop certification systems.Initiate the process of certification training staff on certification		Policy development for using certified seed and not to import seed from out side		Implementation of seed certification process	
b. Water Based adaptation									
Water management system	Community water harvesting tanks	Rs. 200 Cr.	HCCD Deptt/ FSAD Deptt	Construction of structures	Rs. 1000 Cr.	Construction of structures	Rs. 2000 Cr.	Construction of structures	Rs. 4000 Cr.
				Promotion of drip irrigation system	Rs. 200 Cr.	Promotion of drip irrigation system	Rs. 400 Cr	Promotion of drip irrigation system Form and	Rs. 800 Cr.
				Form and strengthen groups for managing structures	Rs. 25 Cr.	Form and strengthen groups for managing structures	Rs. 50 Cr.	Form and strengthen groups for managing structures	Rs. 50 Cr.
c. Soil based adaptation									
Soil conservation measures				Establish soil testing system Mapping soil and develop plans for soil amendment programmes		Continue soil amendment programmes			
Promotion of organic farming	Promotion	Rs. 2000 Cr.	HCCD Department	Promotion	Rs. 10000 Cr.	Promotion	Rs. 5000 Cr.	Promotion	Rs. 5000 Cr.
			Sikkim Organic Mission	Establishment of Organic Research Centre	Rs. 50 Cr.				

d. land use based adaptation									
e. Real time crop monitoring									
Reduce weather related risks	-	-	HCCD Department.	Establish weather stations on pilot basis (4 nos)	Rs. 20 Cr.	Formation of village institutions	Rs. 20 Cr.	Continue formation of village institutions	Rs. 40 Cr.
				Formation of village institutions					
				Data collection and dissemination		Data collection and dissemination		Data dissemination	
f. Mapping of crops according to suitability of climate of various regions									
g. Pests and disease management									
Integrated pest management	IPM	Rs. 100 Cr.	HCCD Department.	Introduction of organic fungicides & pesticides	Rs. 500 Cr.	Popularisation	Rs. 500 Cr	Continue popularisation	Rs. 800 Cr
Institutional strengthening				Training core team from agricultural department on climate change Training material produced for training farmers		Farmers Training programmes conducted to sensitize on climate change issues		Farmers Training programmes conducted to sensitize on climate change issue	

Table 15: Actions in the Animal Husbandry sector									
Strategies	Current programmes/ projects	Fund available	Implemented through (institution/ programme/ project)	Actions in next 5 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices	Actions plan in next 10 years	Approx. cost at current prices
Livestock based									
Disease investigation and health improvement	-	-	DIC	Studies to understand causes of haematuria and other emerging diseases Strengthening of Institutions	Rs. 1 Cr.	Continue studies Field trials	Rs. 50 lakhs	Popularize control system	Rs. 1 Cr.
Preventive health measures	Assistance to states for control for animal disease	Rs. 50 lakhs	AHLF and VS	Prophylactic measures to be strengthened at check post Improve cold chain management system Improve service delivery system	Rs. 75 lakhs	Improve service delivery system	Rs. 75 lakhs	Improve service delivery system	Rs. 1 Cr.
Renovation of cattle sheds to reduce risk from disease	-	-	SMU	Standardization of designs Implement as demonstration in select villages	Rs. 1 Cr.	Renovation of cattle sheds to reduce risk from disease	Rs. 50 lakhs	SMU takes over as its internal programme to cover all milk socities	
Breeding practices	NPCBB	Rs. 1 Cr.	Breeding cell	Studies on threatened breeds	Rs. 50 lakhs	Conservation of local breeds	Rs. 50 lakhs		Rs. 50 lakhs
				Conservation of indigenous siri breed (cattle), banpala (sheep) and yak	Establish embryo transfer centre				
				Establish embryo transfer centre					

Fodder development	Fodder dev programme	Rs. 60 lakhs	Fodder cell	Studies on new cultivars Field trials by establishing fodder demonstration plots Establish fodder banks Formation of user group	Rs. 1 Cr.	Popularization of new fodder varieties Continue establishing fodder banks	Rs. 1 Cr.	Popularization of new fodder varieties	Rs. 1 Cr.
Dairy development	ITDP	-	Sikkim Milk Undion	Establish bulk coolers Strengthen laboratories	Rs. 2 Cr.	Establish bulk coolers	Rs. 2 Cr.	Establish bulk coolers	Rs. 1 Cr.
Livestock based livelihood diversified programme piggery	-	-	Piggery section	Selective breeding awareness camps	Rs. 50 lakhs	Continue selective breeding	Rs. 50 lakhs		
Poultry			Poultry section	Promoting backyard poultry farming	Rs. 20 lakhs	Continue	Rs. 20 lakhs		
I. Risk management through risk sharing - Insurance, microfinance, others	-	-	AHLF&VS	Insurance of animals	Rs. 25 lakhs	Insurance of animals	Rs. 25 lakhs	Insurance of animals	Rs. 25 lakhs
J. Data and information gaps and strategies to fill them									
Institutional strengthening	-	-	Extension and Training Cell	Training core team from animal husbandry department on climate change Training material produced for training farmers	Rs. 50 lakhs	Farmers Training programmes conducted to sensitize on climate change issues	Rs. 30 lakhs	Farmers Training programmes conducted to sensitize on climate change issue	Rs. 20 lakhs

Biodiversity, Forests, Wildlife and Ecotourism

8.1 BIODIVERSITY IN SIKKIM

Biodiversity is the variability among living organisms and their habitats, including the diversity within species, between species and within ecosystems. Biodiversity is essential for human well- being because it provides various ecosystem services, such as food, medicines, clean water and soil stabilisation. Biodiversity is under threat from the loss and fragmentation of habitat, pollution, introduced and invasive non-native species. Also, climate change poses a new challenge as it often exacerbates the impacts of other pressures.

Sikkim lies within one of the two mega biodiverse hotspots in India, namely the Western Ghats and the North Eastern region including Eastern Himalayas. The rich biodiverse flora and fauna of the region is supported by the unique climate created by topography of the Himalayas (see the Box 8). The abrupt telescoping of the terrain from the hot steamy foothill valleys to the arctic cold of the snow capped peaks, has produced the marked altitudinal zonation due to the rainfall, humidity, climate and vegetation (see elevation map of Sikkim, (Figure 8.1). This is also responsible for the great variety and numerical abundance of the resident bird life, making Sikkim perhaps the richest area of its size anywhere in the world (Ali, Salim 1962). Distribution of the biodiversity by the different regions is shown in (Table 16).

Box 8: Biodiversity at a Glance	
Type	**Numbers**
Flowering Plants	4500
Orchids	550
Rhododendrons	36
Conifers	16
Bamboos	28
Ferns and Ferns allies	362
Tree Ferns	9
Primulas	30
Oaks	11
Medicinal Plants	424
Mammals	>144
Birds	552
Butterflies	600
Fishes	48
Mountain & Peaks	28
Glaciers	84
Lakes and Wetlands	227
Rivers and Streams	>104

Source: http://www.sikenvis.nic.in/biodiversity.html

In Sikkim, there are broadly five altitudinal zones of vegetation. They are not clear-cut at their boundaries but merge into one another, often showing considerable local encroachments and recessions above and below the line depending upon physical configuration and exposure of the terrain and the resulting ecological factors. These regions are the Tropical eco-regions; the subtropical eco-region, temperate eco-region, sub alpine, and trans-himalayan eco-region. (Table 16) gives the extent of these regions and lists the major flora and fauna of each region.

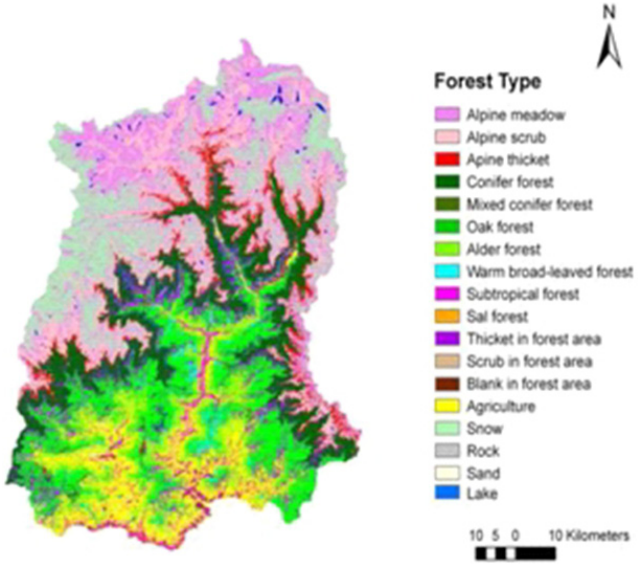
8.2 FORESTS

The forests in Sikkim are a repository of biodiversity, water resources, wild edibles and fodder for livestock, medicinal plants, provides livelihoods to people, is a key eco- tourism attraction of the state, and house the biodiversity hotspots and sanctuaries. It is also one of the natural sources of carbon (C) sequestration. According to Champion and Seth Classification,

Table 16: Biodiversity of the 5 eco-regions of Sikkim	
Tropical eco-region (from foothills of the Himalayas to about 1200m)	**Flora**: *orchids, Rhaphidophora; wild banana, Pandanus; Nettles and giant bamboo; Sal Shorea robusta, Chir Pine Pinus roxburghii;* Important medicinal plants of this eco region are *Terminalia bellerica, Terminalia chebula, Embellica officinalis, Azadirachta indica, Aegle marmelos, Ocimum sanctum, Oroxylum indicum, Holarrhena antidysenterica, Murraya sp.* etc. **Fauna**: endangered species of birds like the Kalij and Red Junglefowl, Great Indian Hornbill *Buceros bicornis homrai* locally called '*Hongraio*', Chestnut-breasted Partridge, Black-breasted Parrotbill, and Grey-crowned Prinia. Also Assamese Macaque, Barking Deer, Wild Boar, Tree Shrew, Peafowl (introduced), Python, Geckos, a host of butterflies and other invertebrates, riverine fish, frogs and toads. Lesser cat species, Chinese Pangolin, Himalayan crestless porcupine, Common Leopard, Himalayan Black Bear, **Weeds**: *Lantana* is a major weed in this region. Also seen now is the alien invasive weed *Mikania micrantha*
Sub tropical eco-region (1200m above sea level to 2400m)	**Flora**: *Castanopsis hystrix* (Katus), *Machilus spp.* (Kawla), *Rhododendron spp.* (Chimal), *Symplocos spicata* (Kholme), *Symplocos theifolia* (Kharane), *Michelia excelsa* (Rani Champ), *Quercus lamellosa* (Buk), *Quercus lineata* (Phalant), *Leucoseptrum canum* (Ghurpis), *Quercus pachyphylla* (Sungure Katus), Betula alnoides (Saur), *Nyssa javanica* (Lekh Chilaune), *Bucklandia populnea* (Pipli), *Engelhardtia spicata* (Mahuwa), *Eurya japonica* (Jhingni), *Rhododendron arboreum* (Guransh), *Vibernum spp.* (Asarey), *Quercus lamellosa* (Buk), *Q. lineata* (Phalant), *Machilus spp.* (Kaula). *Cinnamomum spp.* (Sissi), *Michelia excelsa* (Rani Champ), *Quercus lancaefolia* (Patle Katus), *Acer campbelli* (Kapasi), *Magnolia campbelli* (Ghoge Champ), *Elaeocarpus lancaefolius* (Bhadrase), *Symplocos theifolia* (Kharane) is the main species and *Litsea spp.* (Pahenle), *Rhododendron arboreum* (Guransh), *Bucklandia populnea* (Pipli), oaks and Rhododendrons predominate; Others being Arundinaria maling, ferns, epiphytic mosses and orchids.

	Medicinal Plants: *Swertia chirata, Rubia cordifolia, Astilbe rivularis, Berginia spp, Acorus calamus, Kaempheria rotunda, Costus speciosus, Viscum articulatum, Rhus semialata, Phytolacca acinosa, Litsaea citrata, Drymaria cordata Artemisia vulgaris* etc. **Fauna**: Rusty-bellied and Lesser Shortwings, Kalij and Satyr Tragopan; reptiles like Japalura lizards, Cobra, Krait and Himalayan Pit Viper; Himalayan Bull-frog; butterflies and leeches, including Red Panda - evidences of which are usually recorded from 2000 m and above and it is a characteristic species of Temperate forests and conifer forests. **Weed**: *Eupatorium* is a major weed competing out *Artemesia* and other secondary growth. **Agriculture and horticulture crops:** rice, ginger, orange, large cardamom, guava, banana, squash and marigold. Forest produce like bamboo shoots, ferns and nettles are also collected. Soya bean, millet and cruciferous vegetables are grown; Exotic oyster mushroom cultivation; trial of commercial cultivation of flowers like hybrid orchids, lilies, roses, gladioli and various exotic species like Tulips. **Livestock**: Hybrid stall fed and local breed of '*Siri*' *Cow* **Sericulture**: Domesticated silk worms *Bombyx mori* cultivated with assistance from Sericulture Directorate of the state forest department. **Pisciculture**: Common and Grass Carp.
Temperate eco-region (2400m to 3000m above mean sea level)	**Flora**: mixed coniferous forests of Hemlock, Spruce, Pine, Fir and Junipers with shrubby undergrowth of Rhododendron and Arundinaria bamboo and Wild Seabuckthorn *Hippophae* **Fauna:** Red Panda, Himalayan Langur and Himalayan Black Bear, Lesser cats, Goral, Serow, Himalayan Monal, Fire-tailed Sunbird, Blue Magpie and few species of reptiles and amphibians are characteristic. Brown and Rainbow Trout Salmo trutta fario, Onchorhynchus mykiss have been introduced in high altitude lakes while river systems harbour over 40 species of indigenous hill stream fishes. **Agriculture crops:** Potato, cabbage, wheat, barley and maize, beans, peas, apple, peach and pear are grown on homesteads. Some amount of cattle rearing is practiced with stall fed hybrid milch cows with some trans-humance for local breeds in forest areas
Sub alpine eco-region (region is from 3000 to 4500 m above sea level)	**Flora**: Sub alpine forests and scrub, small crooked trees and large shrubs interspersed with fir and pine. The stunted forest is mainly of rhododendron of many species. The important medicinal plants of this ecoregion are *Aconitum ferox, Aconitum heterophyllum, Heracleum wallichii, Nardostachys grandiflora, Orchis latifolia, Panax pseudo-ginseng, Picrorrhiza kurooa, Podophyllum hexandrum, Ephedra gerardiana, Taxus baccata, Hippophae spp.* etc along with Dwarf rhododendron leaves burnt as incense. **Fauna:** Dominant wild fauna includes Musk Deer, Himalayan Tahr, Blue Sheep, Blood Pheasant, Ibisbill and Snow toads. River systems harbour some of the (introduced) trout *Salmo trutta fario.*
Trans Himalayan ecoregion (upto 5500m above the mean sea level)	**Fauna:** Endangered species. - Kiang, Nayan or Argali, Tibetan Gazelle, Blue Sheep, Snow Leopard, Eurasian Lynx, Tibetan Wolf, Tibetan Snowcock, Lammergeier, Raven, Golden Eagle and Ruddy Shelduck breeding in the wetlands. Within the short 4 month growing season in the region, grasses, sedges and medicinal herbs grow abundantly supporting a host of insect fauna as well as the wild and domestic herbivores, larks and finches. The important medicinal plants of this ecoregion are *Aconitum spp., Nardostachys grandiflora, Picrorhiza kurooa, Meconopsis horridula, Gentiana spp, Rheum spp.* etc.

Forest type map of Sikkim

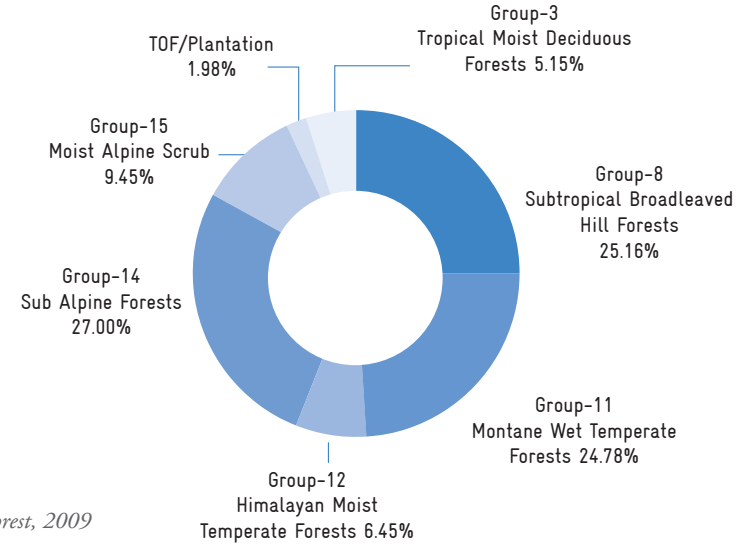


Sikkim has, 6 distinct forest types, viz., tropical moist deciduous, sub tropical broad leaved hill, montane wet temperate, Himalayan moist temperate, sub alpine forests and moist alpine scrub (Figure 8.1), the physical distribution of the same is shown in (Figure 8.2).

The distribution of forest cover by type in 2009, as seen from satellite imageries (Figure 8.3, Table 17), indicates that out of total 3,357 sq. km. of forest area, 14.9% of the area is densely forested, 64.4% of the area has moderately dense forest and 20.7% of the area has open forests. The Sikkim forest and tree cover has increased by 3.5% from 3129 sq. km. in 1997 to 3,357 sq. km. in 2009 (State of the Forest Report, FSI, 2009). The forest cover shows a rising trend due to green policies of the government.

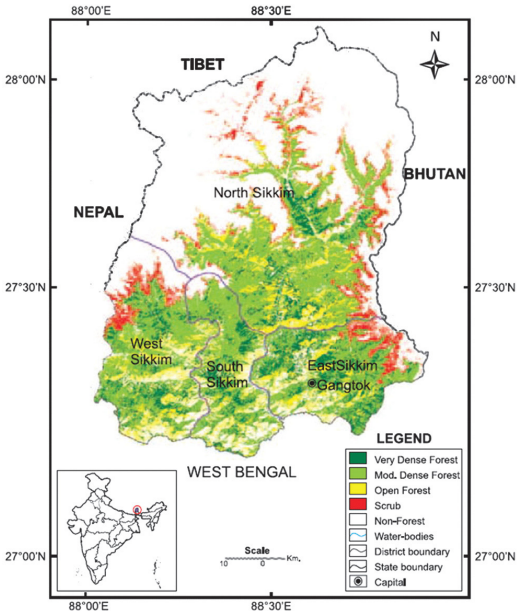
Due to the steep elevation gradient in Sikkim, the various vegetation classes are telescoped together making the landscape heterogeneous. Out of 58 reserve forest polygons, 56 are considerably small (mean extent of 1.6 km2), and comprise just 1.6% (88 km2) of the total reserve forest area (Tambe et al., http://www.sikenvis.nic.in/Reports%20and%20Publications/100years/100%20Years%201.pdf accessed on 17th March, 2011). These are distributed in the lower elevation, having Shorea robusta (sal), subtropical forests and warm broad leaved forests as the dominant land use

Distribution of forest cover by type in Sikkim



Source: State of Forest, 2009

Figure 8.3: Forest density map of Sikkim



Source: State of Forest, 2009

and surrounded by agricultural fields. There is an urgent need to protect and regenerate these small sized, fragmented forests, as they are susceptible to encroachment and degradation.

The sal forest, subtropical forest and warm broad- leaved forest have a limited extent (area less than 145 km2) and relatively higher degree of degradation. Protection of these forests is critical to prevent the loss of the characteristic biodiversity that they possess. Cardamom farming is a perennial, low-volume, high- value, non-perishable, cash crop and it demands less nutrients and other inputs in comparison to other crops. Alder forest occurs in private lands and is grown as a shade tree for large cardamom - a valuable native horticulture plant (Sharma et al. 2000). In this zone, these forests have a sizeable extent of 272 km2 which can be potentially increased to 462 km2 by encouraging this land use to bring more and more areas under forest cover and also to have an eco-friendly buffer to shield the temperate oak forests.

During the last three decades of the 20th century, 317 km2 of degradation has taken place, with the impacts mostly concentrated (196 km2, 62%) in the temperate oak forests, which have been converted into thickets, scrub and blank areas. This degradation was caused mainly due to open grazing, forest fires, selective felling of commercially important mature trees from forests and clear felling of temperate forests for meeting the demand for timber, firewood and charcoal. Thickets of secondary, unpalatable shrubs and bamboos have increased substantially in these degraded forests. Since 1995, several conservation initiatives have been taken up like implementation of the ban on open grazing in reserve forests and ban on green felling of trees in forests.

The main cause of degradation and fragmentation of the temperate oak and subalpine conifer forests is the heavy dependence for firewood and timber, high grazing pressure, vulnerability to forest fire, poor natural regeneration and naturally slow growing nature. While impacts of pastoralism on these forests has been substantially reduced with the removal of about 10,000 cows along with the 500 herders between 2001 and 2006 (Tambe and Rawat 2009), reducing firewood extraction by local communities and road construction labour force and preventing forest fire still needs to be prioritized. Chettri et al. (2006) documented that there is an unregulated extraction of firewood from the forests of the state, and estimated the annual dependence per rural household to be 6-8 tonnes (dry weight).

Table 17: Distribution of forest cover across altitudes in Sikkim (in sq km)

Altitude Zone	VDF	MDF	OF	Total
0-500m	2	16	15	33
500-1000m	16	141	80	237
1000-2000m	206	552	354	1,112
2000-3000m	210	755	136	1,101
>3000m	66	697	111	876
Total	500	2,161	696	3,357

Source: State of Forest, 2009

Greater emphasis is needed for promoting solar water heaters, LPG and ensuring access to alternate and cheap forms of energy and fuel efficient devices will help in substantially reducing the pressure on these forests. Also there is a pressing need to take up a long term restoration program to artificially regenerate these slow growing temperate and sub- alpine conifer forests.

Unlike in other parts of the country, the long dry winter from December to March is the major fire season in the state. However, recent trends indicate to higher incidences of forest fires in temperate forests which are usually unaccustomed to forest fires. There is a pressing need for a greater dissemination of mountain specific fire management technology using participatory approaches.

8.3 BIODIVERSITY AND ECOSYSTEM SERVICES

The biodiversity in Sikkim provides it with the well recognised high value cash crops such as the Sikkim cardmom, only produced in Sikkim in India, the medicinal plants unique to Sikkim, and the exotic orchids which are regularly exported to other parts of the country as well as abroad.

Other than these direct perceivable economic services, the natural landscapes of Sikkim, namely, the forests, grasslands, and wetlands, as well as the managed ecosystems provide a range of 'services' to sustain human welfare in the state. These include:

- provisioning services - food, water, timber, fibre, fuel wood, and genetic resources,
- regulating services - regulation of climate, floods, drought, land degradation, water quality and disease prevention,
- supporting services - soil formation, pollination and nutrient cycling and
- cultural services - recreational (Ecotourism), spiritual, religious and other non-material benefits.

Any change in climate poses a threat to these services.

8.4 CONCERNS OF BIODIVERSITY, FORESTS, WILDLIFE AND ECOTOURISM IN SIKKIM DUE TO CLIMATE CHANGE

The Eastern Himalayan region that includes Sikkim is intrinsically linked to global atmospheric circulation and hydrological cycle, characterising its typical biodiversity and water resources. Global warming affects the atmospheric circulation as well as hydrological cycle as has been documented by numerous publications. The impacts of climate change are being now being perceived in Sikkim (Box 9). The key expected changes in biodiversity that would be the direct result of further climate change can broadly be classified as follows:

1. Changes in geographic distribution of flora and fauna: Some birds, insects, mammals and plants are already showing changes in their geographic distribution and have moved northwards or to higher altitudes in response to the observed changes in Sikkim. There is increasing evidence that many species with the northern limit of their range currently in the tropical and subtropical regions in Sikkim are expanding further north and onto higher ground. In contrast, the southern limits of some cold adapted species may be pushed northwards as temperatures increase and due to limited space available at such heights may vanish altogether, e.g Snow leopard.

2. Limitations of shifting beyond extreme north at higher altitudes: Alpine plant species on mountain ranges with restricted habitat availability above the tree line will experience severe fragmentation, habitat loss, or even extinction as they cannot move to higher elevations. This would have adverse consequence for the Sowa-Rigpa or Amji system of Tibetan medicine dependent almost exclusively on alpine herbs.

3. Changes in timing of seasonal events: Phenology is the study of changes in the timing of seasonal events. As temperatures

Box 9: Observed changes in biodiversity of Sikkim

- Low land species have been appearing in the sub- tropical, temperate and trans-Himalayan belt1
- The house sparrows found only in the low land areas such as Melli in South Sikkim are seen common in subtropical areas in Gangtok1
- House crows are seen to appear at higher elevations of Lachung. Likewise the American cockroach (Periplanata americana) and house gecko have been seen in Gangtok and in the higher elevations[1]
- Mosquitoes have started appearing in the trans- Himalayan Lhonak Valley over 5000 m[1]
- An increasingly erratic cycle of weather patterns is affecting the intricate ecological linkage between the food habits of the wild animals, the phenology of edible wild fruit bearing trees especially the oak trees and fruit production, weather patterns, and the forest denizens straying into human habitations[2]
- Drastic reduction in flow in springs, recharge , especially in the non-monsoon months[3]
- In 2008 the butterfly species Symbrenthia silana was sighted around 1000m near Dzongu, thought to be extinct, as it was last sighted at 600m in 1885 by de Nicéville. The sighting at higher heights might be due to change in its habitat due to changes in climate since the later part of the 19th century[4]
- Maximum species of endemics and threatened birds are found in broad leaved tropical broadleaved forests between 900-1800m above sea level and in temperate broadleaved forests (1800m-2800m). Reduction in their habitats is being observed now which is a combination of direct anthropogenic interference as well as the changing climate[5]
- With increase in temperature, springs in East, South and West districts and few parts of North district comprising of sal and middle hill forests and falling in the rain-shadow of the Darjeeling Himalaya are becoming seasonal. Many of the watersheds especially in the South and West districts have forests along river valley while the villages are in the upper catchments. Consequently surface runoff is high, ground water recharge is low
- Occurrence of forest fires in higher altitudes

Source:

1 *http://http://www.sikenvis.nic.in/docs/BIODIVERSITY/ Sikkim% 20State% 20Biodiversity% 20Action% 20Plan.pdf, page 17*

2 *From Working group paper on Man animal conflict prepared by Karma Legshey, DEFWM*

3 *From working group paper prepared by Sandeep Tambe, special secretary, Department of Rural Management & Development on water and from paper on biodiversity and forests prepared by Usha Ganguli - Lachungpa, DEFWM and Partha Sarathi Ghose, WWF*

4 *Rediscovery of the federally protected Scarce Jester Butterfly Symbrenthia silana de Nicéville, 1885 (Nymphalidae: Nymphalinae) from the Eastern Himalaya and Garo Hills, northeastern India, Krushnamegh Kunte. Published in Journal of Threatened Taxa, 2010, Vol. 2, No. 5, Pages 849-900,*

5 *Status and distribution of endemic and threatened birds of the Eastern Himalaya in Sikkim, India, Bhoj Kumar Acharya & Lalitha Vijayan, 2010. Printed in JOTT communications 2(2): 685-689.*

have increased, spring and summer events are taking place earlier in the year. Evidence includes leafing, fungal fruiting, bird egg laying, spawning of amphibians, arrival of migrants and insect emergence. Autumn events are occurring both earlier and later in the year, and the trends are less clear.

4. Changes to abundance and habitat preference: Species are both increasing and decreasing in abundance in correlation with climate change. Climate change can also cause a change in habitat preference. For example, the Red Panda of Sikkim which is the state animal and according to the IUCN ranking, is a vulnerable species may experience change in habitats as the temperate ecosystems which is its preferred habitat, starts shrinking (Box 10).

5. Changes to species interaction: Species do not respond simultaneously to climate change, which in turn leads to changes in the species composition found in a particular habitat and in the interaction between these species. The conservation implications of interacting species becoming mismatched in space (geographical shifts) or in time (phenology shifts) are only

Box 10: Red Panda – example of likely shift in habitats due to climate change

One of the iconic representative of Sikkim's biodiversity and State animal is the Red Panda (Ailurus fulgens) (IUCN Status: Vulnerable; IWPA: I) Red panda is an unique animal residing mainly in the temperate and coniferous ecoregions ranging between altitudes 2000 m and 4000 m in Sikkim, having healthy undercover of bamboo, which incidentally is the staple diet of the Red Pandas.

These forests are unique in the sense that they develop in the juxtaposition of alpine meadows and sub-tropical forest types and acts as a zone of transition between the two habitat types. It is perceived that a cumulative impact of temperature increase and change in precipitation regimes:

- May lead to more forest fires thereby destroying the existing habitats
- May favour further propagation of the sub-tropical and tropical forest types. Any expansion in the adjoining forest types may result in the shrinkage in extent of the temperate forest – the preferred habitat of the Red Panda. However, the changes may also help in expansion of the coniferous forest types. But whether that would help in maintaining the overall Red Panda habitat intact is still uncertain.
- Along with the possible shrinkage of the suitable habitat there could be progressive reduction in the suitable bamboo undergrowth along the range. Therefore if there is a change in the bamboo species composition along with the change in the preferred habitat type it would further add to the stressed condition to which the red panda is exposed to.
- In addition to the habitat and food, climate change may also impact their breeding strategies too. Red Panda are not prolific breeders with very high rate of juvenile mortality. Hence if there is any further impediment in their breeding regime, in form of unfavourable environmental signals, it would likely hamper their already declining population.

Source: Lachungpa and Ghose, Working group paper on Biodiversity and Forests, 2011.

just emerging and are likely to need increased attention as climate change progresses.

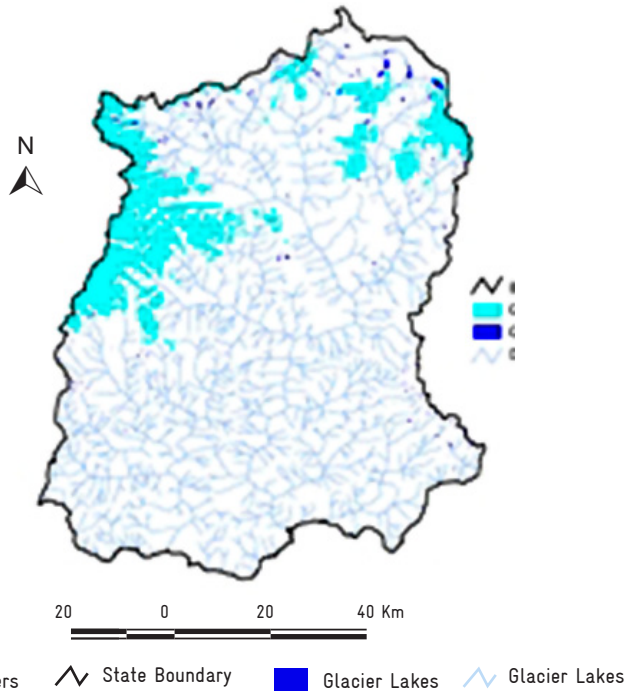
6. Changes to ecosystems: Changes in species composition including intrusion of invasive species and in species interaction eventually lead to ecosystem-level changes. Changes to ecosystems can affect their ability to provide essential services, such as carbon sequestration and food provision.

7. Threat to high altitude wetlands of Sikkim: Climate change, triggering glacier melt and erratic precipitation may likely change the amount, duration and time of runoff from glaciers, leading to altered hydrological cycle, and hence altering the aquatic biota, altering physical and chemical habitat, and resource availability. Further, the altered physical and chemical characteristic of the wetland may lead to mineralisation and more diffusion of O2 in aquatic system, and more microbial activity affecting water quality and release of CH4. Climate change may thus be riding over and above the anthropogenic pressures leading to degradation of environment that affect the ecosystem services provided by the wetlands.

8. Increased frequency of disasters such as landslides, and GLOFs: The Sikkim Himalaya with rugged topography, ongoing seismic activity (by active tectonics) and extreme rainfall is subjected to intense landslide activities. Climate change, bringing more frequent intense rainfall may exacerbate the landslides across the mountains of Sikkim. Also rapid changes in temperatures and intensive precipitation may lead to rapid melting of glacier ice and snow with or without the retreat of the glacier, with resultant lakes putting pressure on the moraines damming the snout. A distribution of Sikkim Glaciers and glacier Lakes is shown in (Figure 8.3).

9. Increase in incidences of forest fires: As the climate warms, the soils are likely to be drier in the summer months, leading to less evaporation, less recycled moisture in the atmosphere, and hence less rain during summer. Further fire mediates the responses of forests to climate change, either by accelerating species turnover or by selecting fire-adapted species (Overpeck et al. 1990). In the same way, changes in species composition may alter fire occurrence by changing the concentration and arrangement of flammable fuels (Bond and Keeley 2005). The strong potential for interactions and feedbacks between fire and its controls suggest that fire occurrence

Glaciers and glacial lakes in Sikkim



Source: Mool and Bajracharya, 2003

over long periods may reflect indirect (ie vegetation and human land use) as well as direct climatic controls (Bergeron et al. 2004). Additionally, increase in forest fire incidences would lead to increase in crop predation in fringe villages by species driven out of the forest like Indian Peafowl as well as genetic dilution in the Red Junglefowl.

10. Impact on livelihoods: Climate change leading to degraded biodiversity of forests, and is likely to impact the quality and quantity of forest products and hence adversely impact the associated livelihoods of communities thriving on the same. The forest products being Eco-tourism, Apiculture, Sericulture, Medicinal Plants, Cane, Bamboo for small scale cottage industries and Natural Fibres.

11. Access to energy: With climate change it is anticipated that the decline in forest biomass may accelerate and rural communities and road transport workers staying and working in the forest fringes dependent on fire wood extraction from forests are likely experience the energy crunch for cooking and heating purposes (development though may make them less and less dependent on forest resources for energy), as there is unregulated extraction of firewood in Sikkim. A pilot study indicates that on an average, consumption of firewood is about 20 kg per household per day which amounts to about 7,409 kg per household per year. A study carried

Box 11: Elevation wise demand of firewood in Sikkim

S. No.	Elevation in meters	Village	Firewood (dry weight in kg)*		
			Demand	Production	Shortfall
1	1670	Sakyong Pentong	6570	1330	5270
2	1780	Yuksam	7300	1220	6080
3	2190	Uttarey	7665	1290	6375
4	2730	Lachen	8030	20	8010
*Fresh weight = 3.5 times dry weight					

Source: Chhetri et al., 2006

Box 12: Concerns of biodiversity in Sikkim due to climate change

Key climate concerns:

- Likely rapid increase in temperatures upto middle of the century
- Frequent extreme temperature events
- Frequent extreme precipitation
- Increased incidences and intensity of forest fires moving to higher altitudes
- Increase in frequency of landslides and GLOFs

Key concerns due to climate change:

Tropical and sub tropical region (300m - 2400m)

- A probable expansion of the hardy subtropical chir-pine at the expense of the broadleaf middle hill forest types.
- Subsequent shrinkage of the home range areas of the species of animals dependent on the middle hill forest types and
  - Loss of bird habitats, especially of the endangered species
  - Shift in butterfly habitats (see Box 8.2)
- Under extreme conditions may lead to loss of the highly sensitive species dependent on the middle hill forest.
- Shortage of fuel wood
- Increase in bush fires and opening up forest areas
- Drying up of recharge and water sheds areas
- Gradual establishment of tropical invasive species in sub tropical areas (e.g tropical Mikania is successfully competing with subtropical Lantana.)
- Upward shift in disease vector species like mosquitoes
- The changing climate affecting the natural cycle of edible wild food production leading to man-animal conflict
- Drying up of water resources and hence reduction in its availability
- Landslides
- Decline in livelihood earnings from forest products
- Decline in access to fire wood

Sub alpine eco-region (3000-4500m)

- Conifer forests likely to become more fragmented
- Decrease in collection of fuel wood
- More forest fires due to more drying spells
- Reduced cover of mosses and lichens leading to reduced water recharge
- Reduced ecotourism and hence reduced revenue earned by Government
- Shrinkage in red panda habitat
- Land slide
- Decline in livelihood earnings from forest products
- Decline in access to firewood
- Impact on subalpine wetlands

Temperate eco-region (2400-3000m asl)

- With climate change oak forests are having an augmented evapo-transpiration rates, altered leafing time and leaf production duration and slow regeneration rates
- Reduced fire and fuelwood collection
- Reduced collection of non-timber forest products (NTFP)
- Increase in incidences and ferocity of forest fires
- Frequent catastrophic destruction of oak forests due to forest fires from increased frequency of dry spells - catastrophic because plants associated with oaks have very high calorific value
- Retardation in the growth of oak forests due to rapid spread of bamboo and herbs like Rumex nepalensis in patches left open by forest fires
- Drying up of springs, less underground water recharge and hence water availability
- Shrinkage in Red Panda habitat (extends from temperate to sub alpine regions 2000-4000m asl)
- Land slides
- Decline in livelihood earnings from Forest products
- Decline in access to firewood

Alpine region (4500-5500 m asl)

- With no room of expansion, shrinkage of alpine eco regions, with expansion of conifer forests from below is expected
- Species depending on snow cover for protection likely to be exposed to frost, and others which require winter chilling
- Also bud- break may not get continued low temperature over sufficiently long period of time
- Reduced fire and fuel wood collection affecting livelihoods dependent on incense making
- Degradation of climax level scrubs such as rhododendrons that mature over almost a century
- Increase in GLOFS due to bursting of moraines from rise in water levels due to rapid melting of glaciers
- Reduced ecotourism and hence reduced revenue earned by Government
- Snow avalanche
- Decline in livelihood earnings from forest products
- Decline in access to firewood
- Threat to high altitude wetlands

out by Chhetri et al., 2006, to ascertain region wise fuel wood demand, indicates that demand increases with elevation though production decreases (Box 11). The gap that exists between firewood demand and supply is ever increasing due to population growth, growing tourism and depleting forest resources (Singh and Singh, 1992).

12. Increase in of man-animal conflict: Climate change may adversely alter the production of biomass and fruits on which the wild animals thrive. As a result, the animals may come in direct conflict with man outside the forests. In Sikkim, man-animal conflict consists of direct encounters and human casualties as well as damage to crop and livestock. From crop depredation and human casualties by Himalayan black bear to occasional leopard attacks, public response often veers towards retribution, which becomes difficult for the authorities to contain. Sikkim, being a global biodiversity hotspot, has diverse fauna which live in close proximity to human beings. The basic economy being agrarian, the boundaries between forest areas and human settlements are forever pushed, with resultant damage to crops and livestock. In the recent past there has been a dramatic increase in direct encounter incidents involving Himalayan black bears with stray incidents of leopards, one of the causes for such situations might have been climate change.

13. Degradation of environment due to release of pollutants from anthropogenic activities: Enhanced fossil fuel combustion in transport sector (due to continuous increase in motorised transport), fossil fuel combustion in industries, the industrial processes and release of waste water from industries as well as homes, unsustainable methods of solid waste management, fossil fuel use in commercial and residential establishments, and also the use of fire wood in rural homes for space heating, cooking and warming of water are some of the causes of emissions of greenhouse gases contributing to global warming. Further the release of pollutants such as SOx, NOx, NMVOCs, particulates etc are leading to the degradation of air, water and the soil.

The region wise concerns due to climate change as perceived in Sikkim is documented in (Box 12).

8.5 THE INSTITUTIONS INVOLVED IN MANAGEMENT OF FORESTS, BIODIVERSITY, WILDLIFE AND ECOTOURISM

Sikkim State Department of Forest, Environment, and Wildlife Management (DFEWM), formerly known as the Department of Forest, Sikkim, is the custodian of over 81% of the total geographical area of the state. The mandate of the department is to sustainably manage natural resources of the state in an integrated manner by implementing the policies of the Government of Sikkim as well as of the Government of India in co-ordination with other sister Departments.

The functions of the department within the purview of the environment, forests, land and water management, include maintenance of environmental stability through preservation and where necessary, restoration of ecological balance of forest resources; conservation and preservation of natural forests of the state; undertaking soil and water conservation and checking soil erosion and denudation of the hill slopes in remote urban and village areas to prevent landslides, flooding and damage to roads, bridges, buildings, etc.; Increasing substantially the forest/tree cover in the state through massive afforestation, social forestry programmes; Help increase the productivity of land through improved management practices of food, timber, fuel wood and fodder for the livestock; prevent diversion of forestlands and good agriculture lands for other purposes; encourage efficient management of land under agriculture by controlling the use of pesticides and insecticides to prevent pollution of soil and water resources and death of pollinators; take measures to prevent pollution of air especially in urban area by prescribing emission levels for vehicles / industries and other air polluting

industries; encouraging efficient utilization of forest produce and maximizing substitution of wood through use of alternative sources of energy for heating and cooking purposes.

The DFEWM, under its wildlife management functions, does strengthening and enhancing of Protected Areas network, manages protected areas, carries out activities towards conservation of wildlife and protection of their habitats, undertakes restoration of degraded habitats, controls poaching and illegal trade, undertakes research and monitoring, promotes ecotourism, undertakes, domestic implementation of international conventions and education and outreach.

The DEFWM also promotes sericulture. The functions in this respect are rearing of improved variety of silkworms; propagation of mulberry seedlings; distribution of the seedlings to the villagers; providing training, financial assistance, infrastructure and other inputs for silkworm cultivation in the state, and organising awareness camps in the village.

Agencies functioning under the DEFWM are State Environment Agency (SEA), the Sikkim State Pollution Control Board (SPCB), the Sikkim Biodiversity Board (SBB), State Medicinal Plant Board (SMPB), the State Forest Development Agencies (SFDA), and the Sericulture and Research, Education and Extension and Ecotourism Directorates. The Central Government has formulated a State Environment Regulatory Authority (SERA), which oversees all the Environment Impact Assessments of all projects being undertaken in the State.

The SEA is an autonomous agency which coordinates all activities related to environment education, environment awareness, environment information. Under this is the District Environment Committee work.

The SPCB oversees the implementation of different Environment Acts and Rules in the State. Its task includes control and abatement of water, air, and soil pollution from industrial sources; to control and restrict use of air horn, playing of loud speakers and bursting of fireworks; to protect the water bodies; to monitor water quality, air quality and noise level at major area in the State; to encourage, conduct and participate in research activities on environmental issues; and disseminate the information available with the board.

The role of the SBB is to advise the State Government on any matter concerning conservation of biodiversity, sustainable use of its components and fair and equitable sharing of benefits arising out of the use of biological resource and knowledge, provide livelihood support to villagers shifting from unsustainable livelihoods to sustainable livelihoods, promote and strengthen individuals and institutions working towards conservation, sustainable use, and equitable benefit- sharing of biological resources and provide technical assistance and guidance to the departments of the State Government. assist other Circles and Divisions of the department with relevant information and facilitate various research organizations to carry out short and long term scientific studies; undertake extensive education and outreach programmes and assist the department with its publication and other extension activities.

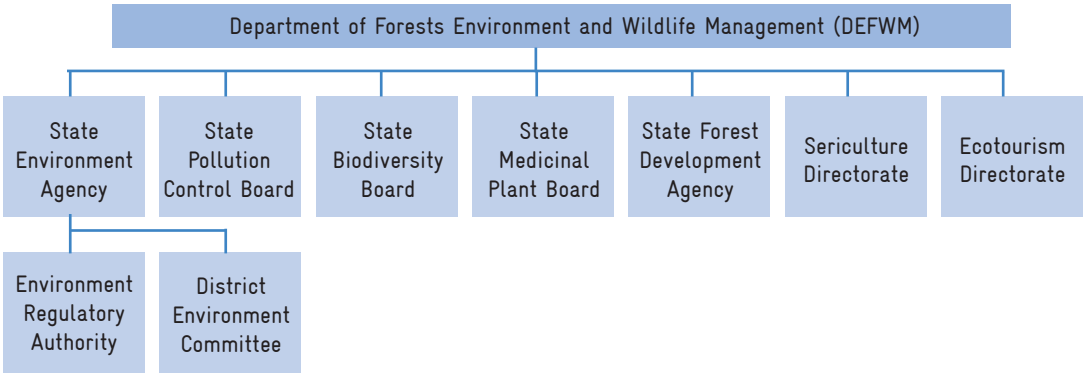
The various agencies, boards and directorate working under DEFWM are shown in (Figure 8.5).

The SMPB oversees formulation of projects/ schemes related to medicinal plants, implementation of such schemes for cultivation of medicinal plants, their collection, storage and marketing, research, protocol for cultivation and quality control and protection of Intellectual Property Rights and other issues related to the medicinal plants.

The SFDA promotes the objectives of forestry development in the state (http://www.sikenvis.nic.in/sfda- sikkim.html) undertaking sustainable management of forests and creates durable community assets.

The Ecotourism Directorate formed in 2006 identifies ecotourism ventures in the state, which will be articulated in the guidelines from NED; allows ratings/ certification of enterprises based

Figure 8.5: Institutional structure of the Department of Environment, Forest, and Wildlife Management



on well laid out criteria/indicators; encourages socio-ecologically responsible tourism by incentives linked to monitoring of natural and social impacts, and assesses the feasibility of and plan to develop and strengthen community-based ventures.

The Research, Education and Extension Directorate has two wings, namely Biodiversity Research and Silviculture, to carry out various biodiversity/wildlife related activities,

8.6 CURRENT POLICIES AND PROGRAMMES AND PROJECTS TO PROTECT BIODIVERSITY

a. Wildlife and Biodiversity

Wildlife conservation has become a worldwide significance. Sikkim has established about 10 wildlife protected areas. It has established the Khangchendzonga Biosphere reserve covering 2,931.12km^2 covering 3 out of districts (North, South, and West districts). Further it has eight Wildlife Sanctuaries including one Fairrieanum Orchid Conservation Reserve, all occupying as much as 42.54% of State's total geographical area under the wildlife protected area network including Biosphere Reserve which is remarkably the highest coverage amongst other States in the country. The State has been able to set aside 51.68% of the State's forest land area under the wildlife protected area network including Biosphere Reserve for the protection and conservation of State's rich wildlife and biodiversity resources. Protection, preservation and conservation is achieved through the people's participation represented by Eco-Development Committees (EDCs) formed around the protected areas. The EDCs are the local village bodies and partners with the wildlife managers for the protection, preservation and propagation of wildlife in the National Park and Wildlife Sanctuaries. 57 EDCs around the protected areas are implementing Wildlife Forest Development Agency schemes since the year 2004. In 2003 the Government of Sikkim recognized eleven Important Bird Areas (IBAs), finalized the Sikkim Biodiversity Strategy and Action Plan (SBSAP) and made a Plan for Conservation and Sustainable Use of Medicinal Plants of Sikkim (CSUMPS). For the list of wildlife protected areas in Sikkim see (Box 13).

Sikkim Biodiversity Conservation and Forest Management Project

Terms of Reference (TOR) have been signed with Japanese International Cooperation Agency (JICA) funded externally aided project with focus to promote ecotourism and natural resource conservation. The project has a financial outlay of Rs. 330.57 Cr. over a 10 year period.

Protection of heritage trees

In order to protect and preserve the very old trees of Sikkim, a concept of identification and

declaration of Heritage trees was started with active participation of the local people. In North Sikkim, a Juniper tree bearing a girth of 42 ft was selected to be declared as a Heritage tree amongst several other trees with big girth.

Research

Some of the specific ongoing studies being carried out in Sikkim that may throw up some information on how biodiversity is changing in Sikkim with climate are:

- Climate change impact on endemic plant species of Sikkim Himalayas, by Yasmeen Telwala, University of Delhi
- Programme Support for Technological Innovations and Ecological Research, and Sustainable use of Bioresources in Sikkim Himalayas, NCBS in association with ATREE and sponsored by DBT
- Research on natural pests of wild ginger in Sikkim by CABI-UK, KFRI, ICAR-DARE & NBPGR
- Study on tree growth by IITM-Pune under Geosphere-Biosphere Programme of ISRO,
- Study on sensitive indicator species, liverworts, lichens, ferns, mushrooms, by BSI
- Carrying Capacity of Tista Basin Project by CISHME, Delhi University (Bird and Butterfly study by Dr. Bhoj Kumar Acharya (SACON); Herpetofauna by Dr. Basundhara Chettri (SACON)) (www.sikenvis.nic.in)
- Study on Butterflies of Sikkim by Dr. Krushnamegh Kunte
- Study on Panax pseudoginseng, Delhi University by Dr. Shiva Kumar Sharma.
- Paleo-environment (short) study in North Sikkim by Dr. Mukund Kajale, Deccan College Pune
- Tree ring study (Zemu Glacier Area) by Birbal Sahani Institute of Palaeobotany; and,
- Study on Long Term Survival of Red Panda in Sikkim by WWF-I, Khangchendzonga Landscape Programme

b. Forests

Strengthening of territorial sector: Forest Management and Protection are the dual functions of this sector. The Government has addressed these vital issues in recent years than ever before in politically sensitive way. A motivated field staff, sound legal enactment, efficient and effective transport and communication, accommodation facilities, self defence and uniforms, etc. are some of the pre-requisites to accomplish the effective management and protection.

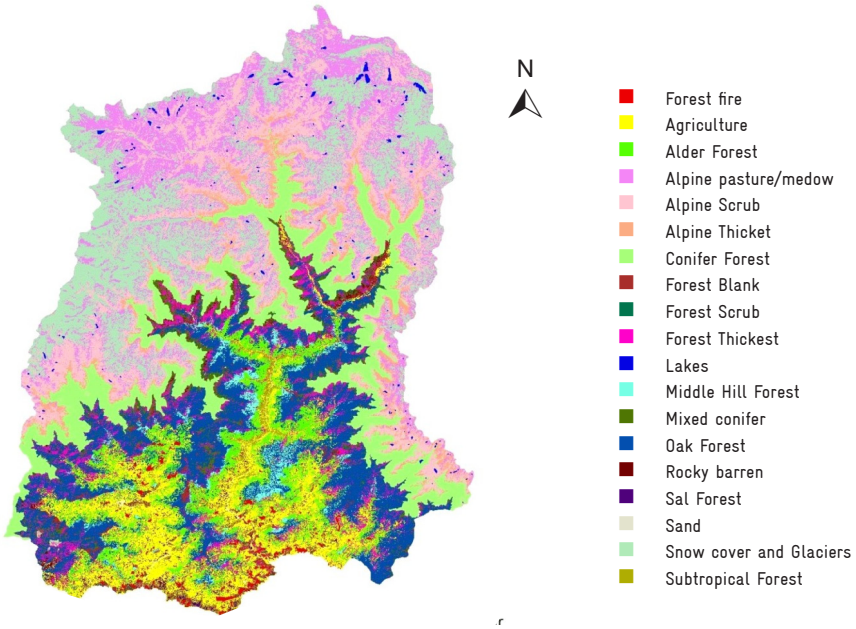
The State Government has brought about vital amendments in the present Sikkim Forest Water Courses and Road Reserve (Preservation and Protection) Act,1988 (Amendment 2000) to make the specified clause more stringent and harsh in enforcement. Offences such as illegal

Box 13: Wildlife Protected Areas in Sikkim

Sl. No.	Name of Wildlife Protected Area	Location District	Area
1	Khangchedzonga National Park	North & West	1784 sq. km. (expanded from 850 sq. km.)
2	Khangchendzonga Biosphere Reserve	North & South West	2931.12 sq. km. (expanded) due to addition of Transition zone)
3	Shingba Rhododendron Sanctuary	North	43 sq. km.
4	Pangolkha WLS	East	128 sq. km.
5	Kyongnosla AlpineSanctuary	East	31 sq. km.
6	Fambonglho WLS	East	51.76 sq. km.
7	Kitam Bird Sanctuary	South	6 sq. km.
8	Meanam WLS	South	35.34 sq. km.
9	Sling Dong Faireanum Orchild Conservation Reserve	South	0.06 sq.kms
10	Barsey WLS	West	104 sq. km.

Source: Sharma et al., 2009

Land use and forest type showing forest fire in Sikkim (2009)



felling of trees, encroachment and grazing in the Reserve Forest have been made non-bailable. Other important initiatives, measures and actions taken are as follows:

Intensification of management & protection: The overall management of forest land and forestry resources have been intensified by better patrolling, effective forest check posts, check on illegal extraction and transit of forest produce, reporting and recording of all forests offences and other information in Head quarter control room and Division control rooms, registration of forest cases, check on leakage of forest revenue and better communication system.

Forest fire management: Forest fire in Sikkim is commonly noticed and experienced below the altitude of 2500m with more intensity in dry zones especially in the sal forest ecosystem to a less extent in the temperate conifer forests, subalpine and alpine forest. Forest fires are more frequent during winters, when long dry spells cause high day temperate, further exacerbated by strong winds and easy availability of dry fuel wood. see (Figure 8.6), depicting the land use and forest type with forest fire distribution in Sikkim in 2009. A forest fire management policy has been developed in the State for the first time to enable the government to focus on fire prevention aspects and to coordinate efforts by various agencies towards this important function. The policy integrates modern fire fighting approaches with community based fire fighting strategies and is devised to preserve the unique biodiversity of the forests of the State especially those of the lower altitudes. The policy provides for zoning of the forests on the basis of their vulnerability, assessed ecological impacts and intrinsic value so that different treatments can be meted out to the different zones.

In, 2009, which was the driest year in Sikkim in recent times, 8 forest fires had been recorded between January to May of that year which were spread across agricultural land, alder forests, sub tropical forests, sal forests, rock barren area, rocky barren area, oak forest, forest blank area and in forest scrubs, exposing 14.03% of the total state area (see Table 18, Sharma et al., 2009).

The forest fires were studied based on land use and forest type classification of Sikkim. The study revealed that the sub tropical forests and sal forests in Sikkim have highest percentage of burning as well as highest intensity of forest as detected through satellite imagery. Susceptibility of sub tropical and sal forests to forest fires will no doubt have far reaching impacts on biodiversity.

Management, development and protection functions of the forests that are located in the vicinity of their villages. So far 155 JFMC's (un-

der four territorial FDAs) have been registered all over the State and the work of JFMC constitution in the villages not yet covered. At the district level all the JFMC's have together been formed into a confederation called the Forest Development Agency (FDA). The JFMC's were entrusted with the task of

Grazing control: The Government has 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 of overall natural resources status. A number of 'goths' or cattle sheds have been removed and the cattle have been impounded and fined along with wide publicity and awareness.

Joint Forest Management Committees (JFMC's) & FDA: The Government has adopted the participatory approach to forest protection, management and development. It has taken up formation of Joint Forest Management Committees/Eco-Development Committees at the village level which comprises of all the villagers who wish to participate in the forest afforestation and protection of the natural resources of their area and implementation of the the National Afforestation Programme through the four FDAs during the Tenth Plan period. More than 10,000 hectares of land was to be developed over the Plan period through this scheme.

Urban forestry issues: Rapid urbanization of rural areas and increase in construction of housing and other complexes in and around existing urban areas as well as road construction and widening results in public demand to cut down large standing trees and biodiverse shrubbery due to dangers real and perceived to life and property. These issues are relatively new to Sikkim and are obvious contributors to the overall climate change issues in Sikkim where microclimatic changes are seen within the state capital Gangtok itself. They must be addressed through well planned urban forests with carefully selected species.

c. Water

There are quite a few programs in this sector mostly funded by the Central Government and the Hydel power developers.

Integrated Watershed Management Programs (IWMP): Wasteland, watershed and dry land development are key action points of the Government and is carried out through the Integrated IWMP by the Department of Land Resources, Ministry of Rural Development. The programme focuses on a cluster of micro-watersheds with sizes ranging from 1,000 ha to 5,000 ha. Assured irrigation area is not included in the project. IWMP includes the role of the Panchayati Raj Institutions and NGO's, and emphasizes, convergence, integration of natural resource management, productivity, livelihood and income. It also takes into account the farming system, micro-enterprising, unique activities for landless, assets less, small and marginal farmers. Cost per ha allocation is Rs. 15,000 per ha with cost sharing between the centre and the state being 90:10. In Sikkim, currently 66,306 ha are under this project and the total project allocation in 2009-2010 was Rs. 7.91 Cr. http://www.sikenvis.nic.in/reports%20and%20Publications/15years/14_Watersheshed%20Mgt% 20pg% 2040-41.pdf, accessed on March 11, 2011).

Catchment Area Treatment Program (CATP): coordinated by the Ministry of Environment of Forests and funded by the hydel-power developers The objective is to conserve and restore the catchment of the rivers which are being harnessed for generating hydel power in order to reduce the silt load, increase the percolation which will result in enhancing the life and the economic returns from the project. These plans are mostly prepared by consultants, reviewed by the Forest Department and finally approved by the MoEF. The works are divided amongst 4 circles of the Forest Department having the following roles or sectoral responsibilities namely, Territorial circle implements mostly plantations in reserve forests areas, Land Use and Environment circle which is the nodal circle implements mostly landslide treatment, flood control and land development using mechanical and vegetative measures, So-

cial forestry circle carried out pasture, fodder and firewood development mostly in private and community lands, Wildlife circle implements habitat improvement measures and biodiversity enrichment inside protected areas. Some of the ongoing projects are Teesta Stage VI,

Teesta Low Dam Project/ NHPC III Stage, GATI Infrastructure Pvt. Ltd. Chujachen HEP, Dans Jorethang Loop HEP, Ramam HEP and Teesta Urja (Stage IV). Activities undertaken include Flood control and Protective Works to treat landslides, slip areas and jhoras in forest and private lands both by measures like jhora training, catchwater drains, protective walls, vegetative measures, plantations and land terracing. Nodal agency is Land Use and Environment Circle of the forest department.

One of the hydroelectric projects Teesta Stage V-510 MW was initiated by NHPC during the year 1999-2000, Since then simultaneously CAT plan was drawn up and implemented right from 2000-2001and still some of the maintenance works is being implemented. The Four major sectors of the department are involved for executing the CAT Plan i.e. Territorial, Land Use and Environment, Social Forestry and Wildlife carried out the treatment works. The total cost of the programme till date is Rs. 36.8 Cr. http://www.sikenvis.nic.in/ Reports% 20and% 20Publications/15years/15_Chapter % 20II% 20LUE% 20SMPB% 20WP% 20pg% 2042-50.pdf, accessed on 11th March 2011).

Technology Development, Extension and Training Programme: Technology support is extremely vital for success of land based programme, especially in the development of wastelands. Proper area specific strategy has to be developed keeping in view the agro climatic conditions and capability of land. Realizing this, a TDET, a central scheme of Department of Land Resources (DoLR), National Wasteland Development Board (NWDB), Ministry of Rural Development (MoRD), Government of India was launched in 1993-94. In Sikkim, implementation of this project was done in the entire district in the state by Land Use and Environment Circle of the Forest Environment and Wildlife Management Department. This project was implemented in the state keeping in mind the - treatment of landslide and soil erosion in watershed of the catchments area. The financial assistance through TDET is for technology development, pilot projects, field trial of established technologies on farmer fields/village commons/other institutional lands and for extension and training.

Landslide being the major natural disaster in the region and its occurrence leads to a lot of soil erosion thus depriving the region of its rich soil, the finances under TDET, were sought for treatment of landslide and erosion control in the identified area of the three Districts vice

North/South and East. The finance allocated to the scheme till Dec 2010 was Rs. 12.2 Cr. http://www.sikenvis. nic.in/Reports% 20and% 20Publications/15years/ 15_Chapter% 20II% 20LUE% 20SMPB% 20WP% 20pg%2042-50. pdf, accessed on 11th March 2011).

MGNREGA Program: Mahatma Gandhi NREGA is a national flagship program with decentralized planning, execution and stringent transparency norms. The Rural Management and Development Department is the nodal agency and has been performing well having bagged national awards of excellence for exemplary work. Water conservation, flood water and protection and plantation activities are amongst the eight activities permissible under this program. Selection of activities is done by the gram sabha at the village level and implementation is through the DDO, BDO and Gram Panchayats.

In heavy rainfall areas in East and North districts mostly flood control, drainage and protective works have been taken up. While in the drought prone areas in the subtropical sal and middle hill forests in East, South and West districts pilot spring shed developments have been initiated, village spring atlas is under preparation and has data of nearly 600 springs and the dried up lakes are also being revived. One of the biggest achievements of this program has been to build a trained pool of master trainers at the Block level with the support of WWF-India, Arghyam NGO, ACWADAM NGO who understand the concepts of ground water, geology, geohydrology and spring shed development. The project has also take up rainwater harvesting through

spring shed development approach and contour trenches, drainage lines and percolation pits have been demonstrated in about 20 locations. Further details on this program MGNREGA-Dhara Vikas are available at www.sikkimsprings.org

d. Disaster Management in Sikkim

Natural Disaster Risk Management Programme: This was carried out during the period 2002-2007, but has far reaching impacts in terms of the states capacity to respond to disaster. The Community Based Disaster Reduction and Recovery through Participation of Communities and Local Self Governments is a programme of the Govt of India facilitated by the United Nations Development Programme (UNDP). As a part of the programme, an online disaster resource inventory called the India Disaster Resource Network (IDRN) for the entire state has been established where information about essential and specialist resources for disaster response has been uploaded. The programme has laid a foundation for accomplishing disaster preparedness and mitigation in Sikkim. The Land Revenue Department has been renamed as Land Revenue and Disaster Management Department with an enhanced area of responsibility to include mitigation and preparedness apart from the responsibilities of relief and rehabilitation. The State Disaster Management Authority is being established to lay down policies and monitor mitigation, prevention and preparedness initiatives. The State Disaster Management Bill and Disaster Management Policy are under formulation and the Town and Country Planning Acts, Land Use Zoning Regulations are being reviewed

Disaster Risk Reduction and Urban Risk Reduction Programme: This is an ongoing programme (2009-2012), being implemented by the National Disaster Management Authority for all districts and the Ministry of Home Affairs for Urban risk reduction in association with Sikkim Government and support from the UNDP. At the State level State Disaster Management Authority (SSDMA) is constituted, headed by Chief Minister as Chairperson, ex-officio. State Executive Committee (SEC) and State Executive Sub-Committee (SESC) also constituted and headed by Chief Secretary and Principal Secretary, LR and DMD as chairpersons respectively. Also constituted is the District Disaster Management Authorities (DDMA) headed by District Collectors as Chairperson and Zilla Adyaksha as Co-chairperson. District Management cells at all District Headquarters have also been set up and established. Eight Human Resources expert in different fields have been recruited to implement the projects. SEC, SESC and DDMAs are responsible for implementing, monitoring, coordinating and auditing of both DRR and URR programmes including other National programmes listed below.

The objectives of the programme are the preparation and formulation of State, District, Block, Village and ULB Disaster Management Plan, formulation of DM Act, DM Rules and Policies; capacity building of engineers, architects and masons on Earthquake Resistant Technologies; training of government officials, police, PRIs, NGOs, SHG etc.; Hazard Risk Vulnerability Assessment Study of entire State and Gangtok city; capacity building Disaster Response Plan of state up to village level; Development of specific tools and methodologies for mainstreaming DRR and URR; organizing of State level Training of Trainers (TOT) to develop capacities at community and local body level; creation of knowledge center; organizing of awareness generation programmes and development of IEC materials; development of techno-legal framework; and strengthening of Emergency Operation Centers (EOCs).

e. Developing renewable energy technologies

Through various programmes like activities of FDA, IWMP, Hariyali Project and others, alternative energy through distribution of LPG cylinders is provided for reducing pressure on existing forests. The distribution is undertaken through the various JFMCs and EDCs for fringe villages around forest areas. Other than this, the State Renewable Energy Development Agency is the nodal agency of the State Government for promotion of use of alternative energy, through which LPG distribution in high fuel wood us-

ing areas. The programme is now being overseen by the Food and Civil Supplies Department. Also Sikkim Renewable Energy Development Agency (SREDA) promotes eco friendly systems like Solar Water Heating systems and has gained much popularity. SREDA has installed a cumulative capacity of 30,000 litres per day (lpd) Solar Water Heating System (SWHs) in domestic as well as commercial establishments and different Government institutions in the State. SREDA has installed SWHs with a cumulative capacity of 5,700 lpd at Raj Bhawan, Gangtok and 4,500 lpd cumulative capacity at State Central Prison in Ronghek, under the Special Area Demonstration Programme of MNRE. Some of the other important places where SREDA has installed SWHs are SIRD, Karfectar, Janta Bhawan, Gangtok and Government Hospital, Namchi , South Sikkim etc. Under State subsidy programme, SWHs are being sold to hotels & private individuals subsidised rate. Demonstration of use of solar water heaters in high altitude areas of temperate zones, for reduction of fuel wood has also been undertaken in the state through WWF – India on a smaller scale.

f. Curtailing man-animal conflict

The Forests, Environment, and Wildlife Management Department (FEWMD) does not have any specific programme for mitigating man-animal conflict issues. However through various other programmes like the Integrated Development of Wildlife Habitats 100% Centrally Sponsored Scheme and Sikkim Ecology Fund and Environment CESS, MAC is being managed with active support of NGOs like WWF.

Programmes of the Sikkim State Department of Forest, Environment, and Wildlife Management (DFEWM) for managing MAC include immediate financial relief of Rs. 5,000/- is being disbursed to kit and kin of the affected families in case of human casualties followed by compensation as per the notified Government rates for human casualties. In case of damages to livestock and human property compensation is being disbursed as per notified Government rates or as decided by village level committees at the grassroot level whichever less is. Field patrolling and combing operations are organized during the affected period which normally starts from August to January. Cages within available budget have been designed and fabricated to trap and transport wild animals straying into human habitations. Squads are organized to undertake push back operations of the wild animals in the field. Presently 143 Forest Guards are being trained at Police Training Centre, Yangang, South Sikkim and the Sikkim Armed Police Camp, Pangthang, East Sikkim. Awareness programmes dovetailed with other Department programmes are undertaken during the affected period and the Eco-Development Committees and Joint Forest Management Committees are activated for community sensitization.

Himalayan black bear habitats have been identified and activities to supplement dietary requirements of the bears during the lean season have been undertaken habitats by planting fast growing edible plants. Feeding stations are being established on the onset of the peak conflict season. Assistance of local trackers and ex-hunters are sought during peak conflict period for tracking and trapping the conflict causing animals.

Oral baits laced with sedatives to trap Himalayan Black Bears for relocation to forests and protected areas

Assistance of trained police shooters have also been sought to cull Himalayan black bears in extreme cases. Vegetative barriers like agave plantations have also been undertaken in areas where there is immense pressure of wild animals especially herbivores like wild boar, porcupines and barking deer foraging in the adjacent agriculture fields. Management plans of the Protected Areas are being revised with strategies to recover disturbed wildlife habitats. Oral baits laced with sedatives have been developed to trap Himalayan Black Bears which are then relocated in the forest/Protected Areas (Figure 8.7a).

Others like the WWF-I have initiated a field survey of the man animal conflict to prepare appropriate future strategies. Apart from this a rapid assessment during the peak conflict period was undertaken by the WWF-I along with FEWMD to formulate immediate short term solution for managing the bear intrusions which led to development of the oral baits and establishment of feeding stations in the field. Community initiatives to manage the conflict at local level by using traditional scaring methods like banging of empty vessels, etc are being encouraged.

In South Sikkim an experimental translocation of five Indian Peafowl has been attempted to curtail incidences of crop predation; in high altitudes Feral Dogs pose a menace to livestock; in other areas Macaques and Langurs damage fruit crops and Large Cardamom plantations.

8.7 STRATEGIES AND ACTIONS TO ADDRESS THE CONCERNS OF CLIMATE CHANGE IN SIKKIM

The Government of India has recently launched the Greening India Mission aimed at mitigation and adaptation. The mission is meant to enhance ecosystem services such as carbon sequestration and storage, biodiversity conservation and provision of biomass and NFTPs. The mission aims at responding to climate change by a combination of adaptation and mitigation measures with the aim towards enhancing carbon sinks in sustainably managed forests and other ecosystems; adaptation of vulnerable species/ecosystems to the changing climate and adaptation of forest dependent communities.

Based on the concerns in Sikkim about, a set of 9 strategies have been devised which are also in line with the recently launched Green India Mission by the Ministry of Environment and the perspectives of the planning commission in managing the environment and ecology. The strategies thus proposed are:

1. Spring recharge and enhancing ground water recharge in forest areas: The aim of this strategy is to make Sikkim a water secure state. This can be through climate proofing of the existing programmes of IWMP, CAT and MGNREGA through appropriate management of water sheds. For climate proofing these programmes the steps that can be undertaken are:

Integrated Watershed Management Programs (IWMP): Focus on drainage line treatment has to be shifted to a watershed development and management of the entire catchment using rainwater harvesting techniques which will help in recharging the ground water. In drought prone areas of South and West districts and small areas in East and North districts, rainwater harvesting component needs to be explored having activities like staggered contour trenches, percolation pits and spring shed development. This will help in recharging the ground water and ensuring perennial spring flow and reviving the entire ecosystem in general. Survival of the vegetative measures and horticulture plants will also increase. Reduced surface runoff will reduce instances of floods as well.

Catchment Area Treatment Program (CATP): CATP plans need to be area specific to be able to cater to the diverse needs of water surplus regions and drought prone regions as well and shift from flood control approach to rainwater harvesting using soil and moisture conservation works like contour trenches, percolation pits, drainage lines etc. and spring shed development of springs originating from forest areas in drought prone areas and in subtropical and middle hill areas which are not very steep. Though the flood control and protective works is essen-

tial for heavy rainfall areas, however, CAT programs. Capacity to identify, plan and execute these rainwater harvesting measures needs to be developed.

MGNREGA Program: To climate proof the water availability through MGNREGA, about 1,000 springs need to be recharged 1,000 in drought prone areas While the program has helped in developing human capacity for this important sector and also carried out pilots to facilitate hands on training, there is a need for earmarked funds for spring shed development to upscale this initiative on a bigger scale

2. Enhancing quality of moderately dense forest, open forests, and degraded forests: The aim of this strategy is to improve the health of these type of forests, improve the ecosystem services and enhance the C sequestration potential.

Actions for enhancing quality of forests would include- regulation and monitoring of invasive species1 and identification of non-native species that can survive climate change and be beneficial to the ecosystem, management of insects and other pathogens, adoption of short rotation species, preventing forest fragmentation by conserving contiguous forest patches, eco restoration of degraded open forests, and restoration of grasslands.

Sustainable management of these forests would lead to increase in soil moisture content of the forests, increase in biomass density, along with increase in the flow of forest goods like NTFPs, fuel wood, hydrological services, improvement in biodiversity and enhancement in C sequestration.

Additionally trees in notified forest patches which are threatened by expanding urban/industrial development, open spaces/green spaces like parks/wood lots set up on municipal land, diffused planting such as on avenues and in households and Institutional lands, especially lands belonging to or allotted to business/industrial houses and educational institutions can be explored for enhancing C sequestration, as well as for improving the quality of soil, water and air of the immediate environment.
Schemes can be developed in the future, in which states having proven C sequestration potential in their forests, can sell the surplus to other states and earn C credits.

3. Linking Protected Areas: Aim of this strategy is secure corridors to facilitate species migration of both flora and fauna and adapt to climate change, especially for species with limited dispersal ability.

It can be done through connecting fragmented forests with 'Canopy Corridors' and 'Flyways' to assist species migration. Corridors will be prioritized and maintained by local stakeholders. As for people living in these corridor areas, rapid agency responses to crop-raiding, man-animal conflict, crop-insurance and hassle-free compensation would be some of the key interventions.

Table 19: IBA site codes and names

IBA site codes	IBA site names
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

Special studies need to be launched to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change.

The Important Bird Areas (IBAs) concept could be used to identify and conserve such potential corridors with peoples' participation (Table 19).

4. Disaster Risk Reduction and Management - In Sikkim, disasters which are likely to be more frequent with projected increase in intensity of extreme events such as extreme heat, droughts, and extreme precipitation include incidences of forest fires, landslides, increase Glacial Lake Outbursts and Flows (GLOFs), land erosion, and threat to hydropower dams. Therefore climate proof strategies for preventing the exacerbated impacts of climate change for these can be as follows:

(i) Effective fire prevention and fire management: Fires are frequent in the subtropical Sal forests in Sikkim and occur in the months. Winter precipitation used to douse the fires. However, with the change in the climate pattern, winters are cold and dry, fires are on for longer periods of time and also occurring at higher altitudes. The extent of the damage depends upon the frequency and intensity of fires and the type of forest, availability of fuel and local climatic factors. Fires in Sal forests, though damage the forest, but regeneration of the ground flora occurs in the next rainfall season. However, the total oak trees catches fire in oak forests, as its calorific value is higher than Sal, and the forest remains degraded for long time. (eg. Major fire occurred in 1970's in oak and coniferous forests in Nyaatham, Karzi Labdang and Yumbung areas which still barren). The strategy for fire management can be two pronged, namely (i) early detection and management extended to higher altitudes, including community participation in management of fire and (ii) planting species in forests, immediately after the area is burnt with trees generated in the nurseries. Therefore nurseries have to be set up of Sal, Oak, and Conifer with adequate saplings available for future requirements. (iii) also considering that climate change is occurring, research needs to be carried out to identify forest tree species that would adapt itself at different altitudes.

ii) Increase in frequency of landslides: The Himalaya, amongst which Sikkim lies, is a young mountain chain in geological time scale, representing a geologically and ecologically fragile mountain ecosystem. It receives immense rain water, and is susceptible to earthquakes (in terms of frequency and intensity) and intensive soil erosion. Therefore, Sikkim is highly prone to landslides. Landslides disrupt traffic on highway every year. Due to the dumping of material into the river the sediment flux in the rivers increases. Increase of sediment flux may have negative impacts on the aquatic ecosystem.

Occasional blocking of the rivers may lead to flash floods. Some of the landslides affect the cultivable lands, thus leading to the wastage of productive soils. Landslides are problems that if not attended, grow with time. It is, therefore, important that they are tackled at the earliest opportunity and undue time is not lost. The corrective measures for a landslide can be (a) Keeping the soil mass free of moisture, (b) Increasing shearing resistance of the soil, (c) Protection of toes of road embankments, and (d) Training of streams to prevent damage.

iii) Land erosion due to increase in precipitation intensity and frequency: Floods in Sikkim predominantly inundate marginal lands on low river terraces and erosion of land also occurs by turbulent rivers and hill streams during monsoon when runoff is highest with climate change and increase in extreme precipitation this may heighten. While the flooding due to over bank spills is not serious and is confined to isolated patches affecting a total area of 10,000 ha, land erosion poses a serious threat to rural and urban population, strategic lines of communication, public utilities, agricultural lands, plantations, forests and mineral resources. Erosion of land has even more adverse effects on environment and ecology not only in the affected areas but also in the plains lower down where the heavy loads of debris are deposited in the river beds and flood plains aggravating the intensity of flood and disturbing the river regime.

Well planned Urban Forests with carefully selected species: Keeping the geo-fragile seismically prone, steep slope topography, as well as nearness to natural forests of urban and semi-urban rural areas in various altitudes in Sikkim, planned Urban Forests will help alleviate micro-climatic stresses and maintain stability of the environment. They will also help minimize man- animal conflict situations, while providing green lungs to the urban human.

iv) Increase in GLOFS: The glaciers as well as glacial lakes are the sources of the headwaters of two main rivers in the region, e.g. the Teesta and the Rangit rivers. Due to climate change, sudden break of a moraine dam may generate the discharge of large volumes of water and debris causing disastrous floods downstream. In a study carried out by ICIMOD, 2005, 14 glacial lakes have been identified as dangerous see (Table 19a). There are several possible methods for mitigating the impact of glacial lake outburst flood (GLOF) surges. The most important mitigation measure for reducing GLOF risk is to reduce the volume of water in the lake in order to reduce the peak surge discharge. Downstream in GLOF prone areas, measures should be taken to protect infrastructure against the destructive forces of the GLOF surge. There should be monitoring systems prior to, during, and after construction of infrastructures and settlements in the downstream area. Careful evaluation by detailed studies of the lake, mother glaciers, damming materials, and the surrounding conditions are essential in choosing an appropriate method and in starting any mitigation measure.

v) Safeguarding hydropower in critical areas: Sikkim has a high potential of hydropower- both large and small hydropower projects are

Table 19a: Potentially dangerous glacial lakes in Sikkim Himalays

S.Nr.	Lake Nr.	Latitude and Longitude	Class	Remark
1	21	27o32'01.48"N. 88o05'15.33"E	Moraine – dammed	Thin lateral moraine, supraglacial lakes, possibility of ice core, two mother hanging glaciers
2	54	27o49'08.11"N. 88o15'47.65"E	Blocked	Seems to have past GLOF event, steep handing glacier, one side is bounded by rock other by moraine
3	55	27o49'34.76"N. 88o15'22.96"E	Moraine-dammed	Thin lateral moraine, supraglacial lakes side by side
4	63	27o51'14.76"N. 88o14'40.23"E	Moraine-dammed	Thin lateral moraine, supraglacial lakes side by side
5	70	27o53'44.32"N. 88o11'.33.33"E	Moraine – dammed	High elevation, contact with steep handing mother glacier
6	71	27o54'53.26"N. 88o12'04.89"E	Moraine – dammed	Seems to have past GLOF, high chances of dead ice, clean glacier and debris glacier is in contact with lake
7	72	27o55'15.53"N. 88o09'51.43"E	Moraine – dammed	Seems to have past GLOF, high chances of dead ice, clean glacier is in contact with lake
8	109	28o00'26.98"N. 88o29'50.13"E	Moraine-dammed	Thin lateral moraine and step hanging glacier
9	120	28o00'32.65"N. 88o34'33.65"E	Valley	Around 400m downstream of gl 121
10	121	28o00'59.42"N. 88o33'56.00"E	Moraine-dammed	Thin lateral moraine and steep hanging glacier
11	127	27o59'34.95"N. 88o49'18.78"E	Moraine-dammed	3 km and 600 m wide, associated with supraglacial lakes at the toe and valley glacier
12	142	28o01'35.08"N. 88o42'58.63"E	Moraine-dammed	Around 600m downstream of gl 143
13	143	28o00'34.46"N. 88o42'16.28"E	Blocked	Blocked by glacier moraine and the distance of the glacier is less than 200m
14	195	27o51'56.13"N. 88o52'12.84"E	Moraine-dammed	Attach with steep hanging glacier

Source: Mool An Bajracharya, 2003

in the pipeline. In this region, Global warming and changes in precipitation patterns is likely to increase the risk of GLOFs and also the timing and magnitude of river flows. With increase in GLOFs, there may be increase in water discharge and consequent power generation in the short term similarly with increase in rainfall. However, hydropower generation is then vulnerable to rockfalls/landslides, increased debris flows, river bank erosion and floods and more extensive outwash plains and, possibly, more frequent wind erosion in intermontane valleys. Enhanced snow melt and fluctuating stream flows may also produce seasonal floods and droughts. As a result of these, faunal and floral species migration may take place. Additionally, earthquakes increase in landslides and other geophysical hazards may also occur in these environments.

Disaster management in the context of climate change entails, establishment of appropriate institutional mechanisms at state, district, block and gram panchayat level for managing the risks associated with the projected enhanced intensity of the disasters, such as landslides due to high intensity of rains, bursting of hydropower dams, due to both extreme rainfall or GLOFS. Further, it is essential to install early warning systems and associated hardware; undertake remote real time monitoring with automatic data transmission; undertake hazard mapping of key watershed areas; implementation of Hazard Zonation Plan; preparation of a state database on landslide prone areas and intensity of landslides to assess the risk of landslides; reforestation of catchment areas and slope stabilization of landslide and flash flood prone areas, doing river bank protection and re-location/resettlement of villages and people in risk prone areas. Further awareness generation amongst general public on impacts of climate change on GLOFS, land slides, dam burst etc. required for disaster preparedness.

5. Preventing man animal conflict: The aim of this strategy is to have sustainable forests that help wildlife to thrive within the limits of the forests.

In the last three years, Sikkim has been witnessing a significant change in the climate patterns. This has manifested in 2008 experiencing one of the driest winters in living memory, followed by a delayed monsoon in 2009. In 2010 monsoon was on time but the snowfall was delayed. An erratic cycle of weather patterns is being experienced and it appears that there is an intricate ecological linkage between the food habits of the wild animals, the phenology of edible wild fruit bearing trees e specially the oak trees and fruit production, weather patterns, and the forest denizens straying into human habitations. The changing climate could have affected the natural cycle of edible wild food production. The strategies to address this concern could include short, medium and long term strategies. Short term strategies could include community initiatives, and identification of conflict areas and periods, extensive patrolling, co-ordination with local community and administration etc can be taken up by the DEFWM. Medium term initiative could include capacity building, strengthening communication etc., sensitization of policy makers etc. Long term strategies could be population estimation of key species, study on agriculture practices, phenological studies of wild edibles.

6. Conservation of High Altitude Wetlands (HAWs): The aim of this strategy is to secure the services provided by the wetland ecosystem even in the context of the likely adverse impacts of climate change.

This actions within strategy need to include Identification of critical wetlands for undertaking long term scientific studies flora and fauna, hydrology, limnology etc.; identification and inclusion of more wetlands and marshes for effective management; strengthening capacities of the stakeholders to manage the wetlands; acceleration of the efforts to include more wetland sites under Ramsar convention and conservation and security of these HAWs through active involvement of the border protection agencies which depend on them for survival.

7. Improving the environment: The aim of this strategy is to (i) to limit the pollutant load in the environment at sustainable levels even when developmental activities are likely to heighten, and to (ii) to understand the changing climate pattern and its impact on Sikkim

With increase in climate change, the quality of water, air, and the biological and land environment is also likely to change. Climate change being an additional driver over and above development. The actions that need to be included in this would be to monitor, the biological, water, air and land environment and create paradigms by way of which cleaner environment can trade its clean quota which is over and above the permissible limits and earn credits. The specific aspects, that could be covered here in the context of Sikkim, and that are not covered anywhere else here could be:

Forests- Monitoring the health of the forests (details given in the strategy)

Water- actions towards improvement in coverage and efficiency of sewage treatment systems, encourage use of low-cost decentralized measures for treatment of wastewater e.g use of microbes for sewage treatment in open drains.; not allowing Net loss (NNL) of wetlands areas and system of permits be introduced to provide replacement wetlands

Air- Air quality improvement, not only is the concerned industry and sector has to work towards it, but air quality monitoring is also an important aspect of improving the environment as it gives knowledge about the levels of mitigation efforts for the same. Therefore networks on monitoring the air quality needs to be augmented which may also include the measurement of levels of emissions of greenhouse gases at different point sources (industries)

Climate - Climate monitoring at high resolution within Sikkim is also an important aspect of understanding the likely impacts of climate change on various systems, which needs to be introduced with setting up of automatic weather stations, transferring data remotely to a centre which does on line processing and disseminates to all stakeholders, along with 7 day forecast and has the capacity to undertake climate modeling for future long term projections of climate and its impact on various systems and sectors.

8. Developing renewable energy technologies: The aim of his strategy is to prevent forests from getting degraded due to over extraction of fuel wood and biomass for fodder and fire as the climate warms.

As indicated earlier in the text in the current situation the demand of firewood far exceeds the supply, and an energy crunch like situation may occur due to reduction in forest biomass due to climate change. Solution this would be 100% penetration of renewable energy technologies in the rural areas and to communities living in the fringes of forests. It will not only reduce the demand for fuel wood, but will also save the forests from over exploitation. It is to be noted that the native trees namely sal and oak in lower altitudes and conifers and firs in higher altitudes take a long time to mature (about 20 years), therefore, continuous availability of ground water is necessary for these areas and hence ground water recharge in these areas is a must as indicated in the first strategy, especially in the dry areas where the forest fires occur frequently.

9. Protecting livelihoods dependent on forest products: Livelihoods of rural population living in the fringes of forests and depending on forest produce and other forest related activities may face decline in earnings as the forest degrade with climate change. Therefore livelihood protection is of utmost importance for these people. This can be achieved by enhanced forest-based biomass in the form of food, fuel wood, grass/ fodder, timber, bamboo, cane and NTFPs. The augmented ecosystem services like water flows, biodiversity and carbon pools would further provide opportunity for augmenting incomes. Rich biodiverse and cultural landscapes could provide the potential to build up community-based Ecotourism enterprises.

The strategies and actions there in are listed in (Table 20).

Table 20: Strategies and actions for the forestry sector						
Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
1. Spring recharge and enhancing ground water recharge at areas within the forests that are vulnerable to CC Aim: To water secure Sikkim • Integrating and climate proofing the works of the FEWMD, CAT, IWMP, and that undertaken in MGNREGA	1. Training of forest officials towards management of water sheds in the forests in the context of climate change 2. Identification and mapping of CC vulnerable spring sources, water sheds and mountain top lakes in drought prone areas of south and western Sikkim. 3. Preparing spring specific project plan reports for implementation incorporating site specific techniques needed for water recharge, and water shed management 4. Implementation of projects	1. FEWMD 2. RMDD	1. Identification and mapping of CC vulnerable spring source, water sheds and mountain top lakes in drought prone areas. Rs. 1.0 Cr 2. Preparing project report Rs. 20 lakh 3. Plot Demonstration project Rs 1.Cr 4. Outreach (dissemination and training) 200 state officials trained @ cost of Rs.10000/person Total Cost = Rs. 20 lakhs Material, workshop, documentation @ Rs.5000 per person for 200 persons =Rs. 10 Lakhs	Implementation in the identified vulnerable sprig sources, water sheds and mountain top lakes Cost: 70 Cr	Upscaling the Implementation to more areas spring sources, water sheds and mountain top lakes Cost: 70 Cr	145.2Cr
2. Enhancing quality of moderately dense forest, open forests and degraded forests Aim: (i) To improve the health of the forests; (ii) To improve ecosystem services and (iii) Enhance C sequestration potential of forests	i. Regulated grazing, invasive species eradication, management of insects and other pathogens ia Managing invasive alien species: - Launch study to collate information on problem species ib. Strengthen quarantine at state borders including that of soil, water, seeds, tubors, and bulbs etc ic. Strengthen mechanism of removal of invasive species through innovative outreach approaches id. Control through human use and as fertiliser, food for livestock, fish, and poultry ii Adoption of short rotation species , iii actions towards reduction in forest fragmentation by conserving contiguous forest patches, iv eco restoration of degraded open forests, and v. Restoration of grass land vi. Restoration of Scrublands that are highly degraded forest/non-forest areas with scrub vegetation recording less than 10 percent forest density.		Research and mapping a) Invasive species b) Short rotation species c) Identification of degraded forest patched in Pas, RFs and urban area d) Germ plasm research @Rs.0.20 Cr / study = Rs. 0.80 Cr. Capacity building of the dept (100) personnel and community (200) Rs. 0.45 Cr Initiation of Mechanical removal invasive species Rs. 15 Cr.	Regular monitoring for new invasive species Rs. 0.20 Cr Capacity building of additional dept (200) personnel and community (400) Rs. 0.90 Cr Upscaling in Phase wise of Mechanical removal of invasive species Rs. 35. Cr. Promote human use of invasive species as fertiliser, food for livestock, fish, and poultry Rs. 50. Cr	Regular monitoring for new invasive species Rs. 0.20 Cr Upscaling in Phase wise of Mechanical removal invasive species Rs. 35. Cr Eco-region wise Nursery development to raise local and indigenous species (3 nursery / eco-region to support entire State. Rs. 10 Cr.	Rs. 239.55 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
	vii. Promote native species -including sea buck thorn to improve soil moisture. viii. Disease management practices to be put in place ix. Programme on Germ plasm conservation to be initiated to conserve native species x. Scope of planting trees in notified forest patches which are threatened by expanding urban/industrial development xi. Open spaces/green spaces like parks/wood lots set up on municipal land xii Diffused planting such as on avenues and in households and Institutional lands, especially lands belonging to or allotted to business/industrial houses and educational institutions with trees that also support wealth of flora and fauna xiii Strengthening of Sustainable forest management cell (SFM) for continued monitoring of invasive species	FEWMD	xiii Strengthening of Sustainable forest management cell (SFM) for continued monitoring of invasive species Rs. 1 Cr.	Eco-region wise Nursery development to raise local and indigenous species (3 nursery / eco-region to support entire State. Rs. 15 Cr. Restoration of highly degraded forest, non forest and urban forest area Rs. 16. Cr Strengthen the green mission initiatives in the state Rs. 10. Cr	Restoration of identified degraded forest, non forest and urban forest area Rs. 30. Cr Strengthen the green mission initiatives in the state Rs. 20. Cr	
3. Linking Protected Areas Aim: To secure corridors for species migration to adapt to climate change	i. connecting fragmented forests with 'corridors' to assist species migration. ii. Institute plans to mange and maintain the corridors by local stakeholders. iii. Plans for rapid agency responses towards crop-raiding, man-animal conflict, crop-insurance and hassle-free compensation for displacement if any. iv. Special studies to understand the feasibility of establishing such corridors and their effectiveness vis a vis natural dispersion and assisted migration in the context of climate change.	FEWMD	Identify, map, demarcate and study species migration pattern along the potential wildlife corridors Rs.3.0 Cr.	Continue studies on species migration and conflict along the identified wildlife corridors Rs.3.0 Cr. Sensitization of stakeholders regarding on identified wildlife corridors Rs. 0.5 Cr	Monitoring of species migration and conflict along the identified wildlife corridors Rs.10.0 Cr. Continued sensitization of stakeholders regarding on identified wildlife corridors Rs.1. Cr	17.5 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
4. Effective Disaster Risk Reduction and Management Aim: To manage the increase in frequency and intensity i. Forest fire prevention and management ii. Landslides, Land erosion, GLOFs, and Hydropower	i. Forest fire prevention and management i.i Early detection and management extended to higher altitudes, including community participation in management of fires i.ii Planting species in forests, immediately after the area is burnt with trees generated in the nurseries. Therefore nurseries have to be set up of Sal, Oak, and Conifer with adequate saplings available for future requirements i.iii undertake research to identify forest tree species that would adapt itself at different altitudes.	State Disaster management Authority FEWMD RMDD National Disaster Management Authority District Level Disaster management Cells Silviculture &Working Divisions	Mapping of fire prone areas and annual mapping of Forest fire Districts- Rs.5.0 Cr Early detection and community involvement Rs.10.0 Cr Dissemination and training on managing fire for officials and communities- 200 state officials trained and 200 community workers trained Rs. 2.00 Cr To identify the tree species which are fire resistant and adapting to different altitude (Research) Rs. 5.00 Cr Development of special Nurseries to raise the species in all the districts RS. 10.00 Cr	Annual Mapping of Forest fires Rs.2.00 Cr Early detection and community involvement Rs.10.0 Cr Development of special Nurseries to raise the species in all the districts RS. 10.00 Cr	Annual Mapping of Forest fires Rs.2.00 Cr Early detection and community involvement Rs.10.0 Cr Development of special Nurseries to raise the species in all the districts RS. 10.00 Cr	Rs.80.00 Cr
	2. land slides, Land erosion, GLOfs, and Hydropower ii. Installation of early warning systems and installation of hardware; real time monitoring (unmanned) with automatic data transmission ii.Hazard mapping of key watershed Areas. iii. Implementation of Hazard Zonation Plan. iv. State database on landslide prone areas and intensity of landslides to assess the risk of landslides. iv. Reforestation of catchment areas and slope stabilization of landslide and Flash flood prone areas. vi. Plans for River bank protection. vii. Re-location/ resettlement of affected villages and people. viii. Awareness generation on disaster preparedness - GLOFS, Land Slides, Forest Fires	DFEWM LR&DM, FEWMD, UD&HD PWD PHED LR&DM, FEWMD, UD&HD PWD PHED DFEWM LR&DM DFEWM RMDD LR&DM District Admn DFEWM Department of Science & Tech. DFEWM LR&DM	Installation of early warning systems and training of local personal to operate and manage Rs. 5.00 Cr Identification and Mapping of all the existing and landslide prone areas, GLOFs and Hydroelectric power generating stations Rs. 20.00 Cr Initiation of reforestation, stabilization of soil Rs. 10.00 Cr in all districts over 5 yr period To prepare river bank protection plan and implement the same - phase I Rs. 1.00 Cr+ Rs.100.00 Cr Awareness generation and disaster preparedness training for GLOFs, landside and forest fire Rs.2.00 Cr	Maintenance of early warning system, data analysis and transmission Rs.10.00 Cr Upscale the reforestation/ afforestation for stabilisation of soils Rs. 10 Cr Continue with implementation of river bank protection Rs. 100.00Cr Continue Awareness generation and disaster preparedness training for GLOFs, landside and forest fire Rs.3.00 Cr	Maintenance of early warning system, data analysis and transmission Rs.15 Cr Reforestation/ afforestation in remaining areas Rs. 5.00 Cr Awareness generation and disaster preparedness training for GLOFs, landside and forest fire Rs.4.00 Cr	Rs.280.00 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
5. Preventing man animal Conflict Aim: To promote sustainable forests for the wild life to thrive within the limits of forests	i. Mobilizing Community initiatives ii. Identification of conflict areas iii. Capacity building, strengthening communication etc, sensitization of policy makers etc. iv. Population estimation of key species, v. Study on agriculture practices, vi. Phenological studies of wild edibles to enhance productivity of Wild indigenous Food /Fruit / Fodder /Fibre species inside Forest. vii. Promotion of Thorny Live-Hedge Fencing with indigenous species to minimize pollution, erosion; enrich soil fertility; attract pollinators; provide food, fodder, fuel, fibre; ix. Introduce the policy of controlled culling to control the outnumbers population of identified wildlife	FEWMD ARMED FORCES	Study of man and animal conflict, phenology, productivity of Wild Food /Fruit / Fodder / Fibre species by conflict causing animals . Study on population, distribution Rs. 3.00 Cr Establish emergency relief fund for affected families Rs. 10. Cr	Monitoring of man and animal conflict using local institutions (JFMC, EDCs, Himal Rakshak) Rs. 5. Cr Establish emergency relief fund for affected families Rs. 10. Cr Promotion of Thorny Live-Hedge Fencing\ with indigenous species and other relevant measures to control man and animal conflict Rs. 20. Cr	Monitoring of man and animal conflict using local institutions (JFMC, EDCs, Himal Rakshak) Rs. 10. Cr Establish emergency relief fund for affected families Rs. 12. Cr Promotion of Thorny Live-Hedge Fencing\with indigenous species and other relevant measures to control man and animal conflict Rs. 20. Cr	Rs. 90. Cr
6. Conservation of high Altitude Wetlands Aim: To secure the services provided by the Wetland Ecosystem	i. Identification of critical wetlands for undertaking long term scientific studies flora and fauna, hydrology, limnology etc. ii. Identification and inclusion of more wetlands and marshes for effective management iii. Strengthen capacities of the stakeholders to manage the wetlands. iv. Accelerate the efforts to include more wetland sites under Ramsar convention.		i. Study on hydrological and ecological value of and their role in adapting to climate change. ii. Effects of climate change on hydrologic functions iii. altitude wetlands- review and modeling iv. Valuation study of high altitude wetlands Rs. 50.00Cr	Building capacities of stakeholders including forest officials on effective wetland management Rs. 5.00 Cr Promote community based conservation and upscale initiatives like Pokhari Sanrakshan Samiti (PSS) Rs. 10.00 Cr	Upscale and improve the management strategies for wetland and other water bodies Rs. 20.00 Cr	Rs. 85.00 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
7. Improving the environment Aim: (i) to limit the pollutant load in the environment at sustainable levels (ii) to understand the changing climate pattern and its impact on Sikkim	i. Forests i.i Monitoring the health of the forests and its biodiversity - tree crown, tree growth, canopy structure etc. - ground vegetation, soil, forest floor - woody debris	FEWMD, SPCB, Universities DST	To monitor the health of forests and biodiversity In all forests areas of the state. Rs. 8 Cr	To monitor the health of forests and biodiversity In all forests areas of the state. Rs.12	To monitor the health of forests and biodiversity In all forests areas of the state. Rs. 16 Cr	Rs.36.00 Cr
7. Improving the environment Aim: (i) to limit the pollutant load in the environment at sustainable levels (ii) to understand the changing climate pattern and its impact on Sikkim	i. Forests i.i Monitoring the health of the forests and its biodiversity - tree crown, tree growth, canopy structure etc. - ground vegetation, soil, forest floor - woody debris	FEWMD, SPCB, Universities DST	To monitor the health of forests and biodiversity In all forests areas of the state. Rs. 8 Cr	To monitor the health of forests and biodiversity In all forests areas of the state. Rs.12	To monitor the health of forests and biodiversity In all forests areas of the state. Rs. 16 Cr	Rs.36.00 Cr
	ii. Water ii.i actions towards improvement in coverage and efficiency of sewage treatment systems ii.ii encourage use of low-cost decentralized measures for treatment of wastewater e.g use of microbes for sewage treatment in open drains.; ii.iii not allowing Net loss (NNL) of wetlands acres and system of permits be introduced to provide replacement wetlands.	State Pollution Control Board, DEFWM, Universities, Other research institutions	To establish a state of the Art high tech laboratory for analysis of Physico-Chemical properties of Sewage Rs. 10 Cr Augmenting Domestic Sewage treatment plant Rs.10.00 Cr	To maintain and manage the Lab with equipments, trained staff Rs. 10 Cr Maintainance and management of the plant Rs. 10 Cr	To maintain and manage the Lab with equipments, trained staff Rs. 20 Cr Maintainance and management of the plant Rs. 10 Cr	Rs. 70.00 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
	iii. Air iii.i Air quality monitoring is an important aspect of improving the environment as it gives knowledge about the levels of mitigation efforts for the same. Therefore networks on monitoring the air quality needs to be augmented which may also include the measurement of levels of emissions of greenhouse gases at different point sources (industries) iii.ii Build capacity to develop predictive modelling of pollutants and greenhouse gases and their dispersion	FEWMD, SPCB	1. Installation of equipment for monitoring of CO2, CH4 , N2O at industrial units Rs. 10.00 Cr 2. Augment the existing air quality monitoring network Rs. 10.00 Cr Buld display boards and broadcast on television Rs. 2.00 Cr Build capacity for modelling Rs. 2.50 Cr		-	Rs. 40.00 Cr
	iv. Climate iv.i Climate monitoring by setting up of automatic weather stations at very high spatial resolution, transferring data remotely to a centre which does iv.ii Build capacity for processing & dissemination to all stakeholders the -7 day forecast, - climate change modelling, and -impact assessment modelling on various systems and sectors	DFEWM SPCB Science &Tech Dept Climate change cell	i. Establishment of at least 10 Automatic weather stations, Rs. 2.00 Cr ii. Building Capacity including modelling Rs. 3.00 Cr	ii. Sustaining capacity Rs. 5.00 Cr	Ii Sustaining capacity Rs. 5.00 Cr	Rs. 15.00 Cr
8. Developing renewable energy technologies Aim: i. To prevent forests from getting degraded due to over extraction of fuel wood and biomass for fodder and fire as the climate warms	Rapid assessment and Identification of high fuel wood villages in all eco regions to identify opportunities of renewable energy technology interventions and Assessment of existing programmes of the departments -LPG distribution Assessment of extraction of wood for commercial purposes	SREDA, FEWMD, RMDD & Power Department	Rapid assessment and Identification of high fuel wood villages in all eco region (1st two years) Rs. 2 Cr. Facilitate Improved LPG distribution facilities in rural area Rs. 0.10 Cr Setup monitoring of commercial extraction of firewood. Rs. 0.5. Cr			Rs.12.5 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
ii i. 100% penetration of renewable energy technologies in the rural areas and to communities living in the fringes of forests	Initiation of state renewable energy mission i. Lower belts since the usage of fuel wood is limited to cooking purposes, fuel wood efficient stoves to be encouraged, LPG / kerosene, ii. Temperate oak and conifer forests- Fuel wood efficient cooking stoves, efficiency enhancement of present means of cooking and domestic space heating; Better access to alternate cooking and water and space heating iii. High Altitude -Introduction of Hybrid system of Bio gas at pilot scale (using yak dung and kitchen waste) -Pilot on harnessing energy from Solar parabola iv. Strict regulation on commercial extraction of firewood vi. Promote use of electric crematoriums to reduce use of firewood for cremations. vii.Ensure electric supply in rural areas for electric cooking / water heating devices may be popularized on a large scale in anticipation of surplus energy to be produced by the state through hydropower	SREDA, FEWMD, RMDD & Power Department	Initiation of state renewable energy mission through demonstration of various renewable technologies in rural areas in a phased manner (3rd, 4th and 5th year) Rs. 30.00 Cr Training to communities / SHGs on Biomass briquette from agricultural residue , Creation of fast growing fodder wood species lots in vacant private or government owned lands Rs. 5.00 Cr Pilot for hybrid system bio-gas Rs. 1.00 Cr Pilots on solar Parabola Rs.1.00 Cr Develop, demonstrate a high energy efficient stoves to meet growing energy requirement Rs. 2.00 Cr Policy to ensure adequate electricity supply to remote area to encourage use of more efficient electric appliances Rs. 0.50 Cr	Up-scaling of renewable technology mission in larger scale to uncovered rural site Rs. 60.00 Cr Continue Training communities in renewable energy technologies Rs.5.00 Cr Promote electric crematoriums to reduce use of firewood . Rs. 2.00 Cr Commercialize use of high energy efficient stoves in the local market Rs. 4.00 Cr Continue monitoring of commercial extraction of firewood. Rs. 0.50 Cr	Up-scaling of renewable technology mission in larger scale to uncovered rural site Rs. 90.00 Cr Promote electric crematoriums and popularized to reduce use of firewood for cremations. Rs. 6.00 Cr Continue monitoring of commercial extraction of firewood. Rs. 1.50 Cr	Rs210.00 Cr
9. Protecting and enhancing Livelihoods dependent on forests Aim: Enhance forest-based biomass production in the form of food, fuelwood, grass/ fodder, timber,	i. Assessment of current livelihood opportunities ii. identification of new opportunities iii Mainstreaming climate concerns in the functioning of of PSS, Himal Rakshaks, JFMCs/EDCs and NGOs	FEWMD	Assessment of current livelihoods and opportunities for enhancing them Rs. 5.00 Cr Capacity building of PSS. Himal Rakshaks, JFMCs/EDCs and NGOs Rs. 5.00 Cr	Exploring new forest based opportunities Rs. 5.00 Cr Capacity Building continued Rs. 5.00 Cr	Exploring new forest based livelihood opportunities Rs. 5.00 Cr Capacity building continued Rs. 5.00 Cr	Rs. 30.00 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
bamboo, cane and other NTFPs. The improved eco-system services like water flows, biodiversity and carbon pools would further provide opportunity for augmenting incomes						
	Improve conservation management strategies through community participation i. Safeguard pollinators - Study on Identification of Nectar and Larval Host Plants. - Study on identification & Conservation of Roosts ii. Promote Conservation & Sustainable use of hardy ornamentals and edibles such as FERNS & MOSSES, LIVERWORTS iii. Conservation & Sustainable use of economically important MUSHROOMS iv. Promote planting of Industrially important Orchid - vanilla orchid v. Conservation & Sustainable use of Indigenous FISH & FOWL varieties vi. Specifically for High Altitude: Promoting Yak & Highland Sheep Conservation as a community based management activity		i. Safe guard pollinators (Research and dissemination) Rs. 2.00 Cr ii. Conservation and sustainable use of hardy ornamentals and edibles- Research and dissemination (Research and dissemination) Rs. 2.00 Cr iii. Mushrooms (research and dissemination) Rs. 2.00 Cr iv. Orchids (research and dissemination) Rs.2.00 Cr v. Fish and fowl (Research and dissemination) Rs. 2.00 Cr vi. Yak and sheep conservation (Research and dissemination) Rs. 2.00 Cr	Continue research and knowledge dissemination in these areas (Rs. 12.00 Cr)	Dissemination continued (Rs. 12.00 Cr.	Rs. 36 Cr

Strategies	Actions	Agencies responsible	Short (1st plan)	Medium (2nd plan period)	Long	Total
	Promote green Solid waste management strategies - Establish policy on extended producers responsibility for private firms, industries to encourage buy back policy of non-biodegradable waste	DEFWM	Assess the current waste management in the tourist destination, urban, rural areas and develop site specific Solid, Liquid waste management plan Rs. 10.00 Cr	Promote sustainable cultivation of NTFPs and other forest produces with high dependencies Rs. 50.00 Cr Develop waste resource recovery centre with multi-chamber segregation facilities Rs. 50.00Cr	Upscale sustainable cultivation of NTFPs and other forest produces with high dependencies Rs. 100. 00Cr Develop additional waste resource recovery centre with multi-chamber segregation facilities Rs. 50.00 Cr	Rs.260.00 Cr
	Promote Agroforestry -Agro forestry in large Cardamom - Promote growing of Medicinal plants in the fringes of forests - Planting Agro-forestry species on fringes for Soil-binding and for increasing Soil Fertility - Promote other Cash Crops in Forest Fringe Area (Research)		Agro forestry in large Cardamom farming in Sikkim in managed forests - cover 50% of area Rs. 10.00 Cr Promote growing of Medicinal plants in the fringes of forests (large scale New species, conserving and protecting existing species) Rs. 20.00 Cr Planting Agro-forestry species on fringes for Soil-binding and for increasing Soil Fertility Rs.10.00 Cr Promote other Cash Crops in Forest Fringe Area (Research) Rs.2.50 Cr	Agro forestry in large Cardamom farming in Sikkim in managed forests - cover 50% of area Rs. 10.00 Cr Promote growing of Medicinal plants in the fringes of forests (large scale New species, conserving and protecting existing species) Rs. 20.00 Cr Planting Agro-forestry species on fringes for Soil-binding and for increasing Soil Fertility Rs.10.00 Cr Promote other Cash Crops in Forest Fringe Area (Research) Rs.2.50 Cr	Promote growing of Medicinal plants in the fringes of forests (large scale New species, conserving and protecting existing species) Rs. 20.00 Cr Planting Agro-forestry species on fringes for Soil-binding and for increasing Soil Fertility Rs.10.00 Cr Promote other Cash Crops in Forest Fringe Area (Research) Rs.2.50 Cr	Rs.117.50 Cr

Urban and Rural Habitats

View of urban Gangtok

9.1 DEMOGRAPHIC PROFILE AND OVERVIEW OF THE URBAN DEVELOPMENT SECTOR

The state comprises of a total of 4 districts (North, South, East and West) and 9 towns with a total population of 5,40,000 as per the 2001 Census. Despite a considerable increase in development activities which resulted in rapid urbanization and therefore increase in urban population, only 0.05% of the total state's area is under urban use, with just over 11% of the total state's population inhabiting the 9 urban centres of

Figure 9.1 a: Town wise share of urban population

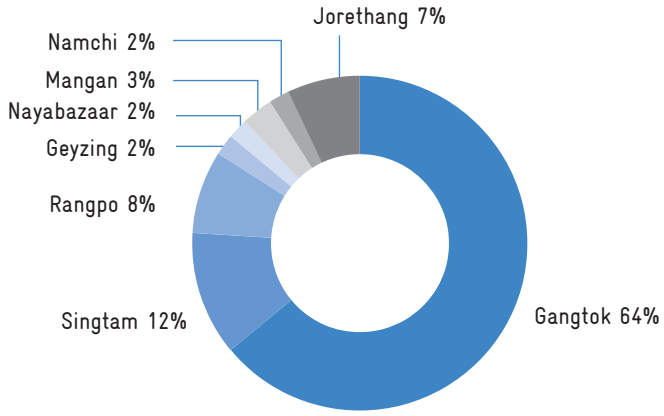
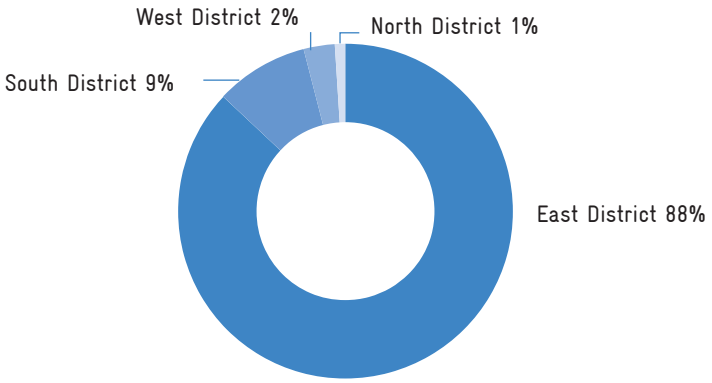


Figure 9.1 b: District wise share of urban population



Gangtok, Rangpo, Singtam, Geyzing, Mangan, Namchi, Jorethang, Nayabazaar (Figure 9.1a). As the graph alongside shows, Gangtok has the highest urban population comprising of 64% of the total Urban Population, with Rangpo, a far second with just 12% of the population inhabiting the town. All other urban centres have a urban habitat comprising of 7% or even less of the total urban population of Sikkim.

The gross density of population in the state averages to 76 persons per sq. km. However, the density of population varies drastically with the East District which comprises of Gangtok having the highest denisty of population of 295 persons/ km2 (as per census 2011), while the 10 persons/ km 2 (as per census 2011) (Figure 9.1b).

In terms of trends of growth in urban population, the rate of growth in the initial years of 1951 and 1961 were roughly in the region of 1.90 and 4.20% respectively, but saw a huge growth in 1981 with a decadal growth of 16.15% and 2001, saw a decadal growth of 11.07%.

9.2 TRENDS OF GROWTH OF URBAN POPULATION IN SIKKIM

From a total population of 1,37,725 in 1951, the population of Sikkim has growth to 5,40,851 as per the 2001 Census. The rate of growth in the initial years of 1951 and 1961 were roughly in the region of 1.90 and 4.20% respectively, but saw a huge growth in 1981 with a decadal growth of 16.15% and 2001, saw a decadal growth of 11.07% (Figure 9.2).

As per the 1951 Census, the urban population of Sikkim was just 2,744, while the 2001 census records the urban population to be 59,870.

As per estimates of the Urban Development and Housing Department, the population of Greater Gangtok today is close to 1,20,000.

Figure 9.2: Urban population

Year	Population						Urban Population to Total Population (%)	
	State	Urban Area	East	North	South	West	India	Sikkim
1951	1,37,725	2744	2,744	-	-	-	-	190
1961	1,62,159	6848	6,848	-	-	-	-	420
1971	2,09,903	19,668	17,019	331	1222	1096	19.91	9.37
1981	3,16,309	51,054	43,242	780	5365	1697	23.34	16.15
1991	4,06,457	37,006	31,872	803	2583	1762	25.73	9.10
2001	5,40,851	59,870	52,552	1245	3945	1824	27.30	11.07

Source: Sikkim census

9.3 BROAD OVERVIEW OF URBAN HOUSING AND TRENDS IN URBANISATION, PARTICULARLY FOR GANGTOK

Given the terrain of Sikkim and with the view that connectivity and accessibility is the bottom line for growth to take place, urban development in Sikkim has been taking place along the main roads and the growth pattern is linear in nature. Therefore, the urban centres in Sikkim have come up and developed based on the premise of connectivity and accessibility and keeping in trend with the increase in urban population, the towns have also spread to wider areas.

Since the guiding factor for the development is accessibility and availability of suitable land profile, the land use pattern in urban centres of Sikkim is mixed with no specific activity been earmarked for specific locations.

The existing land use pattern of Gangtok is as follows: -

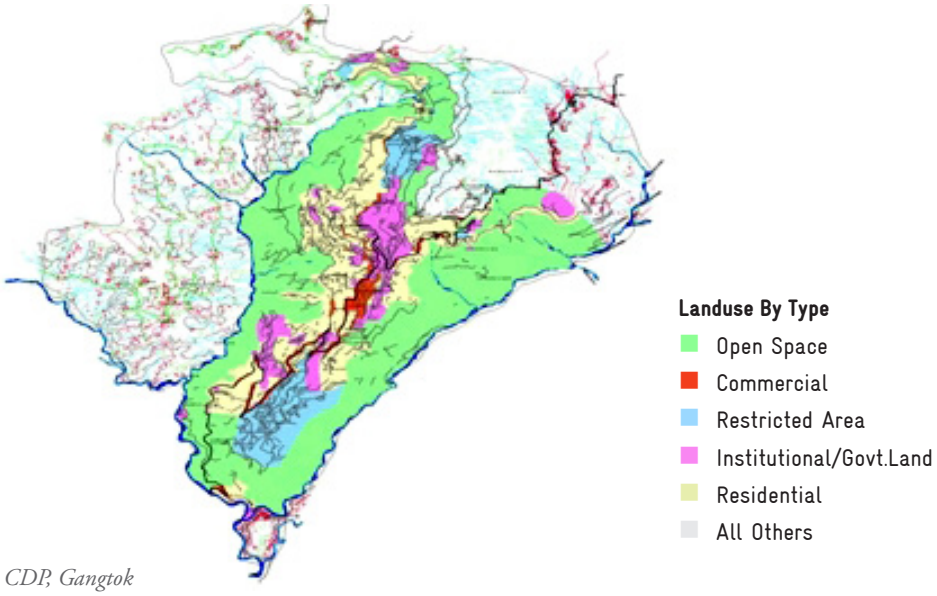
Residential	-	43%
Commercial	-	4%
Public and Semipublic	-	15%
Roads	-	19%

Figure 9.3 b. Greater Gangtok Planning Area

Source: CDP, Gangtok

In the past few years, Gangtok has experience unprecedented spatial expansion, with the total area of Gangtok city being 25 kms2, though the Greater Gangtok area roughly comprises of 77 kms 2, with a total estimated population of around 120,000 and with an estimated 35,000 residential units. The notified area of Gangtok at present houses 55.5% of the Urban Population of Sikkim as per the 2001 Census.

Figure 9.3 a: Urban housing trends



Source: CDP, Gangtok

9.4 ADMINISTRATIVE AND GOVERNANCE STRUCTURE FOR THE URBAN DEVELOPMENT SECTOR

The urban development in Sikkim has been largely in the domain of the Urban Development and Housing Department (UDHD), headed by the Secretary, Urban Development and Housing Department. The Urban Development and Housing Department has a number of key sections for administrative efficiencies, which include, the Engineering Section: entrusted with planning and construction of developmental works, implementation of projects and also regulation of construction of buildings in notified towns, the sanitation section, which is responsible for keeping the town areas clean, which includes the maintenance and upkeep of the "Jhoras" in the town areas and the Liscence section which is entrusted with the responsibility of issuing trade licences for carrying out the business as per the legal provisions of the Trade Licence Act 1985. However, for hotel liscencing, the UDHD works in coordination with the health and tourism department in awarding liscenses to hotels and homestays.

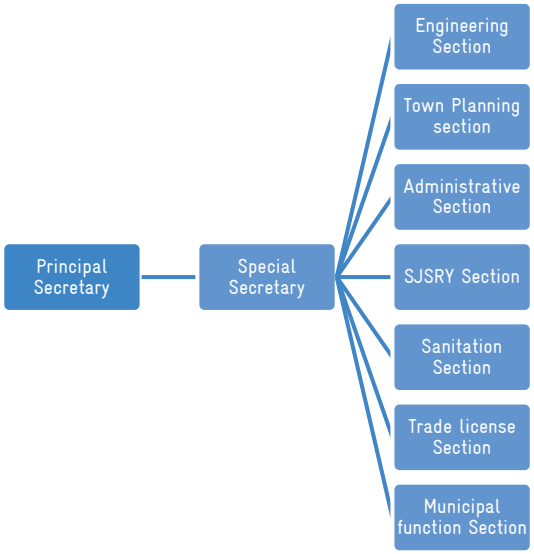
In addition to the Urban Development Department, the Public Health and Engineering Department, which is entrusted with the responsibility of Urban Water Supply and Sanitation. The Power department takes care of the installation and maintenance of Urban Public Lighting, which include street lighting, public building lighting etc. The Buildings Department takes care of all Government buildings, which include buildings in Urban Centres.

The tranport department is entrusted with the responsibility of providing public transport services through the Sikkim Nationalised Transport. The policy wing of the Transport Department looks at the the creation of policy framework to guide the overall urban transportation and the regional transport authority is entursted with framing of rules and regulations for vehciles and vehicle registration in Sikkim.

The transport department works in close coordination with the Urban Development Department in planning and regulating transport within Sikkim, which also looks at key issues related to urban development such as road congestion and traffic management.

The newly constituted Gangtok Municipal Corporation headed by the Mayor as political appointee is proposing to take over some administrative responsibilities for Gangtok City from the UDHD, particularly related to liscencing regualtions, santiation and city upkeep. It is also proposes to work in coordination with the Power Department to determine street lighting within Gangton city.

Figure 9.4: Administrative and governance structure



9.5 CURRENT POLICIES AND PROGRAMME GOVERNING THE URBAN DEVELOPMENT SECTOR

The Urban Development Department drew up two key plans, one being the Comprehensive Mobility Plan for traffic management in Urban Centres in coordination with the Transport department and the City Development Plan for Gangtok and the other district head quarters. These plans are anchored on the goals of the Jawaharlal Nehru National Urban Mission goals of creating economically productive efficient and equitable and responsive cities.

Prior to the development of these two policy documents, there were very few policies per se on urban development for Sikkim. Some of the key policies which govern the urban development in Sikkim, relevant to this document are

- Sikkim Building Construction Regulation, 2001
- Sikkim Vehicles Parking Rules, 2000 and 2001
- Garbage Control Act, 1997
- Sikkim Non-biodegradable Garbage Control Rules, 1997
- Sanitation rules, 2001

The City Development Plan is fairly comprehensive document and focuses on the strategies that deal specifically with those issues that affect the urban poor, adopting practices and structural changes that provide for improved financial management and elimination of legal bottlenecks that discourages private investments in the cities infrastructure and provision of services.

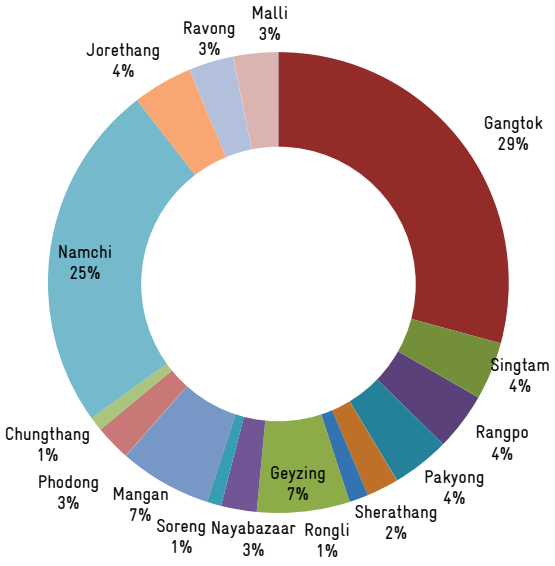
9.6 PROJECTED TREND IN URBANISATION IN SIKKIM

The State Strategic Urban Plan looks at developing a total of 16 urban centres by 2040, which includes the current 9 centres. The long term urban growth of Sikkim is proposed to be buided by the structure of "Moderated Multiple Nuclei Structure".

The proposed plan positions Gangtok and Namchi as parallel First Tier Urban Centres, with the two district headquarts of Geyzing and Mangan as second tier urban centres to facilitate West and North District population.

The projected growth of Urban Population by 2040 is expected to more than double, from the current unofficial number of close to 200,000 to roughly 550,000. (Needs to be noted that as per the 2001 census, the urban population of Sikkim was only 60,000, but as per the estimates of the

Figure 9.6: Population projections and trends



Source: CDP, Gangtok

Urban Development and Housing Department, the population of Gangtok currently is 1,50,000 as against the 2001 Census Data of 30,000.)

The following graph (Figure 9.6) give an estimate of the projected population in the 16 Urban Centres of Sikkim by 2040 and the share of population in each of the identified Urban Centres, while the graph illustrates the distribution of population amongst the urban Centre.

9.7 KEY PRIORITIES FOR THE URBAN SECTOR

- Decongesting Gangtok for new development in the immediate period and gradually extending to other urban centres as the need arises
- Encouraging peri-urban areas as counter magnets and interconnecting Gangtok with the new counter magnets.
- Encouraging peoples' participation in developmental activities
- Modifying legal and regulatory system for the parastatal bodies
- Incorporate a disaster management mechanism with a comprehensive network of fire fighting system in place
- Developing climate friendly designs for urban water supply and sewerage
- Energy efficiency street lighting in the whole of Sikkim
- Design and building aesthetic as well as user friendly Pedestrian and non-motorised pathways where ever possible
- Detailed strategy and implementation plans for waste collection, segregation and conversion to organic fertilizer in the short run and explore possibility of waste to energy in the long run (waste to energy currently is not a feasible solution for Gangtok, given the quantity of waste)
- Piloting energy efficient buildings in all Government buildings in Gangtok in the short run and extending it to all Government buildings in urban centres in the medium run and all over Sikkim in the medium to long run
- In the promotion of ecotourism, introduce enhanced licensing norms for hotels and homestays to incorporate high level of energy efficiency, water harvesting and water re-cylcing norms

9.8 KEY STRATEGIES FOR THE SECTOR

Table 21: Key strategies for the Urban Sector		
Sector	**Issues**	**Strategies**
Water Supply Sewerage and Sanitation	- Streamlining and strengthening asset registers with a detailed but evolving asset management plan - Putting in place a long term financial plan with institutional dynamics and implementation plans - Streamlining systems to regulate and monitor sustainable water use through a set of compliance oriented policies and framework	- Increase in water supply will affect the sewer hydraulics - Proper estimation of floating population as tourist - Planning for segregated systems for areas of floating population as far as possible - Stopping of discharge into Jhoras - Proper plan for periodic replacement and repairs of old pipes and system - Strict implementation of Rules and Regulation - Penalties for the defaulter - Capacity building of implementing authority - Zoning of towns to put in place and ensure rationalization of water distribution. (The focus to be shifted from Supply Driven to Demand Management)
Drainage	- Mapping of drains in Gangtok - Inflow and MFL assessment - Mapping of watershed areas - Documentation of landslides - Awareness campaign to educate the community	- Improving understanding of the situation through detailed investigation - Awareness campaign to educate community for confirming the development control rules - Establishing the institutional, financial and operational foundation
Solid Waste Management	- Improvement of collection efficiencies - Improvement in existing system for transportation of waste - Treatment and disposal of waste in accordance with SWHR - Augmentation of garbage collection fleet with modern vehicles and increased numbers	- Source segregation of biodegradable from non- biodegradable - Manual handling to be reduced - Separate collection and treatment facility to be arranged for biomedical and hazardous waste - Storage of waste in mechanized containers - Providing personal protective equipments to sanitary workers - Capacity building and educating workers - Awareness of community to be upgraded with the help of NGO's
Roads and Transportation	- Encroachments by vehicles - Low operating speeds. - Congestion in the city. - Inadequate parking space. - Improper traffic management - Poor public transportation system - Lack of pedestrian facilities	- New links and improvement in old ones - Mass transport system for commuters in the form of mono rail - Pollution free vehicles - Pay and use rental, two and four wheelers for tourists - Difficult junctions improvements - Development of bus terminals
	- Inadequate road capacity	- Development of truck terminals. - Development of parking areas for public vehicles - Development of parking areas in existing residential area for private vehicles - Street fixtures for pedestrian - Provision of goods signage and landmarks highlighting systems

Urban Renewal and Urban Environment	- Congestion & poor infrastructure - Contamination of water along down streams - Conservation of Forest and Improve the Scenic Beauty - Absence of parks and open recreation spaces - Absence of adequate Tourist Infrastructure - Street Lights to LED Lights - Convert Jhoras into picnic and beauty spots with energy generation through Pico/Micro hydels	- Redevelopment of degraded area. - Protective measures in landslide prone areas. - Water body conservation. - Development of embankments. - Afforestation in Khasmal and Gorucharan. - Afforestation for protecting the soil cover. - Development of botanical garden. - Development and exhibition of flowering plants, gardens, picnic spots. - Development of adventure sports and infrastructure development for it
Slum Upgradation and Public Facilities	- Non-access to water supply, major water source being springs; - Most of the population are daily wage labourers; - Non-functional toilets; - Waste disposal to jhoras; and - No organized employment for the slum dwellers	- Upgrading the house building condition upto the standards - Upgrading the economic condition of urban poor - Upgrading the social awareness towards good and hygienic living conditions - Meeting the gaps in infrastructure available - Providing better social infrastructure
Urban Governance and Institutional Strengthening	- Sharing of Responsibilities with the Gangtok Municipal Corporation and other Municipal Councils of Sikkim - Strengthen mechanism for collection of taxes and maintaining the accounts - New norms for building codes - Government buildings to mandatorily follow green building norms in line with the Energy Conservation and Building Code of the Bureau of Energy Efficiency, Government of India	- Introduction/ Amendments in legal framework (building regulations, environmental sustainability regulations etc.) - Sharing responsibilities in new framework. - Capacity building of authorities (GMC, UD&HD, autonomous WS & Sewerage & Drainage Agency, Transport Authority etc.) - Involvement of NGO, community groups and social organizations for inducing awareness in people. - Transparent functioning of parastatal body or local body. - Effective accounting of local funds (introduce double entry accounting system). - Introduction of performance based Human Resources Management System. - Methods of constant monitoring and modifying the schemes. - Introduction of E-Governances - Mandatory Solar water heating in all hotels and home-stays having more than 10 rooms

9.9 ACTIONS, BUDGETS AND TIMELINES OF ACTION

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S. No	Strategies	Responsible agency	Actions to be taken in the Short Term (2011-2015)	Budgetary Require-ment	Actions to be taken in the Medium Term (2015-2025)	Budgetary Require-ment	Actions to be taken in the Long Term (2025-2040)	Budgetary Require-ment
1	Awareness Generation Programme	Urban Development and Housing Department	Creation of IEC materials for publicity Involvement of Private Sector to have components of their Corporate Social Responsibility (CSR) for environment protection	Rs. 3 Cr.	Organising Public debates and programmes on Solar Passive Architecture Organising public debates on mandatory compliance of green building norms	Rs. 5 Cr.	-	N/A
2	Urban Renewal, Urban Governance	Urban Development Department Gangtok Municipal Corporaton Transport Department	Upgrading and improvement of the existing road network that requires urgent intervention. Restricting super markets and malls including vegetable markets to come up in and around the Core Business District (CBD). Such commercial hubs will have to be moved away from the city centre so that there is a natural tendency for the associated economic activities to move away from town. Maintaining status quo of open areas in Gangtok as they are, and or converting them into parks and gardens, wherever possible. Banning of site allotments by the UDHD on Government land Creating localized parking areas. Relocating the bus terminal from SNT and the private bus stop to the lower reaches of Gangtok, in Sokaythang.	Rs. 150 Cr.	To create a ring road around the city through the lower reaches of Sichay, Samdur, Siyari, Tathangchen, Chanmari, Tashi view point. To create alternative roads from areas along the Eastern and Western parts of Gangtok. This is essential to off load the pressure on the National Highway Other link roads also need to be created so that there are options for a commuter to reach one point. These roads will also make inaccessible areas accessible. Mention has been made in Urban Transportation.	Rs. 300 Cr.	To off load the pressure on Gangtok, it is intended to develop growth centres/ magnets in the peri-urban areas of Gangtok that shall constitute the proposed Gangtok Metropolitan Region	Rs. 450 Cr.

3	Urban Renewal and Urban Environment and		Converting the following street lights to LED lighting Improving lighting efficiencies in 6 key iconic Government buildings with partial funding from the Bureau of Energy Efficiency (Covered in Detailed in the Energy paper) Introducing Solar Passive architecture norms in building bye-laws Introducing hotel and home-stay licensing regulations with a phase in period to comply with energy efficiency measures, rain water harvesting measures and water usage and recycling measures in all big hotels with more than x number of rooms. Introducing norms for government buildings to ensure incorporating of green building norms for all new government buildings. On the lower reaches of Gangtok, the riverfront needs development into parks and recreational areas. Avenue plantation in conformity and continuation to the State Green Mission. Positioning of appropriate street furniture and walkways. Train Jhoras and convert a couple of key Jhoras in and around Gangtok into a picnic spot with a pico hydro generation to cater to the electricity needs of the Jhora Park.	Rs. 100 Cr.	Extending the cover of ensuring energy efficient lighting in all Government Buildings Enhancing the coverage of LED street lights for all streets in Gangtok and select streets in other Urban Centres. Mandatory compliance of energy efficiency measures, rain water harvesting measures and water usage and recycling measures in all big hotels. Mandatory compliance of Energy Conservation Building Code for all new large commercial buildings in Gangtok in accordance with the ECBC of the Bureau of Energy Efficiency Solar Passive Architecture and compliance to be mandatory for all new Government buildings coming up in Urban Centres Solar Passive Architecture and compliance to be mandatory for all new large hotels coming up in Urban Centres and linked to star rating of hotels	Rs. 200 Cr.	Extending the cover of ensuring energy efficient lighting in all semi-government and even panchayat bhawans and buildings and Government educational institutions Enhancing the coverage of LED street lights for all streets in all Urban Centres and Panchayat Squares. Mandatory compliance of energy efficiency measures, rain water harvesting measures and water usage and recycling measures in all hotels and home- stays which is linked to license fee license extension Solar Passive Architecture and compliance to be mandatory for all new buildings coming up in Urban Centres. Mandatory compliance of Energy Conservation Building Code for all new buildings (both commercial and residential) in Gangtok in accordance with the ECBC of the Bureau of Energy Efficiency	Rs. 350 Cr.

4	Land Slip Protection and Land Reclamation	Urban Development and Housing Department Irrigation and Flood Control Department	Landslip protection and land reclamation through jhora training. The jhoras or natural drains in and around Gangtok have been mapped and numbered. These waterways are steadily being encroached upon alongside the increase in the volume of surface runoff of water. Intervention in formalizing these waterways is required. Training of jhoras within the city's jurisdiction need to be carried out in accordance with the environmental threats they pose. Drains in various localities alongside the storm water drains are inadequate, hence need to be constructed in order to mitigate disasters such as landslips. Mapping and identifying areas in and around Gangtok which could be reclaimed using debris from road widening of the National Highway. One such identified aea is the one near Topakhani, which could then be converted into a lorry/truck terminal	Rs. 100 Cr.	Continued implementation Landslip protection and land reclamation through jhora training. The jhoras or natural drains in and around Gangtok have been mapped and numbered. These waterways are steadily being encroached upon alongside the increase in the volume of surface runoff of water. Intervention in formalizing these waterways is required. Training of jhoras within the city's jurisdiction need to be carried out in accordance with the environmental threats they pose.	Rs. 150 Cr.	Continued implementation Landslip protection and land reclamation through jhora training.	Rs. 200 Cr.
5	Solid Waste Management and Improved Drainage System	Urban Development and Housing Department	Improvement of collection efficiencies Improvement in existing system for transportation of waste Treatment and disposal of waste in accordance with SWHR Augmentation of garbage collection fleet with modern vehicles and increased numbers Mapping of drains in Gangtok and inflow assessment Awareness campaign to educate the community	Rs. 50 Cr.				

9.10 OVERVIEW OF RURAL HABITATS

Sikkim is all set to adopt a comprehensive and holistic planning and budgeting framework in the form of "Village Development Action Plan", based on an Action Plan prepared by Professor Bernard Dafflon of Fribourg University, Switzerland. The study by the Professor is being used as a road map for scientific development of villages under the eco-city state concept and with the intention of further strengthening the decentralization of villages.

With close to 85% of its population living in rural areas, the Sikkim Government has also prioritized rural development and a total of 70% of plan allocation is for village development with the government firmly believing that without the development of the rural areas and the people of grass root level, total and overall development is not possible. Given this and from an energy perspective, one of the priorities of the Government would be to ensure "energy access" to all its rural communities and also to ensure "sustainable Transport" to the extent possible.

One of the main challenges however, is the terrain and altitudes coupled with the fact that most villages in Sikkim are not in the usual cluster formation but houses are spread and afar. However, despite this, Sikkim is one of the very few states in India, which has a near 100% village electrification and close to 75-80% household electrification. In addition to this, the Government has also endeavoured to supply LPG to rural communities at highly subsidized cost and is also keen to explore other forms of energy sources to ensure 24x7 energy access to rural communities.

Some of the areas which the Government wishes to explore further is to address the heating needs of people. In general, most rural communities tend to use traditional bio-mass or fuelwood for heating purposes.

Sikkim also gets close to 200,000 tourists coming in every year. While the bulk of the tourist traffic will be Gangtok, a sizeable number also go to remote locations such as the Kanchenjunga National Park, Nathula Pass, Pelling and to monasteries such as Sangachoeling Monastery, Dabdi Monastery, Tashiding Monastery amongst others.

Sikkim is also a trekkers' and adventurers' paradise, from mountaineering in numerous peaks in and around the state or white water rafting along the turbulent rivers of the Teesta and the Rangit, tourists have a great time. This also means that tourism is a flourishing business and likewise could also be carbon intensive, such as maintenance of tourist and trekking camps, camp fires and room heating, to water heating and cooking.

9.11 KEY PRIORITIES AND STRATEGIES FOR RURAL HABITATS

One of the key priorities for rural habitats is to ensure 100% energy access which is not only environmentally friendly but also sustainable. This would not just cover rural households but also address rural tourism and ensure that monasteries and other habitations in high altitudes and remote locations have access to modern and sustainable energy.

Heating being the most crucial element, large scale penetration of solar water heating systems with heat exchangers are being explored for rural water heating and to ensure warmth for buildings particularly in winter months, solar passive architecture is also being considered, with a couple of pilot models. Further to augment the heating requirement, large scale penetration of bio-gas plants are also being considered.

The other priority for the rural sector is in terms of communication and using communication. Given the high altitude, terrain, geographic location and topography of the state, the major challenge for the state amongst others is to provide internet and net banking in each and every nook and corner of the state without promising on the speed of the network, laying transmission and distribution of electricity cables in these regions and laying of roads, without destroying the fragile eco-system/s of the region.

Table 23: Budgetary Estimates			
	Short Term	Medium Term	Long Term
Solar Hot water Systems	Rs. 1 Cr	Rs. 3 Cr	Rs. 10. Cr
Bio-gas plants	Rs. 2 Cr	Rs. 3 Cr	Rs.5 Cr
Solar Passive Architecture	Rs. 10 Cr	Rs. 25 Cr	Rs. 50 Cr
Weather monitoring stations	Rs. 100 Cr	Rs. 500 Cr	Rs. 500 Cr
Rural Health Energizing	Rs.5 Cr	Rs. 10 Cr	Rs. 20 Cr
Rural Education infrastructure energizing	Rs. 5 Cr	Rs. 15 Cr	Rs. 20 Cr
Forest Department	Rs. 5 Cr	Rs. 15 Cr	Rs. 25 Cr
Monastery Energizing	Rs. 3 Cr	Rs. 6 Cr	Rs. 9 Cr
Tourism Sector	Rs. 2 Cr	Rs.5 Cr	Rs. 20. Cr
Total	Rs. 133 Cr	Rs. 582 Cr	609 Cr

One of the ideas being explored is for Sikkim to get weather stations with satellite enabled internet facility. These weather stations can provide the much required data and information on everything related to weather and provide farmers and others with the crucial information at the earliest without having to depend on forecasting exercises. The satellite enabled internet facility is believed to be a double edged or even a multiple edged sword, which could address a number of issues by providing continuous internet facility even in the remotest corners of the state. Some of the impacts of this could be:

Setting up of one stop kiosks to book air tickets, rail tickets and even bus tickets from even the remotest corner of Sikkim. As of now, any one desiring this, will have to travel all the way to Gangtok, thereby traveling a radius of 100 Kms and spending over 15 litres of fuel one way or 30 litres of fuel two ways.

Ensure that people can pay their electricity and other utility bills on line and meter readers can also use the internet facility to get the required information from someone in the panchayat to do the metre reading. As of now, if a metre reader is expected to go every month to remotest village with no proper transport, either he/ she tends to avoid it, thus leading to approximation of bills or avoidance of bills. This can in a way help in reducing T & D Losses.

Can help in reaching out to students even in the remotest corner through computer aided education. A small solar PV system in a school with computers can go a long way in improving education of students.

Internet can also help in addressing urgent medical issues. Given the terrain and the weather conditions, it is not always possible to even air-lift medical help. However, for immediate emergencies, a doctor can always get on-line through skype video mode and advice the local people on what to do and how to do demonstratively in case of medical emergencies.

Other areas where renewable energy equipments and appliances can potentially play a very crucial role is in Primary Health Centres, Rural and remote areas schools and educational institutions, Rural Dairy Farms, Monasteries and tourist camps and forest department buildings and outposts.

Urban Transport

Aerial view of a road in Sikkim

10.1 OVERVIEW OF THE URBAN TRANSPORT IN SIKKIM

Cushioned in the eastern Himalayas surrounded by Bhutan in the East, Nepal in the West, Tibet in the north and West Bengal in the south, Sikkim, the 22nd state in India is a small state that attracts a large number of tourists for its vivacious, scenic topography. Even with an area of 7,096 km2 with an altitude ranging from 800-28,208 ft, transport and connectivity pose major challenges. Gangtok, being the capital of the state and a major tourist spot, on an average day, has about 30,000 vehicles entering and exiting its limits.

Figure10.1: Origin destination finding

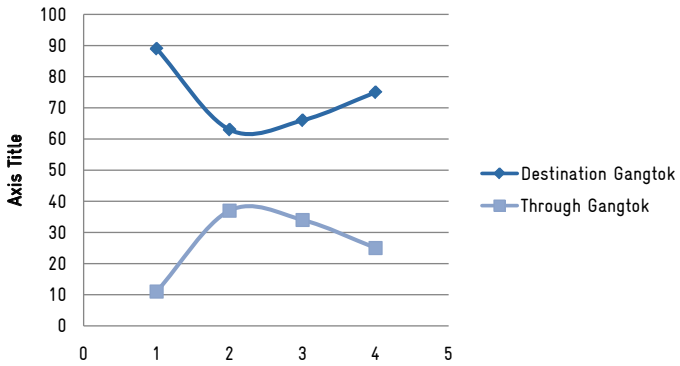
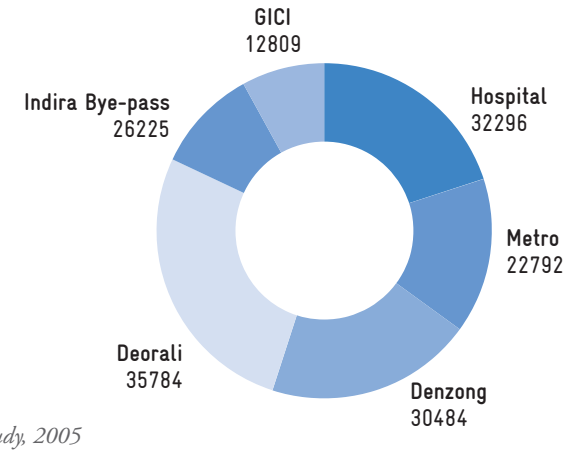


Figure 10.2 a: Daily movement of the vehicles



Source: CIRT Study, 2005

Roads constitute the main mode of mobility in Sikkim, given the fact that the nearest air link to Sikkim is the Bagdogra Airport and the nearest rail link being Siliguri, both in West Bengal and roughly a distance of around 120 km from Sikkim. Sikkim is connected to the rest of India by National Highway 31A to Siliguri and onwards through the network of National and State Highways.

From an average of 8000 tourists every year in the early 1980s, there has been a substantial influx of tourists in to the state and it currently stands at around 2,00,000 tourists coming in to Sikkim every year. This large influx of tourists coupled with increasing population and urbanization and increase in purchasing capacities, has led to a substantial increase in vehicle movement into Sikkim and particularly affects the capital city of Gangtok. Since there are no freight or goods terminals in and around Gangtok and given that a number of areas within Gangtok are not accessible by large vehicles, goods are often transferred to smaller vehicles for further transporting it within Gangtok, which also adds to the cities congestion.

Figure 10.2 b: Milk being transported by road

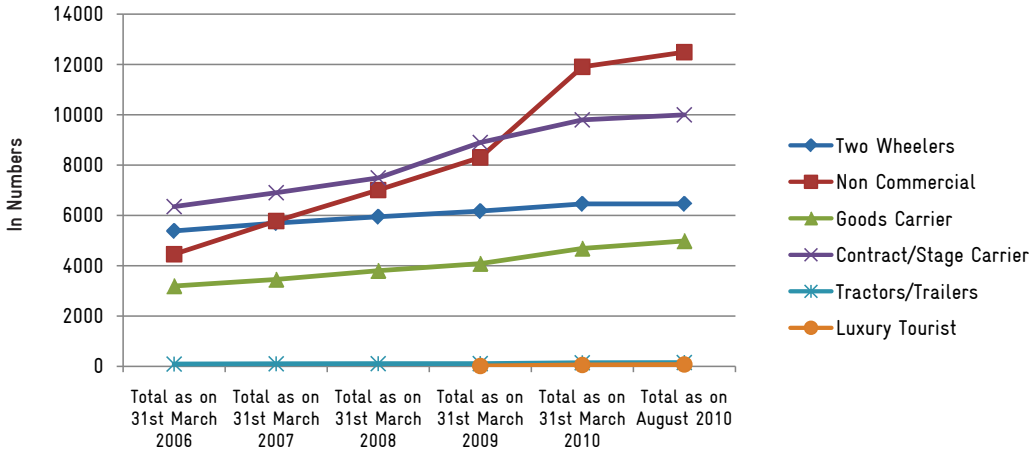
Most of the road length in Gangtok, is of two lane undivided carriageway with foot path on one side of the road and drain on the other. The steep gradient of the different road stretches coupled with spiral road configuration act as a constraint for smooth flow of vehicular as well as pedestrian traffic.

About 75% of the primary road network has a carriageway ranging from 6-8m. Another 25% of the road length has carriageway ranging between 8-10m.

Road congestion in Gangtok is on the rise and at least nine junctions have recorded very high levels of congestion. This has resulted in journey speeds being extremely low, varying from 11km per hour to a maximum of 27 km per hour, with traffic volumes data recorded at various locations point out that in the above identified junctions, traffic volumes are in the region of 10,000 to 35,000 vehicles during the day, with the peak volume varying from around 350 to 600 vehicles per hour in peak times.

Out of the total vehicular trips intercepted at the selected locations in and around the city, about 38% of the trips are made for work, 15% for education, 17% for shopping and remaining

Figure 10.3: Trends in growth of various categories of vehicles in Sikkim



Source: Annual Reports of the Transport Department

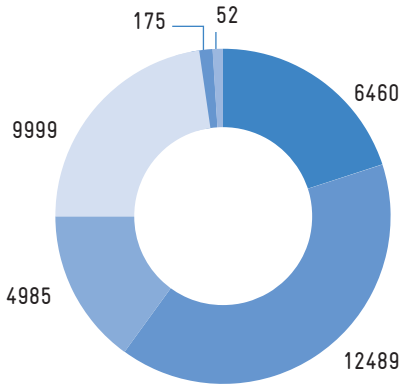
30% for other purposes. Of the total goods vehicle intercepted at Gangtok city limits, approximately 66% of LCVs/Tempos and 75% of two and three axle trucks have both the origin and destination within Gangtok city. The goods traffic desire patterns reveal that 63% of the trips are to Gangtok.

10.2 VEHICLE PROFILE AND GROWTH TRENDS IN SIKKIM

The annual growth rate of registered motor vehicles in Sikkim was in the region of 11% to 13.6% during 1998-99 to 2004-05, with an annual growth rate of taxis and cars being in the region of 33-46 % particularly in the years of 2002-2005. The growth rate of vehicles between 2005 and 2010 averaged to 13% per annum with a total of 70% increase in the number of registered vehicles in 2010 as compared to 2005.

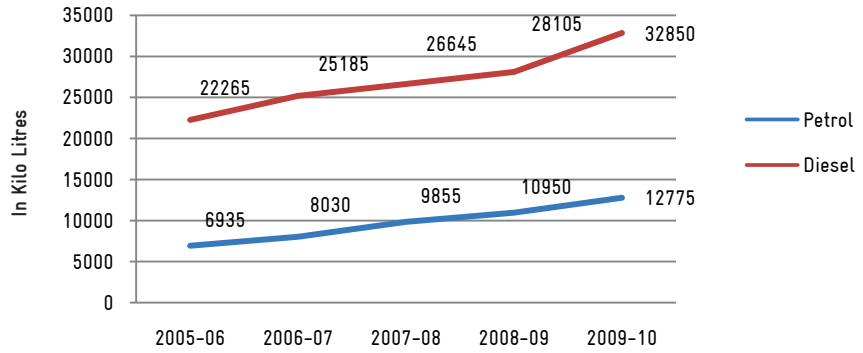
As far as the profile of vehicles is concerned, there is a substantial increase in the purchase of four wheelers and even amongst the four wheelers, the trend of purchase of vehicles which fall in the category of Sport Utility Vehicles and Multi-Utility Vehicles is on the rise.

Figure 10.4: Cumulative vehicles registered upto August 2010 (Numbers)



Source: Annual Reports of the Transport Department

Figure 10.5: Trends in the consumption of energy fuels for transportation sector



Source: Based on data from food and civil supplies Department, Gangtok

10.3 ENERGY CONSUMPTION PROFILE FOR TRANSPORT PURPOSES IN SIKKIM

The energy consumption for transport tends to vary with tourist seasons, with peak tourist seasons recording a high fuel consumption with a considerable dip in energy consumption during off tourist seasons.

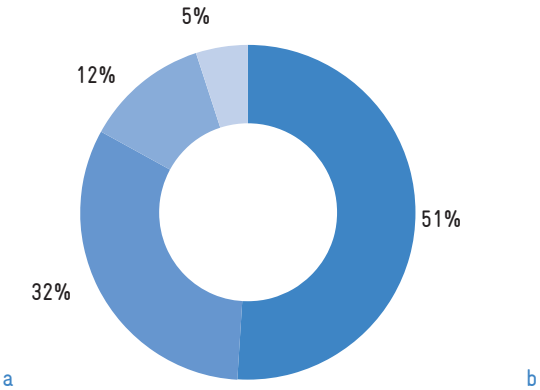
On an average the daily consumption of fuel is 35 kilo- litres of petrol and 90 kilo-litres of diesel per day.

There has been a steady rise in the fuel consumption pattern in the last five years, which is primarily due to an increase in tourist flow into Gangtok and Sikkim and also due to the increase in the number of vehicles.

10.4 TRENDS OF USE OF TRANSPORTATION AND OVERVIEW OF PUBLIC TRANSPORTATION IN GANGTOK

Out of the total vehicular trips intercepted at the selected locations in and around the city, about 38% of the trips are made for work, 15% for

Figure 10.6 a: Preferred mode of transportation within Gangtok city limits
b: Trends in percent of use of transportation in Gangtok



a

b

Sl. No	Purpose	%
1	Shopping	36
2	Education	16
3	Business	12
4	Sight seeing/Recreation	12
5	Health	12
6	Return Home	8
7	Work	4
	TOTAL	100

Source: Comprehensive Mobility Plan, Gangtok

Figure 10.7: Public transportation

education, 17 % for shopping and remaining 30% for other purposes. Of the total goods vehicle intercepted at Gangtok city limits, approximately 66% of LCVs/Tempos and 75% of two and three axle trucks have both the origin and destination within Gangtok city. The goods traffic desire patterns reveal that 63% of the trips are to Gangtok.

Gangtok remains prime destination in Sikkim for vehicles coming to or moving within Sikkim. Gangtok as the destination accounts for 89% of passengers vehicle, 66% of Light Commercial Vehicles (LCV), 75% of heavy vehicles and 63% of goods

The most preferred public transport in Gangtok and Sikkim is the taxi service. However, the Sikkim Nationalised Transport provides city buses for Gangtok with a total fleet of 25 buses procured as part of the Jawaharlal Nehru Urban Renewal Mission programme. However, the Public buses do tend to ply full load during peak hours, in non-peak hours, the number of passengers tends to dip substantially as is indicated in the graph below:

Picture of ceremony commemorating the laying of the foundation stone taken at Pakyong, Sikkim

10.5 CONNECTIVITY OF SIKKIM TO REST OF INDIA

Sikkim is not connected by either air or train, though does operate Helicopter Service from Bagdogra Airport to Gangtok Heliport. The Helicopter service is operated by Pawan Hans Limited. An airport catering to ATR aircrafts is expected to be operational in 2012, in Pakyong, near Gangtok. The foundation stone for the airport was laid and construction commenced in March 2009.

A railway line from Siliguri to Rangpo, about 50 kms from Gangtok is also on the anvil and feasibility studies, planning and designing are all underway. The rail head is expected to be completed by 2015. In terms of road network, highway 31A connects Sikkim to rest of India and this highway also connects rest of India to Nathula Pass.

10.6 ADMINISTRATIVE AND GOVERNANCE STRUCTURE OF THE TRANSPORT SECTOR OF SIKKIM

The overall administration of the transport sector is the responsibility of the Transport Department. The department is entrusted with framing and implementation of policies governing the sector. The Motor Vehicle Department is a constituent of the Transport Department and is responsible for vehicle registration and licensing norms. The Motor Vehicle Department also issues driving licences amongst other functions. In the management of urban sector, of which transportation is also a key constituent, the transport department works in conjunction with the Urban Development and Housing Department, primarily on issues related to traffic congestion and urban planning from a transport point of view.

The transport department also works closely with the Department of Roads and Bridges in the planning of road network in the state.

10.7 OVERVIEW OF POLICIES GOVERNING THE SECTOR

In alignment with the National Urban Transport policy, the vision for Gangtok is a well contained city having efficient people-friendly transport system with minimum travel time and maximum safety and comfort that also factors optimal use of facilities. The Mobility plan for Gangtok and other towns in Sikkim revolves around following issue:

Improve connectivity and travel throughout the urban area and their regions.

Improve mobility within neighborhood, wards, zones and satellite towns to address inner-and inter-city transport needs.

Achieve efficient management land use and transport systems to minimize overall travel cost

Offer viable and reliable transport options that aim at reducing dependence on cars, private vehicles, with widespread use of non-motorized modes and mass rapid transit systems.

In view of this, the Sikkim Government has introduced a number of policies and measures to address the issue of road congestion or road decongestion, and promotion of non-motorised transport is one of the priorities for the government. Therefore, various alternatives such as rope-ways, pedestrian pathways, steps and stairways are being built and planned, particularly around urban centres to de-congest the towns and limit vehicle usage.

The Sikkim Government is implementing strictly the “Parking regulation”, which primarily allows the registration of new vehicles only if the adequate proof of indoor parking for vehicle is provided which is inspected and verified before allowing the registration of vehicles.

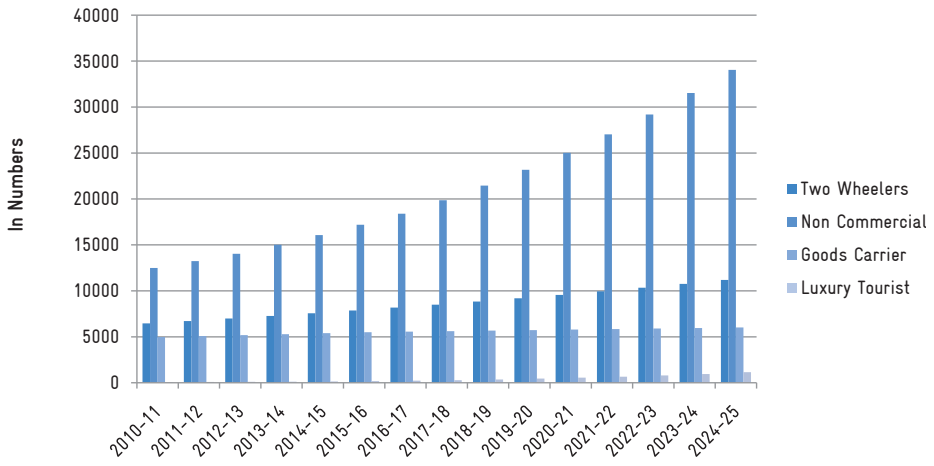
In addition to the above, the government has also made it strict for registration of vehicles for the use of “Taxi Purposes”. A person intending to run a “taxi service” will have to provide proof of “unemployment”, “sources or lack of sources of other income” “parking space proof and a recommendation from the area Member of the Legislative Assembly.

Further to ensure that public parking spaces are not over used, the Government is also implementing “Short Term Parking”, which will be a slab rate and higher the number of hours a vehicle is parked in the parking lot will have to pay a higher parking rate.

As far as pollution control norms is concerned, as per the State of Environment Report done in 2004, close to 80% of all vehicles were complying with emission control norms as per a survey which was done in connection with the report.

In terms of Policy, as per the National Fuel and Emission Policy, all new vehicles in Sikkim will have to be Euro-III compliant, which came in to force in June 2010.

Figure 10.8: Project growth of vehicle population in Sikkim



10.8 FUTURE PROJECTED GROWTH IN THE TRANSPORTATION SECTOR

Based on past trends, the personal transport population or the non-commercial vehicle segment is expected to grow at a rate of 6% to 8% per annum for the next 15 years, while the luxury tourist segment is expected to register a 12% -15% growth for the next 10 years and then go on to touch 20 to 25% with a peak of 30%. The good carrier segment will also show a marginal increase of 2 to 3% every year till about 2015, primarily due to the increase in demand for goods vehicles with many new power projects and infrastructure projects coming up in the next 5-7 years, which also include the new railway line and airport, but is likely to dip to1-2% growth annually from 2017-18.

10.9 KEY PRIORITIES FOR URBAN TRANSPORTATION

Public transport should cater to the travel needs of 90% of population. Trip origins and destination will be within 500-1000mt of public transport terminals and stops. For those who can't avail public transport within walking distance, dedicated cycle lanes with secured bicycle parking facility to reach the public transport system.

80% of total trips should be made by public transport with one (or two) modal changes. In residential, commercial and institutional areas, safe and convenient pedestrian/NMV facilities should be provided. Integrate urban land use with transport system to develop efficient and sustainable mobility.

10.10 BROAD STRATEGIES FOR THE SECTOR

Some of the broad strategies or Policy initiatives being thought off for Sikkim include the following:

a. Vehicle registration policy/ taxation

Introduce appropriate taxation that, in one end, acts as a deterring factor for the artificial demand created due to conspicuous consumption pattern, and at the other, augment the resource that is required to upgrade public facilities such as roads, parking places, terminals, transit points, etc. The tax proceed from such measures

to be earmarked and used for the purpose of improving the transport infrastructure and public transport facilities.

b. Public Transport Policy

This policy aims at developing mechanisms to guide and regulate the operation of buses and other modes of public transport by introducing fiscal incentives, concessions and obligations for public transport operators. Creation of a nodal agency with the powers to scheduling and routing of services, regulating and monitoring operations with respect to planned routes and schedules is necessary to promote and ensure user friendly services.

c. Reschedule/adjust work/activity timing

Gangtok having a significant population being salaried working class with majority among them in government services has to face the typical peak traffic congestion and road jam prior and post to the office opening and closing hours. The problem get further complicated due to almost all government offices located in the city centre. In addition a lot of activities are concentrated at this specific timing. If the school hours can be aligned local daylight cycle as a matter of convenience, traffic flow would be distributed.

d. Transport regulatory authority

To establish a transport regulatory authority as is mandated by the National Sustainable Urban Transport Policy and a requirement by the JNNURM programme of the Central Government. The Transport Regulatory Authority would be a nodal agency with the powers to scheduling and routing of services, regulating and monitoring operations with respect to planned routes and schedules is necessary to promote and ensure user friendly services.

e. Regulatory mechanism which would ensure the following:

Traffic control: Deals with Traffic signs, road markings, traffic signal, computerized traffic control system, traffic cones and drums, Barricades, speed-breakers, traffic lighted bollards, central refuges and intersection channelisation

Traffic segregation: Deals with pedestrian grade separator, pedestrian mall, sidewalks, central dividers, footpath and central railings, creation of storage lanes at turning points, bus bays, bicycle lanes, off street loading/unloading facilities

Demand management: Deals with Parking restrictions, parking supply reduction, parking pricing, preferential parking and preferential lanes for high-occupancy vehicles, road and bridge tolls, supplementary licensing, area tolls, vehicle ownership taxation, general fare reduction on public transport

Bus priority: Deals with priority maneuvers, bus lanes, bus precincts, bus priority single systems, bus operation management

Self enforcement: Dividers, railings, channelizers, queue channels, parking notches, sleeping policeman, bus bays, sharing of taxis and fixed taxi tariff system

f. Promoting non-motorized transport system

Promoting non-motorized transport system in Sikkim, through a combination of constructing pedestrian pathways and footpaths, steps and stairs, rope ways

g. Dynamic Fuel policy

A dynamic Fuel policy for largely government and public transport vehicles and exploring the possibility of extending it to other vehicles as well.

The details of the measures along with timelines given in the following table:

Table 23: Policy measures and timeline of action for the urban transportation sector		
Short term (2011-2015)	**Medium term (2016-2025)**	**Long term (2025-2040)**
a. Vehicle registration policy/taxation: Introduce appropriate taxation that, in one end, acts as a deterring factor for the artificial demand created due to conspicuous consumption pattern, and at the other, augment the resource that is required to upgrade public facilities such as roads, parking places, terminals, transit points, etc. The tax proceeds from such measures to be earmarked and used for the purpose of improving the transport infrastructure and public transport facilities.	a. Transport regulatory authority: To establish a transport regulatory authority as is mandated by the National Sustainable Urban Transport Policy and a requirement by the JNNURM programme of the Central Government. The Transport Regulatory Authority would be a nodal agency with the powers to scheduling and routing of services, regulating and monitoring operations with respect to planned routes and schedules is necessary to promote and ensure user friendly services.	a. New area/city expansion plan New areas are being added to the urban area limits. Decision to develop new areas for residential or other activities should firmly align with integrating that area in to a sound public transport system with proper physical and social infrastructure at these locations, create or extend roads to provide accessibility to provide mobility.
b. Public transport policy This policy aims at developing mechanisms to guide and regulate the operation of buses and other modes of public transport by introducing fiscal incentives, concessions and obligations for public transport operators. Creation of a nodal agency with the powers to scheduling and routing of services, regulating and monitoring operations with respect to planned routes and schedules is necessary to promote and ensure user friendly services.	b. Shift and relocate work centres With all government offices located around the centre of the city, as in the case of Gangtok, travel to the city centre becomes absolute necessary. Shifting offices and work centres to appropriate locations is another policy option available. With these relocations, activities around these government offices will shift; and with that allied and supporting activities that take place in the private sector would shift. This will also pave way for shifting location of residential colonies in relation to work centres	b. Developing new urban centres From the current 9 Urban Centres, by 2040, the Government is planning 16 Urban Centres and each of the Urban Centres will also serve as work points, which would in a way complement the "Shift and relocate work Centres" policy which is being considered for medium term implementation
c. Reschedule or adjust work/activity timing Gangtok having a significant population being salaried working class with majority among them in government services has to face the typical peak traffic congestion and road jam prior and post to the office opening and closing hours. The problem get further complicated due to almost all government offices located in the city centre. In addition a lot of activities are concentrated at this specific timing. If the school hours can be aligned local daylight cycle as a matter of convenience, traffic flow would be distributed Actions proposed		

Short term (2011-2015)	Medium term (2016-2025)	Long term (2025-2040)
Promoting mass rapid transit / sustainable transport system		
a. Pedestrian walkways and footpaths In places where vehicular traffic is heavy, with very little or no pedestrian facilities, the following stretches are being proposed to have pedestrian walkways and foot paths on an immediate basis or strengthened, if one already exists. This could also potentially result in a reduced use of vehicles, particularly personal vehicles.	a. City bus service on demarcated lines/bus priority lanes: This form of transport system would be built upon existing system with very low capital and low operating cost with high Demarcated bus lanes to run city bus service with mid-size CNG buses would be put in place, this could be a viable option. Private cars, taxis and truck will have to be given alternated route.	a. Personalised Rapid Transit(PRT): Having a carrying capacity of 4-6 passengers per vehicle and operated either on battery or electricity, PRT itself acts as a feeder service for mass transit systems. PRT has the advantage of low operating cost per unit than any other means, pods movement flexibility, low pollution levels and needs limited urban space if elevated or underground. PRT is could be integrated to the mobility management plan at a later stage of development and can connect Pakyong airport to Ranipool
b.Steps and stairs The idea of having steps and stairs is to reduce travel time and also distance while commuting on foot which could potentially mean a reducing of distance covered by road from 2-4 Kms to 0.5 to 1.5 Kms by foot.	b. Modernisation of the Pakyong Airport: To be modernized to accommodate Large bodied aircraft to reduce movement time and increase passenger and tourist coverage from Bagdogra to Gangtok	b. Sky bus: Sky bus system provides excellent alternative for mass transport and enjoys many advantages over other forms of transport.
c. Junction improvements Most junctions in Gangtok are in acute angles with improper geometry. Some junctions have already been identified for modification in Gangtok	c. Rail link to Rangpo by 2015 Feasibility studies for extending rail link from Rangpo to as close a location to Gangtok	c. Extension of rail link from Rangpo to Gangtok Ensuring lobbying with the railway ministry to implement the recommendation of the feasibility report of rail link from Rangpo to a location closer to Gangtok (if the report confirms feasibility)
d. Foot over bridges A number of areas within Gangtok have been identified for construction of foot over bridges	d. Extend the non-motorised forms such as detailed in Short term to other locations in and around Sikkim	d. Construction of freight terminals and parking area. 3 projects have been identified at an estimated cost of Rs. 91.50 Cr.
e. Ropeways A couple of new ropeways in Sikkim are in various stages of planning and commissioning Feasibility studies to be undertaken to have ropeways in all districts and district to district linkage. Commencement of operations at the Pakyong Airport catering to ATR Aircraft by 2012	e. Ropeways to be extended to all four districts and also explore district to district linkage	

Short term (2011-2015)	Medium term (2016-2025)	Long term (2025-2040)
Pollution and fuel emission norms a. Full Implementation of Euro-III norms for vehicle pollution and fuel Efficiency b. Implementing Euro-IV norms for vehicle pollution and fuel efficiency as a measure to be leaders for Metro cities Government Procurement policy which ensures that Government buys only Euro-IV Norms Compliant Vehicles	a. Feasibility of implementing Euro-V norms for all vehicles in line with the leadership taken by the Sikkim Government to declare Sikkim as a Organic, zero chemical fertilizer state	
Fuel policy		
a. To explore the possibility and run all Government vehicles on Bio Fuel	a. To have large government run Bio-Fuel Farm for producing bio-fuels for government vehicles and public transport vehicles without compromising on forests and agriculture land	a. To incentivize or disincentives Government employees for following a non-vehicle ownership policy. Perhaps a 15% hike in pay, if a person owns only a 2 wheeler and a 30% hike in salary if a person has no vehicle and -5% reduction in salary, if a person or his family owns more than 1 car. This to be on a slab rate basis
b. To have three mini-buses to be run on battery and solar charged for commuting Government Employees from Tashling Secretariat to Deorali and beyond	b. To set up battery charging stations for electric vehicles across the length and breadth of Gangtok in association with Petrol bunks and also to have battery exchange stations	
c. To introduce bio-fuels for all forest vehicles for patrolling work	c. To introduce hybrid vehicles in Government fleet	
d. To introduce battery operated vehicles on all Zoos and National Parks		
e. To conduct feasibility studies to introduce battery operated buses for intra-city connectivity		
Fiscal policy and government procurement		
a. Introduce appropriate taxation that, in one end, acts as a deterring factor for the artificial demand created due to conspicuous consumption pattern, and at the other, augment the resource that is required to upgrade public facilities such as roads, parking places, terminals, transit points, etc. The tax proceeds from such measures to be earmarked and used for the purpose of improving the transport infrastructure and public transport facilities.	a. Disincentivising the purchase of more than two 4 wheeler per family starting with Government employees b. Incentivise with extra salary, employees who buy energy efficient and other wise carbon neutral or carbon positive vehicles on a slab basis	
Government vehicle procurement policy		
a. All quotations received for procurement of Government vehicles will be on the basis of at least 3 star labeling of Vehicles by BEE to be put in place	a. All quotations received for procurement of Government vehicles will be on the basis of at least 5 star labeling of Vehicles by BEE to be put in place	a. All quotations received for procurement of Government vehicles will be on the basis of at least 5 star labeling of Vehicles by BEE to be put in place and would be carbon positive

Short term (2011-2015)	Medium term (2016-2025)	Long term (2025-2040)
Tourism sector norms		
a. All Tourism and trekking camps in high altitude areas to have bio-gas for cooking and solar water heating facility b. Kanchenjunga National Park in addition to the above will also have battery operated patrol and visitor vehicles for movement within the park	a. All monasteries in Sikkim in high altitude and remote areas to be connected with renewable energy power b. all Remote monasteries and tourist locations to have be 100% energy neutral which would include solar passive architecture, LED lighting, solar heating and even solar cooking where ever possible	
c. All core area vehicles will be on biofuel, emission free vehicles		
Decongestation of existing roads and creating new road networks		
Creating localized parking areas. Since Gangtok has a hilly terrain and all houses area not accessible by road, smaller parking nooks for taxis and private vehicles that are available locally, in and around Gangtok especially for off the road structures is essential. Some areas have been identified for this purpose.	Existing road network to be redeveloped along with construction of new roads like Inner and Outer Ring Roads. Total number of 29 projects has been identified at an estimated cost of Rs. 485.17 Cr.	
	Relocating the bus terminal from SNT and the private bus stop to the lower reaches of Gangtok, in Sokaythang.	

Budgetary estimates:

Short term (2010-15): Focus on strengthening and improving of existing traffic and transportation. Priority being on developing pedestrian construction and improvement of footpath, stairs connecting roads, geometry improvement of junctions and also developing new links for alternate routes. Under NMT facility, development ropeway network, few critical parking sites and bus terminals and expansion of ropeways. Total number of 75 projects has been identified with an estimated cost of Rs. 299.08 Cr.

Medium term (2016-25): Existing road network to be redeveloped along with construction of new roads like Inner and Outer Ring Roads. Total number of 29 projects has been identified at an estimated cost of Rs. 485.17 Cr.

Long term (2025-40): Construction of Freight Terminals and Parking Area. 3 projects have been identified at an estimated cost of Rs. 91.50 Cr.

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